

**THE EFFECTS OF ALCOHOLIC HANGOVER**  
**ON HUMAN PERFORMANCE**

BY

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## **PREFACE**

The Study described in this dissertation was conducted in the School of Psychology, University of Natal, Pietermaritzburg, under the supervision of Dr. Stuart Anderson. It represents original work by the author, and has not been otherwise submitted in any form for any degree or diploma to any university. Where use has been made of the work of others, it is duly acknowledged in the text.

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## ABSTRACT

This dissertation aims at determining the possible effects of alcoholic hangover on human behaviour by examining the effects of acute alcohol consumption ( $> 1\text{g/kg}$ ) 14-16 hours following alcohol ingestion on simple and choice reaction times, divided attention tasks and driving skills. The hypotheses are that cognitive and behavioural functioning is impaired even after the blood alcohol concentration level has returned to zero. The California Computerised Assessment Package (CALCAP) together with selected driving skills tasks, repeated breath analysis measures, a biographical questionnaire, a subjective hangover rating scale, and blood glucose tests were administered to a group of 63 mixed gender student volunteers. The experimental group was tested prior to, and during hangover. The control group was pre- and post-tested in order to determine the impact of practice effects. Results indicate that hangover individuals performed less well than control subjects on measures of reaction time and driving precision. Further more, the findings show that subjective experience of hangover is not a good predictor of reaction time or driving performance, and that the absence of hangover symptoms does not guarantee full mental recovery. Statistical analysis of the data showed that post-test findings could not be attributed to a gender effect.

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## CHAPTER 1: RATIONALE AND PURPOSE OF THIS STUDY

This dissertation was inspired by a study carried out by Anderson and Dawson (1997,1999) and aims to investigate the possible neuropsychological effects of alcoholic hangover by examining the residual effects of alcohol on cognitive and psychomotor performance. The appropriate literature citations for the points made in this chapter will be given in the Literature Review, Chapter 2. Existing literature on the lasting effects of alcohol on performance is scarce and so diverse that for caution's sake one can only suggest that any demanding performance may be impaired after consummation of alcohol even several hours following drinking. Studies are varied and often so methodologically inadequate that in conclusion it is often difficult to say when, how and why performance is impaired. Modern research on the after-effects of alcohol is often characterised as being ambitious rather than rigorous. Many studies 'test' elaborate hypotheses about the cognitive and biological processes underlying post alcohol impairment while using tasks that have never been validated as acceptable measures of any aspect of performance. Studies finding no long-lasting effects of alcohol on some tasks are particularly problematic. In the absence of evidence that the tasks are generally sensitive to drug or similar effects, the absence of an effect may be due to the design of the study being insufficiently powerful to detect the effect. Research or measures of performance which completely fail to show the significant post-alcohol effects are also questionable in terms of possible under-reporting, especially as the consensus belief seems to be that alcohol does impair performance. Available findings often cannot guarantee accuracy in research

and, therefore, there is a need to establish the basic facts about the effects of post-alcohol impairment on performance under methodologically adequate conditions. In an attempt to address the above gaps in the literature, this study takes into consideration the following:

- (1) the lack of female subjects in previous studies; this study therefore includes women in both the experimental and control groups;
- (2) previous studies have used very few subjects (e.g. N as low as 6) and results drawn from a small sample size make for weak conclusions. Therefore, it was necessary to provide enough subjects to lend confidence to the findings;
- (3) many studies do not report or assess blood alcohol levels. This research includes repeated blood alcohol concentration measures;
- (4) this study attempts to provide a standardised measure of alcohol administered to subjects (i.e. sufficient alcohol drunk to achieve a blood alcohol reading of 100mg/dl). In addition, this includes an awareness of reports in the literature that different alcoholic beverages may have different effects on human performance and, so restrictions were placed on the type of drink used in testing (i.e. wine or beer);

- (5) consideration is given to the effects of individual differences in metabolism and effects of food on the digestive system, previously absent in much of the literature;
- (6) most studies to date have taken place in an experimental or laboratory-type setting. This dissertation considers the ecological validity of such testing in terms of the social meaning attached to drinking which is most often reflected within a natural setting. Therefore, this study attempts to improve ecological measures by way of utilising a genuine pub setting;
- (7) the pre-/ posttest design provides a baseline measure for change and cognisance is given to the importance of using both a within-subjects design, as well as a between subjects design to address differences between experimental and control groups as well as individual differences between pre- and post-testing; and,
- (8) subjective measures such as mood and physical distress in relation to the hangover state are not measured in a number of studies. The inclusion of a 19-item subjective rating scale of hangover provides further insight into individual ability to assess the individual experience of the degree of hangover and its effects.

In summary, the purpose of this dissertation is two-fold: one is to report on previously published and new data concerning the long-term after-effects of acute high dose alcohol

administration; the second is to examine the acute effects of post-alcohol impairment on human performance whilst maintaining as rigorous a methodological protocol as circumstances would allow.

## CHAPTER 2: REVIEW OF THE LITERATURE

### 1. INTRODUCTION

There is no question, as accumulating evidence reveals, that alcohol in excess negatively affects the brain and neuropsychological functioning, both immediately and in the long-term (Delin & Lee, 1992; Finnigan & Hammersley, 1992; Reitan & Wolfson, 1985). Whereas the deleterious effect of acute ethyl alcohol intoxication on psychomotor skills related to human performance (Evans, Martz, Rodda, Kiplinger & Forney, 1974; Nelson, 1959; Seppala, Leino, Linnoila, Huttunen & Ylikahri, 1976) and in simulated traffic (Buikhuisen & Jongman, 1972; Linnoila & Hakkinen, 1974) has been fairly well documented, less attention has been paid to the duration of impairment, particularly where the blood alcohol level (BAL) has returned to zero<sup>1</sup>. Work in aviation research has demonstrated that pilot errors increase on some tasks in flight simulators the day after moderate alcohol consumption (Cook, 1997). These findings suggest that there can be similar effects on everyday tasks such as driving and operating machinery (Finnigan & Hammersley, 1992)<sup>2</sup>. The physiological and subjective effects of acute ethanol

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<sup>1</sup> In normal human functioning BALs should not strictly be considered to be 0 mg/dl owing to the endogenous production of small quantities of alcohol, and the technical accuracy of measurement. A BAL of 'zero' will therefore refer to an amount < 5 ml/dl.

<sup>2</sup> Studies which measure breath or blood alcohol express their findings in a diversity of units, the most common of which is grams of absolute alcohol per kilogram of body weight.

withdrawal, or the "hangover" state in humans occurs in the period following an intake of alcohol exceeding 1 g/kg (Delin & Lee, 1992) and correlates with declining blood alcohol concentrations, peaking once the blood alcohol levels approach zero (Anderson & Dawson, 1997). These complex physiological and subjective effects following an acute alcohol dose are potentially detrimental to human performance and functioning (Anderson & Dawson, 1997; Finnigan & Hammersley, 1992; Gauvin, Cheng & Holloway, 1993). For motor vehicle drivers the important question is whether or not the hangover state continues to impair neurobehavioural functioning in either the medium or long-term following alcohol ingestion (Delin & Lee, 1992).

Assessing the seriousness of hangover is difficult because of the paucity of studies investigating the effects of post alcohol impairment on human performance (Cook, 1997) and existing research into alcoholic hangover is fraught with methodological difficulties. According to Finnigan and Hammersley (1992), the literature on the effects of alcohol on human performance is so disparate that for caution's sake one may determine that following the consumption of any amount of alcohol, any exacting performance may be impaired. However, studies are so varied and so often methodologically inadequate that it is impossible to specify exactly when, how and why performance will be impaired. Not only is research investigating the effects of post alcohol impairment on human performance scarce but earlier studies are problematic as definitions used and measures taken vary considerably across researchers and studies (Cook, 1997). These include an absence of standards in the measurement of alcohol dose and measurement over time, a lack of awareness of the role of expectancy effects and type of setting during

intoxication, varied performance measures, problems with design (e.g. small sample size), and subject variables, e.g. gender and individual differences (Anderson & Dawson, 1997). Thus, problems outlined in this dissertation make an impartial review of the literature difficult, as studies are not always directly comparable, and this limits the potency of conclusions and generalisations drawn from such results.

## **2. ALCOHOLIC HANGOVER**

The complexities of the physiological and subjective delayed effects produced after an acute high dose alcohol administration differ between individuals, and cannot be simply accepted as a universal phenomenon (Gauvin et al., 1993; Smith & Barnes, 1983; Victor, 1966). Alcohol and its metabolic by-products have been reported to have significant toxic reactions with a number of physiological systems, with animal and human experiments indicating both 'mood' and performance decrements 8-22 hours after the ingestion of moderate to large doses of alcohol (Gauvin et al., 1993).

There is a complex constellation of physiological indices of experimentally induced hangovers, described in both animal and human studies (Freund, 1980; Myrsten, Rydberg & Idastrom, 1980; Smith & Barnes, 1983). Hangover appears to be triggered by the elimination of alcohol from the body rather than by its presence with reported drops in blood glucose and urinary output during the hangover phase (Majchrowicz & Hunt, 1979;



1980). In addition, studies also report changes in physiological markers of cardiovascular functioning, and serum electrolyte imbalances (Brackett, Gauvin & Lerner, 1993.).

Reported symptoms include a number of complaints potentially detrimental to neuropsychological functioning (e.g. dizziness, headache /pressure in the head, nausea, tinnitus, tachycardia, excessive thirst, insomnia, unsteadiness in standing or gait, diaphoresis, shakiness, lethargy and sleepiness, hypothermia, muscle weakness, flu-like symptoms, depression and anxiety), and there is some suggestion that both psychological and physiological factors may play a role in the development of hangover symptoms (Gauvin et al., 1993; Harburg, Davis, Cummings & Gunn, 1981). Proposed mechanisms of alcohol-induced hangover include toxicity caused directly by alcohol or metabolic by-products and circadian dysrhythmia (Cooper, 1976; Gauvin et al., 1993). Such studies correlate the severity of hangover symptoms directly with the amount of liquor consumed.

Existing research reports many possible causes of hangovers. Some researchers attribute the hangover phenomenon to impurities found in alcoholic beverages (Pawan, 1973; Schroeder & Collins, 1979). However, in cases where pure ethyl alcohol without impurities has been administered to animals and humans, delayed after-effects were still reported (Gauvin, Harland & Criado, 1989; Gauvin, Youngblood & Holloway, 1992; Sinclair and Taira, 1988). Diuretic actions of alcohol, are also thought to contribute to the hangover state, studies reporting physiological homeostatic compensatory responses with longer durations than the immediate drug action (Gauvin et al., 1989; Rydberg, Myrsten & Neri, 1977).

More specifically, there are indications in the literature suggesting that the hangover is a complex phenomenon which seems to be associated with some endocrine changes, notably in plasma levels of aldosterone, renin, cortisol and testosterone (Majchrowicz & Hunt, 1979; Ylikhari, Huttunen & Harkonen, 1978). However, the subjective relationship of symptoms to these findings remains obscure (Gauvin et al., 1993).

Other studies indicate that the constellation of behavioural and cognitive changes demonstrated during hangover may be the result of delayed compensatory and secondary responses in physiological systems such as sex and stress hormones, neurotransmitter levels, blood pH, and serum electrolytes (Gauvin et al, 1989; Sinclair, Gustafsson & Aalto, 1984; Sinclair & Taira, 1988; Suzdak and Paul, 1988; Ylikhari, Leino & Huttunen, 1976). Several investigators have proposed an opponent-process theory of drug compensatory responses in which the initial drug effect (alpha process) leads to a compensatory response (beta process) in order to return the system to homeostasis (Barrett, 1986; Staiger & White, 1988; Wilkins, Jenkins & Steiner, 1983). This would serve to account for the many effects associated with alcoholic hangover produced by acute alcoholic ingestion. Gauvin et al. (1993) describe some of the initial effects of high alcohol consumption as anxiolytic, anticonvulsant and muscle relaxing. If this were so, then the delayed compensatory response should be anxiogenic, CNS excitability, and muscle rigidity (*ibid.*). This hypothesis appears to be supported in the literature where, following an acute high dose ingestion of alcohol, all of these delayed effects have been found in studies of both humans and animals (Gauvin et al., 1992; Majchrowicz & Hunt, 1980).

In addition there is significant evidence to indicate that large, acute doses of alcohol disrupt the circadian rhythm in a number of systems e.g. sleep architecture, temperature and urinary potassium output (Redfern, Campbell & Davies, 1985; Roehrs, Yoon & Roth, 1991). The effects of a hangover may therefore be the result of shifts in the normal circadian rhythmicity of multiple physiological systems (Gallaher & Egner, 1987; Gauvin et al., 1993).

Cooper (1976) suggests that many of the symptoms of hangover may be exacerbated by hypoglycaemia in the individual. Other researchers have suggested that hangover is a miniature model of the classic alcohol-withdrawal syndrome in that the numerous physiological and subjective delayed effects produced after acute high-dose alcohol administration are similar to those experienced after the cessation of long-term chronic alcohol exposure (Bowden, Walton & Walsh, 1988; Newlin & Pretorius, 1990).

Thus, the delayed effects of alcohol ingestion may be caused through a number of competing or complimentary underlying mechanisms. In an experiment with rats, using the cueing properties of alcohol induced delayed subjective effects in a drug discrimination task, Gauvin et al. (1992) found that the hangover state did not completely return to baseline until 48 hours after administration. The authors concluded rebound and toxic effects play a role in the development of the interoceptive stimulus properties of hangover.

To summarise the literature, precipitating events leading to alcohol associated hangover seem to be generalised into the following categories: (1) alcohol/physiological rebound, (2) alcohol and/or alcohol metabolic by-product toxicity, and (3) alcohol - induced circadian dysrhythmia. Although these categories may not be mutually exclusive, they could account for the constellation of effects developing many hours after the ingestion of physiologically significant levels of alcohol when the BALs approach zero (Gauvin et al., 1993).

Thus, hangover does appear to result from disruptions in a number of physiological systems, which produce numerous symptoms in both animals and humans. Studies strongly suggesting that hangover symptomatology may compromise health functioning in certain individuals (ibid.).

### **3. POSSIBLE MEDICAL IMPLICATIONS OF HANGOVERS**

Although the physiological effects resulting from a hangover are not obviously life threatening, and symptoms, unless severe and long-lasting do not usually warrant medical treatment, Gauvin et al. (1992,1993) warn that certain sub-populations of individuals experiencing hangover place themselves at risk for medical intervention. The reported drops in blood glucose level and urinary output during the hangover phase has severe implications for the diabetic individual (Damrau & Goldberg, 1971; Gunn, 1973; Ylikhari, Huttunen & Eriksson, 1974; Ylikhari et al., 1976). Changes in markers of

cardiovascular functioning and electrolyte imbalances recorded during alcoholic hangover, may cause individuals with premorbid myocardial injury, coronary artery disease or congestive heart failure to run the risk of these symptoms precipitating events for major medical intervention (Brackett, Gauvin & Lerner, 1993; Kelly, Myrsten & Neri, 1970; Kentala, Luurila & Salaspuro, 1976; Kupari, 1983). Lenox as far back as 1941 (Lenox as cited in Gauvin et al., 1993) was one of the first researchers to repeatedly warn that the sequelae of hangovers from acute alcohol intoxication are of particular concern to individuals suffering from epilepsy. Since then, the susceptibility to electroencephalopathies in epileptic and non-epileptic patients during hangover has been reported in both animal and human research (Begleiter, Porjesz, & Yerre-Grubstein, 1974; Dember, Ellen & Kristofferson, 1953; Mucha & Pinel, 1979; Pinel & Mucha, 1980).

Acute alcohol ingestion appears to cause a differential density of the fluid within the cupule of the semicircular canal of the inner ear and the density of the endolymph which surrounds it causing some individuals to experience symptoms of nystagmus, vertigo and even nausea (Money & Myles, 1975; Schroeder, 1972). Casswell, Gilmore and Ashton (1988) suggest that these types of hangover symptoms are sometimes severe enough to result in absenteeism from employment.

#### 4. HANGOVER INTENSITY

Popular belief has it that people generally have control over their alcohol intake. If this be true, then it is sensible to assume that control over intake is based upon people's judgements about their current intoxication and their guesses about future intoxication. Moreover, it would follow that people would therefore, tend to limit their intake when performance is required (Finnigan & Hammersley, 1992). To do so, people should be able to judge the amount of alcohol they are consuming. However, subjective intoxication has not been measured consistently or with a validated instrument, although this does not seem to make much difference to the basic findings (Finnigan & Hammersley, 1992; Smith & Barnes, 1983). Studies reveal that generally people are poor at measuring their subjective intoxication, and tend to feel most intoxicated over time when BAL has peaked and then feel less intoxicated over time while BAL remains elevated (Anderson & Dawson, 1997; Harburg et al., 1981). The fact that human beings have difficulty using internal cues to measure their levels of intoxication indicates that neither internal or external cues to intoxication are used accurately (Lukas, Mendelson & Benedikt, 1986; Millar, Hammersley & Finnigan, 1992; Portans, White & Staiger, 1989; Radlow & Hurst, 1985).

Larger doses of alcohol and longer delays since drinking probably increase under-estimation. Thus, people are unreliable judges of their own intoxication and unlikely to be skilled at limiting impairment by drinking sufficiently little. It also appears that these 'hangover effects' can also occur when people do not feel subjectively hungover,

although this does not seem to have been explicitly studied. However, based on Mills and Bisgrove (1983a) people may be slightly better at judging how well they have just performed, although Finnigan and Hammersley (1992) warn that in natural work settings, this could well be too late.

Studies examining hangover intensity tend to follow a subjective analysis by the individual in the form of a rating scale. Research carried out by Seppala et al. (1976) aimed at measuring the intensity of hangovers on two rating scales at each test time. In rating scale 1, the intensity of fatigue, headache etc. was graded from 0-4 by the subjects. Each volunteer's values were added up and the totals were used to express the subjective feeling of hangover. In rating scale 2, the intensity of paleness, tremor perspiration, nystagmus and vomiting were graded from 0-2 by the observer, being used to score the objective signs of hangover (Ylikahri et al., 1974). Similarly Watson, Anderson and Jacobs (1985) used a 5-point scale with values that ranged from "much more than most people" to "much less than most people". Anderson and Dawson (1997) also included a 15-item hangover symptom questionnaire in their study in which subjects were asked to rate the severity of their symptoms on a 5-point Likert-type scale. A total severity score (based on summated ratings) was then computed for use in the statistical analysis. In spite of the subjectivity of the measure, the questionnaire in this study, was found to have been of moderate reliability, and therefore deemed a useful instrument for assessing hangover symptomatology (ibid.).

## 5. PERFORMANCE EFFECTS OF HANGOVERS

Effects of alcohol on performance have been well documented, but less attention has been paid to the duration of impairment, particularly where BAL has returned to zero. Alcohol has predictable effects on the central nervous system (CNS), which can provide a model of the effects which alcohol should have on performance. Alcohol is a general CNS depressant (Begleiter & Platz, 1972). As dose increases, so increasingly primitive brain functions are depressed (Tiplady, 1991 in Finnigan & Hammersley, 1992). Firstly, higher cortical functions are likely to languish, then perception, and fine motor control, then memory and sensation, and finally breathing and other autonomic functions (*ibid.*). According to the Tiplady study (*ibid.*) alcohol may impair long-term planning and attention. In addition, drinkers may ignore information such as non-verbal signals to which they would normally attend. Current research indicates that alcohol frequently affects some tasks and not others, and tends to have the most impact on complex cognitive functions e.g. decision-making, but there is not a clear taxonomy of tasks affected by alcohol and tasks not affected by alcohol (Bowden et al., 1988; Finnigan & Hammersley, 1992).

Studies recording both performance and BAL over time, conclude that performance at a given time is not highly correlated with current blood alcohol (Hammersley, Finnigan & Millar, 1990; Millar et al., 1992). Instead, after a given dose of alcohol, impaired performance is relatively constant over time. Hammersley et al. (1990) found that secondary reaction time slowed to about 112% of baseline after a dose of alcohol



achieving a peak of about 40 mg% BAL. Impairment failed to improve as BAL reduced over time. Two hours after drinking, performance was still at 115 % of baseline, whereas BAL had reduced to below 10 mg% from peak. (ibid.). In addition, it was found that performance could be better predicted from initial alcohol dose than from current BAL. Therefore, a larger dose of alcohol had larger effects on performance, which persisted while BAL was reducing. With smaller doses, some subjects were still impaired once BAL had returned virtually to zero (ibid.).

In a study aimed at correlating alcohol consumption in the previous week and current cognitive deficit on some standard neurological tests, Bowden et al. (1988) found no such relationship. However, the large number of errors in their data and the presence of effects which just miss statistical significance for abstraction and vocabulary, suggest that these findings may have been due to an insufficiently powerful procedure, and that with more subjects and/or more sensitive tests of performance, long-term hangover effects may have been found (Finnigan & Hammersley, 1992). Studies often contradict each other; for example, Nelson (1959) found no alteration in the accuracy of hand movements 24 hours after drinking whereas Kelly et al. (1970) observed impaired hand-steadiness and reaction speed in a similar post-alcohol phase.

In spite of the use of different procedures in different studies, there is still sufficient evidence to suggest that individuals may remain impaired after a considerable period (up to 14 hours or longer) after drinking alcohol (Finnigan & Hammersley, 1992). The doses studied have been sufficient to achieve BAL of about 100 mg%, which requires about 5

or 6 units to achieve, depending on sex and body weight. This quantity of alcohol is likely to be reached or exceeded by many individuals during a normal evening of drinking (ibid.). Eight hours after a large dose of alcohol some people may still have elevated BAL and even after a modest dose people may still be somewhat impaired. Low or zero current BAL some time after alcohol consumption does not indicate that performance ability has necessarily returned to normal levels (Finnigan & Hammersley, 1992; Gauvin et al., 1993).

The methodological difficulties associated with existing literature, together with the lack of attention given by reliable research in examining the after-effects of acute ethyl alcohol intoxication on behaviour and psychomotor skills, results in failure to guarantee accuracy in findings (Finnigan & Hammersley, 1992). This gap in the literature offers strong indication of a need to establish the basic facts about the effects of alcohol on performance under methodologically adequate conditions. This should perhaps include a biochemical component in an attempt to identify a long-lasting biochemical marker in the blood that may be able to account for performance deficits.

## **6. TESTS OF PERFORMANCE**

In a review of the literature from 1940-1992 on the general topic of alcohol induced hangover, Gauvin et al. (1993) focused on the behavioural, physiological and performance decrements demonstrated hours after a relevant dose of alcohol was

administered. The studies examined included both animals and humans. The authors concluded that following alcohol administration, two events occur in temporal sequence: a primary drug effect followed by a secondary compensatory response (ibid.). In addition, research suggested that the intensity and duration of the physiological and psychological compensatory responses appeared to be determined by a number of pharmacodynamic, pharmacokinetic and pharmacogenetic factors (ibid.).

Maylor and Rabbitt (1987) have shown that alcohol slows the rate of processing independently of practice or cognitive judgements and control over performance, but recognise that performance after alcohol has as much to do with the general state of the person, as with the particular effects of alcohol. While the reported neuropsychological effects of acute alcohol intoxication include impairments in motor tracking, choice reaction time, complex reaction time, signal detection, memory, simulations of driving, divided attention tasks and decision-making tasks (Finnigan & Hammersley, 1992), there is less agreement about the effects of alcoholic hangover on neuropsychological functioning (Anderson & Dawson, 1997). Many studies measure performance on more than one task, and it is common for alcohol to affect performance on one task but not the other (Finnigan & Hammersley, 1992). When alcohol does not affect performance, it is often difficult to ascertain whether this is because of a genuine null effect or because the particular version of the particular task was insufficiently sensitive to the effects of alcohol (ibid.). Research is further complicated when investigators utilise tasks that were originally designed for another purpose, e.g. neuropsychological assessment or in the measurement of individual differences.

In a study aimed at testing the hangover hypothesis Bowden et al. (1988) using standardised tests, examined the effects of recent drinking (average of 2,6 days prior to the test) among a mixed gender sample of tertiary students and their friends in their late 20's. Regression analysis revealed that the level of education was the only predictor of ability. Thus, they were unable to support the hypothesis of the lingering toxicity of alcohol.

Bates and Tracy (1990) were concerned that if impairment does indeed persist to a sober state, i.e. when BALs have returned to zero, key developmental processes might be disrupted in young drinkers who were likely to have intermittent episodes of immoderate drinking. They reported a mere suggestion in the data that frequency of consuming a 'maximum amount' (defined as the highest quantity consumed on a given occasion) of alcohol during the previous year related to poorer performance in the older group.

A study by Roehrs et al. (1991) found increased errors on a divided attention task, but not on a reaction time measure in subjects with hangover. Murdoch (1976) investigated the effects of hangover on EEG alpha frequency and amplitude in 94 subjects, but results failed to demonstrate any differences between the experimental and placebo groups. However, Sainio, Leino, Huttunen and Ylikhari (1976) found evidence of EEG slowing (increased theta activity) in their sample of 29 individuals.

Gauvin et al. (1993) conclude in their analysis that most studies indicate both 'mood' and performance decrements 8-22 hours after moderate to large doses of alcohol in both

human and animal studies. There are indications that simple reaction time tasks do not seem to be affected during experimentally induced hangover. However, more complex choice reaction time tasks do show significant decrements (*ibid.*). Performance on selected parameters of more complex cognitive/motor tasks, notably driving and flight simulator tasks, are significantly affected long after the BALs have returned to below the intoxication limit (in one case, up to 14 hours after drinking), whilst other performance parameters are not affected at all (Cook, 1997).

Anderson and Dawson's (1997) study set out to determine the possible neuro-psychological effects of alcoholic hangover. A within-subjects and between-groups pre-/ post-test design was set up in which selected neuropsychological measures were administered to a small group of university students. A hangover group (8 males and 8 females) was tested prior to and during, a hangover (12-16 hours and a control group of 5 male and 5 females) was pre- and posttested to determine the impact of practice effects. A univariate analysis of the individual tests indicated that one of the cancellation measures successfully discriminated between the groups. Although significant practice effects on the neuropsychological tests were found for both the hangover and control groups, the effects were stronger for the control group, suggesting more efficient test-retest gains in the non-hangover group. These results suggested evidence of attentional problems in individuals suffering from hangover with potential behavioural consequences.

## 7. MOTOR SKILLS

Although fraught with methodological inconsistencies, there have been several studies examining the effects of alcohol on motor skills (Buikhuisen & Jongman, 1972; Seppala et al., 1976; Tornros & Laurell, 1991). However, the equivalent research on post-alcohol impairment is noticeably absent from the literature. Nevertheless, it is important to take a brief look at existing studies.

The literature indicates that simple reaction time tasks do not seem to be affected during experimentally induced hangover, although there are significant decrements in the more complex *choice* reaction time (Finnegan & Hammersley, 1992). Performance on selected parameters of more complex cognitive/motor tasks, notably driving and flight simulator tasks, are significantly affected long after the BALs have returned to below the intoxication limit (ibid.).

### 7.1. Tracking

Popular wisdom is that tracking is one of the skills involved in driving a car and that alcohol impairs tracking (Finnegan & Hammersley, 1992). Studies involving tracking tasks require subjects to move some kind of pointer, keeping track of a moving target, or tracing some kind of pattern or maze. Overall cognitive skills and levels of difficulty demanded by tracking tasks vary considerably from study to study (ibid.). For example, in some instances tracking tasks are completed in conjunction with a secondary reaction

time task whilst others are not. Furthermore, some studies do not place emphasis on steadiness of hand while in others it is a requirement.

Research on 'simple pursuit rotor tracking', found a significant difference between placebo conditions and conditions where subjects had achieved 40mg% alcohol on the ascending limb of the blood alcohol curve (Connors & Maisto, 1980). Studying the effects of tracking after alcohol by use of a 'Tracometer' but not placebo conditions, Beirness and Vogel-Sprott (1984) found tracking still to be impaired. Examining gender differences in acute response to alcohol, Niaura, Nathan, Frankenstein, Shapiro and Brick (1987) reported impairment on tracking performance to be more impaired when BAL was increasing towards peak than when it was decreasing after peak. However, with the absence of a control group there is no guarantee that the improvement in tracking was a result of practice effects rather than a recovery from the effects of alcohol. In a similar study examining behaviour sensitivity and acute behavioural tolerance to alcohol, the subjects receiving alcohol failed to perform as well as the placebo group for at least two hours after drinking a dose to achieve 100 mg% (Wilson et al., 1984).

Assessment of the research is difficult as tracking tasks are rarely described in sufficient detail to understand what was actually required of the subject. Studies lack clarification of the different task requirements and this variation is significant in terms of the diversity of skills required from the subject. Never the less, according to the review of literature done by Finnigan and Hammersley (1992), in 6 out of 9 studies examined, alcohol showed impairment of tracking in a variety of conditions.

## 7.2. Co-ordination

Several studies in the past twenty years have measured body sway as a result of acute alcohol ingestion, reporting a definite correlation between increasing alcohol dose and increase in body sway (Lipscomb, Nathan, Wilson & Abrams, 1980; Niaura, Wilson & Westrick, 1988). Measuring body sway is problematic in that measures used vary considerably from study to study. Studies seem to omit using a baseline measure of sway, which introduces the difficulty of individual variation.

Finnigan and Hammersley (1992) describe other co-ordination studies including Breckenridge and Berger (1990) who used the Purdue pegboard as a measure of fine motor skills. Their findings demonstrated that, compared with placebo conditions, performance was reduced after alcohol. Wilson et al. (1984) assessed alcohol effects not only on body sway, but included dowel balancing, rail walking and tapping tasks. Following a dose of approximately 10 mg%, there was evidence of deficits in performance on both the dowel balancing and rail walking tasks for up to two hours subsequent to drinking. Tapping appeared not to be impaired.

According to Finnigan and Hammersley (1992) eight out of ten studies reviewed found body sway increased with alcohol, with the design and findings of the remaining two being more obscure. Although evidence that alcohol probably increases body sway in a dose-related fashion, its effects on co-ordination have yet to be studied adequately (ibid.).



### 7.3. Perception

There have been few studies examining the effects of alcohol on purely perceptual tasks. Farrimond (1990) examined changes in phenomenal regression (the tendency to perceive objects as closer to their 'ideal' shape than they would appear on the retinal image alone) after alcohol. Although the study is not without difficulties, there was sufficient evidence to conclude that alcohol decreases phenomenal regression. If this result applies outside the artificial psychophysical judgement setting used, then after alcohol people might have relative difficulty identifying familiar objects, or tend to over-estimate distance (Finnigan & Hammersley, 1992).

In a within-subjects design using baseline measures and blind administration of alcohol, McNamee, Tong and Piggins (1980) examined the effects of alcohol on various parameters of judgement of velocity. The task required the subjects to estimate the time of arrival of a moving light on a target. Although no overall main effects of alcohol were found, planned comparisons using placebo conditions showed a small reduction in over-estimation of time of arrival (*ibid.*). In a further study comparing fast versus slow velocity pairs, these authors found that alcohol led to a larger impairment on the latter harder discriminations (*ibid.*). Several studies have used tachistoscopic tasks as a measurement of perception, but in each case, the methodology was unsound (Baker, Chrzan, Park & Saunders, 1985; Moskowitz, Burns & Williams, 1985). Finnigan and Hammersley (1992) refer to this portion of the literature as being "...incoherent and no conclusions can be drawn." (p.95).

#### **7.4. Memory**

Pre-1980 studies examining the effects of alcohol on memory mostly found that alcohol has substantial effects on various aspects of memory (Jones & Jones, 1977; Moskowitz & Murray, 1976). According to Finnigan and Hammersley (1992) alcohol can reduce both short- and long-term memory performance, although the locus of impairment is not clear (ibid.).

It is possible that alcohol can reduce the efficiency of both encoding and retrieval processes as well as altering the direction of attention, which would in turn affect which aspects of an event could be remembered (Jones & Jones, 1977; Moskowitz & Murray, 1976; Weingartner & Murphy, 1977). Finnigan and Hammersley (1992) conclude from their review that it is clear that memory is often impaired after alcohol consumption.

#### **7.5. Reaction Time and Decision-making Tasks**

Decision-making tasks of one kind or another have been most frequently used in the study of the effects of alcohol on performance. These include signal detection tasks, simple reaction time tasks, choice reaction time tasks, complex reaction time and divided attention tasks, all of which are covered in points 7.6 - 7.10. Finnigan and Hammersley (1992) found 29 such studies between 1980 - 1990. Although the studies represented a wide variety of tasks, a common feature was that the responses required were relatively easy to learn with task difficulty depending on which decision to make and when. This

would depend also on the number of options available, and on the complexity of the decision involved.

## **7.6. Signal Detection Tasks**

These require subjects to respond every time a particular stimulus occurs. Response is required within a time frame, but not otherwise timed and is not supposed to be problematic. The difficulty of detecting the stimulus varies depending on its prominence in the visual or other perceptual field, the regularity of its appearance and other factors. Signal detection error consists of not detecting the stimulus and usually increases with the length of the task, due to boredom and other factors (*ibid.*). Fagan, Tiplady and Scott (1987) found that signal detection became impaired three hours after drinking 0.8g / kg. However, the authors failed to clarify the nature of the statistical analysis, and the *N* was somewhat small at only 8. Although there is a diversity of tasks used in studies and some are not methodologically sound, alcohol does appear to impair vigilance on simple detection tasks (Patel, 1988; Moskowitz & Murray, 1976; Rohrbaugh et al., 1988).

## **7.7. Simple Reaction Time Tasks**

Simple reaction time (RT) aims to measure the speed of response. The task requires a set response to a particular, but easily detectable stimulus. The response is not supposed to be problematical and few errors are expected. Response is generally evaluated in terms of

a 'decision time' where the stimulus is recognised and the response stimulated, and a 'moving time' where the response is planned and executed.

Both components can be influenced by complex cognitive factors, as well as by the specific physical design of the apparatus used.

Baylor, Layne, Mayfield, Osborne and Spirduso (1989) used a 'brake' and 'accelerator pedal' apparatus, combined with electromyographic recordings of muscle activity which allowed simple RT to be decomposed into pre-motor time and time to react, both of which were slowed by an alcohol dose achieving 170 mg% but not a dose achieving 100 mg%. It was found that there were more errors in both alcohol conditions, but movement time, i.e. time to move off the accelerator and hit the brake, were unaffected. The study has been criticised on several issues, e.g. subjects were also unusually practised at the task, and the small number of  $N$  (5) and a within-subjects design which limited the reliability of the findings (Finnigan & Hammersley, 1992).

Millar et al. (1992) combined reaction time and tracking tasks showing some evidence reaction time is slowed by alcohol. Studies by Taberner (1980) and Maylor, Rabbitt, James and Kerr (1990) also support the hypothesis. However, except for Maylor et al. (ibid.) none of these studies is a fully adequate study of simple RT (Finnigan & Hammersley, 1992).

### 7.8. Choice Reaction Time Tasks

These are similar to simple reaction time tasks except that subjects have to make one of a fixed set of responses, depending on which of a small, fixed set of stimuli occurs. Thus, both thinking time and moving time are usually longer than in simple reaction time tasks and there are more likely to be response errors. Baylor et al. (1989) examined choice reaction time (doing nothing at a green light versus braking at a red light). Choice RT was slower than simple RT. Results from both tasks were pooled in analysis, so presumably the effects (on pre-motor time and time to react but not on moving time), were the same. Fagan et al. (1987) used the Leeds psychomotor tester in order to assess alcohol on reaction times. Results showed that although alcohol did slow choice reaction times, the effect on their signal detection task was not significant until 150 minutes after drinking 0.8 g/kg.

Results from studies by Connors and Maisto (1980) and Golby (1989) for both choice and simple reaction times are inconsistent in terms of alcohol sometimes affecting performance and sometimes not. Finnigan and Hammersley (1992) again comment on the reliability of such studies because of flaws in design. Existing research often does not take into account that if subjects can maintain speed by sacrificing accuracy and vice versa, without measuring both, a genuine impairment may be overlooked (*ibid.*). In addition, reaction time is not the result of a unitary process and Finnigan and Hammersley (*ibid.*) warn that strategies may change over time or vary with alcohol dose. This may be why some studies have found effects at low doses, but not at higher ones.

### 7.9. Complex Reaction Time and Decision-Making Tasks

Although similar to the preceding tasks, complex reaction and decision-making tasks differ in that they include a more overt component of cognitive decision-making. Thus, subjects' responses are likely to be slower and include more errors than in simple reaction time tasks (Finnigan & Hammersley, 1992). However, there is much variability within such tasks with some requiring a substantial component of knowledge compared to others (ibid.).

Studies such as Fagan et al. (1987) and Linnoila, Erwin, Ramm and Cleveland (1980) ultimately found no alcohol effects on semantic and numeric decision-making tasks. However, small sample size and insensitivity in their methodology introduces a fair amount of doubt on the conclusions drawn (Finnigan & Hammersley, 1992).

In a study examining memory load, Hockey, MacLean and Hamilton (1981) found increased alcohol dosages resulted in slower mental transformation as the size of the transformation increased. Maylor and Rabbitt (1987) used a simple video game to assess the effects of alcohol and practice on performance. Subjects were required to 'bomb' a 'tank' moving across the screen. Across sessions, alcohol appeared to affect mean performance with increased variability and decreased accuracy. Maylor and Taylor's study also included a word categorisation task and a visual search task aimed at further examining the effects of practice and alcohol (ibid.). Both tasks allowed for either consistent mapping (where targets stayed the same and automated processing could be learned) or varied mapping (where the targets varied and processing could not become

automated). The authors found that for either condition on both tasks, alcohol increased rates of error, but failed to have a main effect on mean response time. In addition, although practice improved performance, it did not reduce the impairment caused by alcohol (*ibid.*). Over viewing several tasks pertaining to complex reaction time and decision-making tasks, Finnigan and Hammersley (1992) conclude that in spite of variation and methodological difficulties, studies generally provide some evidence that alcohol does slow cognitive decision-making across a range of tasks.

#### **7.10. Divided Attention Tasks**

Studies focusing on divided attention employ dual or multiple tasks where subjects are required to do two or more sub-tasks at once. According to Finnigan and Hammersley (1992), all driving tasks are of this kind and when attention is divided it becomes possible for subjects to maintain performance on one task after alcohol by neglecting the other. A common experimental procedure is to link a tracking task with a secondary reaction time task (*ibid.*). Connors and Maisto (1980) who reported a deficit on tracking but not on reaction times carried out such an experiment. In a later study by Millar et al. (1992) it was found that after alcohol, subjects were more likely to sacrifice their reaction time performance in order to maintain their tracking performance than vice versa. Mills and Bisgrove (1983a; 1983b) conducted two studies in which divided attention tasks were measured in conjunction with body sway. The first study demonstrated that low alcohol dosage (0.37g/kg) did not affect performance, but higher dosages (0.76 g/kg) did. In a replication study, Mills and Bisgrove (1983b) found a linear relationship between BAL and impairment, with the latter being highest where mean achieved BAL was 95 mg%.

Maylor et al. (1990) combined tasks of tracking, divided attention and simple reaction times, concluding that alcohol showed impairment on reaction times but not tracking. In addition, they found that practice failed to reduce impairment (ibid.). Even with the methodological difficulties and variation in tasks in all the studies examined by Finnigan and Hammersley (1992), there was always some reported evidence of alcohol affecting and impairing tasks of divided attention, thereby supporting the hypothesis that alcohol slows mental processing. Thus, "depending on the task and given that the task is sufficiently sensitive to such slowing, subjects may either perform decision-making tasks more slowly or maintain speed by becoming less accurate or neglecting some other aspect of performance, such as a secondary task." (ibid., p.105). Furthermore, Finnigan and Hammersley warn that it is difficult in the extreme to prevent such strategy shifts, "and studies which fail to measure all relevant aspects of performance or which collapse performance data across different measures, may miss genuine impairment." (ibid., p.105).

## **8. MEDIATORS OF THE ALCOHOL-PERFORMANCE RELATIONSHIP**

Alcohol is accepted as being the most widely used drug today, and information about alcohol is readily available to many individuals from childhood (Aitken, Eadie, Leather, McNeill & Scott, 1988). Unlike prescription drugs, alcohol ingestion remains the



responsibility of the individual falling under fairly precise personal control. According to Russ, Harwood and Geller (1986), most drinkers can judge intake moderately accurately by drinking gradually and thus, achieving and maintaining a desired level of subjective intoxication. Some drinkers may plan their alcohol ingestion to avoid conflicts with demanding tasks, or alternatively drink to reduce the stress of demanding tasks (Young, Oei & Knight, 1990). Furthermore, alcohol is often consumed with food and taken only rarely after hours of fasting (Finnigan & Hammersley, 1992). According to MacAndrew and Edgerton (1969) behaviour following the ingestion of alcohol is saturated with social meaning in that individuals may engage in behaviours which are qualitatively different, becoming more extravert or noisier than usual. Thus, Finnigan and Hammersley (1992) suggest that the pharmacological model of drug action, where alcohol simply affects normal behaviour, may be of little relevance to natural drinking.

In laboratory studies where the pharmacological model is imposed on subjects, participants are prevented from being able to identify what they have drunk or tell how much alcohol they have ingested. In addition, they have no control over the dose consumed, and are required to drink within a fixed time period, often having to fast prior to testing. Following this, subjects are then required to engage in given tests of performance, whether they like it or not. Finnigan and Hammersley (*ibid.*) criticise such research claiming that these tests are relatively meaningless in such conditions for everyday life, suggesting that natural intoxication may lead to more impairment, less impairment, or different impairment. It is therefore necessary, to extend present research to include studies which take place in more naturalistic settings.

Thus, while studies easily confirm that alcohol impairs performance (assuming that a simple correlation exists between dose or current BAL), impairment may be premature, as several factors mediate this relationship.

### 8.1. Food

Alcohol is taken into the body via the mouth, and almost immediately following its ingestion, alcohol begins to enter the blood stream. The liquid enters the stomach and then passes into the small intestine where further absorption takes place. Although some absorption takes place in the stomach it occurs primarily through the wall of the small intestine by way of a diffusion process (as cited in Schwar, 1979). Alcohol alone does not require any breakdown, but a great deal of emphasis has been placed on the rate of absorption being influenced by the presence and type of food in the digestive tract. (Kwazulu Natal Road Traffic Inspectorate, 1998). It is generally accepted that food (particularly fatty food) tends to retard absorption (Schwar, 1979). The precise mechanism is not known but it appears that the phenomenon is due partly to the diluting effect of the food present (ibid.).

In studies such as Lin, Weidler, Garg and Wagner (1976); Sedman, Wilkinson, Sakmar, Weidler and Wagner (1976) and Welling, Lyons, Elliott and Amidon (1977) it has been well established that food prior to drinking reduces subsequent BAL. The assumption is that this reduction would be associated with less impaired performance. Millar et al. (1992) set about testing this hypothesis and found that although food reduced

performance impairment on a secondary reaction task, performance was only moderately related to current BAL due to confounding variables such as time and hangover effects. Fisher and Atkinson (1979) and Pollitt, Lewis, Garza and Schulman (1982) examined the effects of fasting on performance, finding a positive correlation with impairment. Additional studies examining the effects of eating lunch on performance (Craig, Baer & Diekmann, 1981; Smith & Miles, 1986) concluded that performance is affected by a lunchtime meal, although an earlier study by Christie, Cort and Venables (1976) found no such effects. Nevertheless, the interaction between food and alcohol may result in performance effects other than a simple reduction in impairment due to reduced BAL (Finnigan & Hammersley, 1992). The literature further suggests that alcohol-related research using fasted subjects may lack authenticity because people seldom consume alcohol after fasting for several hours or longer (*ibid.*).

## **8.2. Metabolism of Alcohol**

When considering the dynamics of alcohol metabolism the literature indicates that, in general, higher doses lead to higher blood alcohol levels for longer (Juntunen, 1984; Myrsten et al., 1980; Ylikhari et al., 1974). However, given the considerable individual differences in the metabolism of alcohol, testing performance at a fixed time after alcohol consumption may not reflect results over the period of hours when alcohol can affect performance. The literature shows that following a standard dose of alcohol there is a marked individual variation in both peak BAL and the time to achieve the peak (Finnegan & Hammersley, 1992). Similarly there is a significant variability in the rate of elimination of alcohol from the blood which adds further complication to the

interpretation and generalizability of results (*ibid.*). Unless taken into consideration, this introduces serious methodological difficulties in studies that rely on simply testing performance at fixed intervals after drinking. The BAL curve varies with dose, and after fixed periods of time e.g. half an hour, lower dose subjects may have returned to virtually zero BAL, while higher dose subjects may be about to peak BAL (Rix, 1983).

Furthermore, how subjects metabolise alcohol differs significantly from individual to individual. In a study examining the absorption, distribution and elimination of alcohol in the human system, Dubowski (1985) demonstrated that under controlled conditions, following a single dose of alcohol there was a fourteen-fold variation between absorption time BALs. Acknowledging the importance of performance and subjective intoxication as a function of time, Hammersley et al. (1990) found similar individual differences in absorption and elimination of alcohol after the administration of a constant dose of alcohol. Subjects were unable to estimate their current intoxication, rating themselves less drunk than they were (*ibid.*). Whilst reaction time was impaired by alcohol the magnitude of impairment over time was found to be unpredictable and poorly related to the BAL (*ibid.*). Taking into account the influence of the setting, Sher (1985, as cited in Finnigan & Hammersley, 1992) used a balanced placebo design to assess individual differences in alcohol expectancies on subjective feelings following alcohol intake of either 1g/kg or placebo. The results of their study indicate both main effects for expectancy and setting and a complex interaction between these two factors. The impact of these effects is dependent on the limb of the alcohol curve, setting and individual differences in expectancies (*ibid.*).

In addition, research needs to consider that practice effects can occur so that the subject will become less impaired with time, and fatigue effects may occur which means that subjects may become more impaired over time. Furthermore, effects of fatigue differ markedly depending on the set of tasks used.

### **8.3. Expectancy Effects**

Another problem identified in the literature (Finnigan & Hammersley, 1992), is that the observed effects of alcohol may be in part to expectancy effects. According to the authors, when subjectively assessing one's own level of intoxication, people's beliefs and knowledge about what they are drinking have been shown to affect subsequent performance. Although there is evidence for the existence of both compensatory and placebo, or anticipatory responses to alcohol and other drugs, it is unclear as to exactly how these will affect performance (Laberg, 1990; Powell et al., 1990). Once again Finnigan and Hammersley (1992) comment on the literature including a diversity of approaches and being mostly inadequate in methodology.

### **8.4. Effects of Gender and Age**

There is little evidence at this time that age or sex substantially affect performance after alcohol, and therefore, a direct comparison between alcohol in the body of men and women cannot be made. However, the Kwazulu Road Traffic Inspectorate (1998) report that based on experience, women generally have a higher blood alcohol concentration level than men when consuming the same amount of alcohol. This occurs for a variety of

reasons including the fact that because women tend to have a smaller body mass than men, there is therefore, less volume for the distribution of the alcohol consumed (ibid.). In addition, alcohol does not readily diffuse into fat and as women usually have a higher percentage of body fat, there is again, less volume for the distribution of alcohol (ibid.). This is supported by Dubowski (1985) who found that men and women differ in their metabolism of alcohol with women tending to peak more rapidly at a higher BAL, even when dose was calculated according to body weight.

Jones and Jones (1976) examined the menstrual cycle effects on female metabolism and concluded that the highest and fastest BAL tended to be achieved during the pre-menstrual phase. Together with this finding and the ethical issues surrounding the potentially adverse effects of alcohol on early foetal development, many studies either use male subjects only, or include very few female subjects. Therefore, many studies do not mention gender differences in their research (Finnigan & Hammersley, 1992).

Existing literature on women's responses to alcohol tend to focus on social and emotional tasks, which are not particularly relevant to this study. The difficulties with research in this area make it impossible to assess whether the absence of sex differences is a genuine null-effect or due to inadequate sensitivity in research methodology (ibid.).

Available research in the area of age and alcohol is scarce and inadequate, failing to adequately control for drinking history and other possibly relevant variables. Furthermore, studies offer conflicting findings, for example, Parker and Noble (1980) report a trend for older subjects (over 42 years) to drink more than younger subjects, but most

surveys (Wilson, 1980) find the opposite. Performance data on non-verbal tests of abstracting and problem solving abilities suggest that the old were more affected by alcohol than the young, although Wilson (*ibid.*) found that men in their late teens and early twenties tend to drink more, and a random sample of young males is likely to have a higher mean tolerance to alcohol than an older, female sample.

Existing studies of the effects of drinking history on the response to alcohol are not considered in this dissertation as they only focus on the difference between alcoholics and normal drinkers.

## **9. AVIATION STUDIES**

Hangover effects or post alcohol impairment (PAI) is potentially responsible for causing aviation accidents well after a pilot is, according to most regulations, considered fit to fly (Cook, 1997). Reproduction of studies supporting this hypothesis has been difficult and the literature suggests that these discrepancies may be due to methodological differences involving task complexity. However, research on the phenomena of PAI strongly suggests that after heavy drinking, performance may be impaired for at least several hours after BAL has fallen to below 5mg/dl. Pilot performance has been shown to be impaired at BALs as low as 11mg/dl, and the number and seriousness of errors committed rises in proportion to the BAL (*ibid.*). Although it is apparent that even low BALs can impair the performance of aircrew in a way which may be expected to

compromise flight safety (Finnigan and Hammersley, 1992), there is further evidence that aircrew performance may be impaired by alcohol consumption even after their BAL has returned to 'zero' (ibid.).

A number of studies have demonstrated measurable impairment of simulator performance several hours after a peak BAL of 100mg/dl (Cook, 1997; Morrow, Leirer & Yesavage, 1990; Yesavage & Leirer, 1986). Using a range of measures obtained on flight simulators, Yesavage and Leirer (1986) tested pilots in a flight simulator on two mornings (having abstained from alcohol for a period of 48 hours), and found significant impairment of performance 14 hours after alcohol consumption when the BAL of the subjects concerned had returned to "zero"(ibid.). The general rule is that aircrew should not fly unless their BAL is 'zero' defined as <5 mg/dl. The time that must elapse, following alcohol ingestion, before this will occur, is related to the amount of alcohol that has been consumed, and to numerous factors that influence the rate of metabolism in the body (Finnigan & Hammersley, 1992). Morrow et al. (1990) examined the cumulative effects of alcohol and age on performance using young and more mature pilots in a flight simulator. They found that more mistakes were made in reporting heading and altitude over the radio on the rising rather than on the descending limb of the BAL curve and that some performance decrement persisted for eight hours after drinking. Collins and Chiles (1980) tested pilots during intoxication and the following morning and found circadian disruptions but no hangover effects. However, their tests did not involve full flight simulation and may have been less sensitive than those used by Morrow et al. (1990).



The 'eight hour from bottle to throttle rule' imposed by some aviation authorities may be insufficiently stringent. Eight hours after a large dose of alcohol some people may still have elevated BAL and even after a modest dose people may still be somewhat impaired (Finnigan & Hammersley, 1992). It is of interest to note that in South Africa, the Civil Aviation Authorities support this rule whilst the South African Airways (SAA) are more cautious defining their "bottle to throttle" rule at 12 hours after alcohol consumption.

## **10. ALCOHOL AND DRIVING**

Driver safety relies upon appropriate human performance, and is thus highly sensitive to alcohol-related impairment of performance. At the very least, the relationship between motor vehicle accidents and alcohol is probably more complex than can be explained by alcohol's impact on simple psychomotor performance. Finnigan and Hammersley (1992) comment that even more cognitive/emotional factors such as risk taking and parasuicidal behaviour may be important. This said, several studies have included relatively naturalistic driving tasks. Brewer and Sandow (1980) examined whether the correlation between accident involvement and intoxicated drivers could be attributed to errors involving divided attention. They found that one source of driving impairment after ingestion of alcohol, is a reduced ability to allocate cognitive resources to more than one task at a time. Experimental research applied to drinking and driving, suggests that repeated performance of certain tasks under the influence of alcohol leads to 'learned' tolerance (Cook, 1997). Therefore, it is quite possible that a driver's performance may

not be significantly impaired by alcohol while he is engaged primarily in familiar tasks, but there may be a marked deterioration in performance when faced with novel or unexpected circumstances (*ibid.*). This would imply that we should be cautious in interpreting research showing minimal alcohol impairment at low BALs. If the test conditions involve performance of routine tasks, the potential degree of alcohol induced impairment may be underestimated.

Attwood, Williams and Madill (1980) also used a real driving task, although only six subjects were used in a within-subjects design. The three driving tasks used were: driving at a constant speed; following a car moving at a variable speed and stopping the car. Several measures such as lane position, velocity and brake pressure were recorded for each task. Baseline 'familiarization' data was discarded. Although the results showed no differences between conditions, the very small sample size gives little power to the findings.

Seppala et al. (1976) researched the effects of thirty healthy male volunteers who drank ethyl alcohol (1.75 g/kg) from 6pm to 9pm, inducing a hangover the next morning. Ten subjects served as controls. The subjects who drank alcohol, received glucose or fructose during the evening (1.0 g/kg) and on the following morning (0.5 g/kg). In the hangover phase, a choice reaction test, two co-ordination tests and an attention test recorded psychomotor performance. The intensity of the hangover was graded subjectively and objectively. In addition, blood ethanol, acetaldehyde and glucose concentrations were analysed. Testing procedure was repeated three times at two hourly intervals. They found

that hangover at a level of 1.75 g/kg of ethanol, decreases driving ability by reducing the accuracy of choice-reactions and information retrieval the 'morning after'. They concluded that a feeling of mild hangover does not necessarily mean normal psychomotor function because there is no correlation between the subjective sensitivity of hangover, and the deterioration of psychomotor skills (ibid.).

A report from Sweden's National Road and Traffic Institute (Medical News, 1983) indicates that a hangover may diminish driving ability as much as by 20%, even when the BAL is 0 mg/dl. Based on a study involving 22 volunteers (6 women and 16 men), it was concluded that a person's ability to carry out complex driving manoeuvres is reduced for at least three hours after the BAL has reached zero. Furthermore, hangover subjects demonstrated a marked inability to subjectively determine their fitness to drive. All subjects were self-reported moderate drinkers between the ages of 19-38 years taking no other form of drugs or medication. Subjects were required to drive a motor vehicle along a pylon marked test course. On a random signal, they performed the difficult manoeuvre of swerving the car quickly to the left or right and then steering it between two rows of pylons placed with a minimum tolerance on either side of the car. Subjects were motivated by way of payment with a sum being deducted for each pylon knocked over. Subjects practised until a stable test score was established (N1), and another test being given three hours later (N2). It was found that 19 of the 22 subjects scored significantly worse under hangover conditions than when not hangover, with an average decrement of 20%. Subjects were asked to rate the severity of their hangover and it was found that there was no significant correlation between how a subject felt and his/her driving ability.

Subjects were also unable to estimate their BALs or when this had returned to zero. The results give impressive evidence of the performance degrading effects of alcoholic hangover.

If this hypothesis is correct, there are important implications for the safety of a 'legal limit' for drinking and driving. As a result of the abundance of studies on 'drinking and driving', it is widely accepted that the risk of being in a motor vehicle accident increases after alcohol, and increases dramatically with higher doses. As already discussed, flight simulator studies strongly indicate that pilot performance may be impaired with very low BALs, e.g. 11 mg/dl with degrees of error increasing proportionately with the BALs (Cook, 1997). Although less sensitive to alcohol-related impairment, a similar dose response relationship has been determined for driving. The relative risk of road traffic accident increases exponentially with the BAL of the driver, and a BAL as low as 10-40 mg/dl is associated with an increased risk (*ibid.*). However, there are few studies examining the effects of impairment during the hangover phase once BALs have returned to zero. Existing research more often than not fails in design, making it difficult to draw useful conclusions (Anderson & Dawson, 1997; Finnigan & Hammersley, 1992). In addition, because of ethical considerations, recent work has usually, at most administered alcohol to achieve a BAL of up to 80 or 100 mg%, which are common legal limits for driving. Although impairment below these levels is modest, such legal limits seem generous because impairment sometimes occurs at lower levels and there is not sufficient data to accurately plot the relationship between dose and impairment (Cook, 1997). It also seems likely that the impairment persists as BAL reduces, meaning that in practice

current BAL will often under-estimate impairment, someone who at some point exceeded 100 mg% but now has 10 - 20mg% BAL may be more impaired than someone who is currently peaking at 20 mg% (Delin & Lee, 1992).

## 11. MEASURING BLOOD ALCOHOL LEVELS

Blood containing alcohol that has passed through the wall of the small intestine feeds into the portal vein which in turn delivers the blood directly to the liver. The liver extracts a small amount of alcohol and destroys it. The blood still containing alcohol, then flows to the heart and is pumped into the lungs where another diffusion takes place. This diffusion is the process of the blood receiving oxygen and eliminating carbon dioxide. The oxygenated blood containing alcohol then flows through the rest of the body tissue and organs including the brain.

Alcohol is eliminated from the body by several different processes. Approximately 95% is destroyed in the cells of the liver by the action of enzymes (KwaZulu Natal Road Traffic Inspectorate, 1998). The alcohol is initially oxidised to acetaldehyde which generally does not accumulate in the body, but oxidises further to form carbon dioxide and water (Schwar, 1979). The remaining alcohol is excreted unchanged in the urine, with smaller quantities being eliminated in the breath and perspiration. The overall effect of the net rate at which alcohol is removed from the body will govern the concentration in

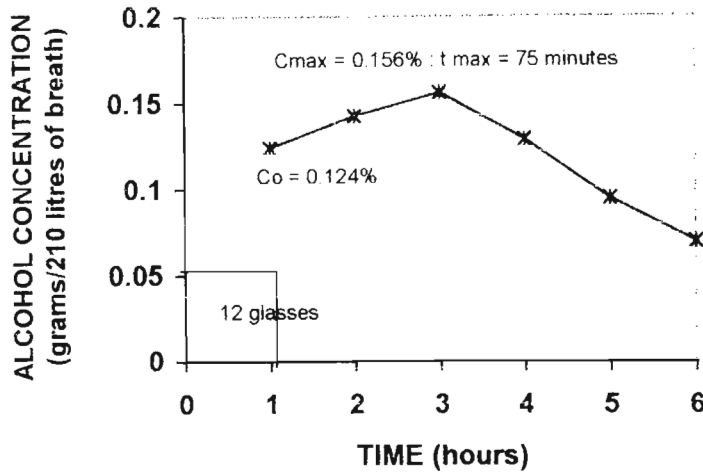
the blood at any given time. This in turn governs the concentration in the blood supply to the brain (ibid.).

Alcohol is miscible with water in all proportions, and is distributed throughout the body wherever there is water. In addition, any tissue or fluid containing water is suitable for alcohol determination (De Graad, 1976). The most commonly used materials are blood, urine and breath. The relative BALs of these fluids have been studied from both the practical and the purely academic aspect with the result that several fluids have been used for the indirect determination of alcohol in the blood. Breath alcohol analysis is a well established and sound process for confirming the presence and proportion of alcohol in blood (KwaZulu Natal Road Traffic Inspectorate, 1998; Schwar, 1976). Testing is easy to administer, and thus, for the purposes of this dissertation it was decided that BALs would be measured by way of breath alcohol analysis.

### **11.1. Blood Alcohol Curve**

The blood alcohol curve (Figure 1) reflects the continuity of change in alcohol concentrations from the time alcohol is absorbed into the system until elimination is complete. It also describes the interplay between factors influencing absorption, distribution, metabolism and elimination. The blood alcohol curve is a graphical representation of analytical results from a series of samples taken at predetermined intervals, or from calculations based on the results of analyses of other fluids, tissue or breath (Schwar, 1976).

**Figure 1 : Blood Alcohol Curve Illustrating the Three Phases of Diffusion in the Body**



This curve is the result of a subject consuming twelve 200ml glasses of full strength beer (just under 8.5 standard drinks) in one hour

A normal blood alcohol curve has a rising limb, a peak and a declining limb (Payne, Hill & King, 1966). The rising limb represents the increasing blood concentrations caused by a greater flux of alcohol into the blood than the elimination from it. Skewness depends on the amount of alcohol ingested and the speed of absorption into the system (ibid.). The peak denotes the turning point of the blood alcohol curve at which the rate of absorption into, and elimination of alcohol from the blood is equal (Schwar, 1976). It pinpoints the end of the rising limb and the beginning of the declining limb. In some analyses there may be multiple peaks appearing during the falling tide because of the person drinking smaller quantities of alcohol over longer intervals. In cases where no changes occur in the blood alcohol concentration for a certain amount of time, the blood alcohol curve may form a plateau (Payne et al., 1966). The declining limb is that part of the alcohol curve

between the peak and complete elimination of alcohol from the body. During this phase, the rate of elimination of alcohol from the blood through excretion and metabolism exceeds the rate of absorption into the blood (ibid.). The very last portion of the declining limb becomes exponential, when the enzymes involved in the metabolism of alcohol are no longer saturated with alcohol substrate (ibid.). According to Schwar (1976) and Cook (1997), studies reveal that although there is some individual variation in the metabolism of alcohol, the average person having peaked at 0.1 mg/dl will take between seven and eight hours for the body to return to a zero BAL.

### **11.2. Breath Alcohol Analysis**

The exchange of gases, including alcohol vapour, between blood and breath takes place in the alveolar spaces in the lungs. As a result, the alcohol concentration of mixed expired air is governed by the alveolar air contained in the sample (Schwar, 1976). Breath analysis is based on the existence of a definite ratio between the alcohol concentration of the blood passing through the lungs and that of the air in the alveoli. Therefore, the amount of alcohol present in deep lung air is proportionate to the amount of alcohol in the blood. The KwaZulu Natal Road Traffic Inspectorate (1998) in their Operator's Manual warn that the legitimacy of a breath analysis is subject to the technical standard and proper operation of the device used.



### 11.3. Mouth Alcohol

Mouth alcohol is the term used to refer to the situation where a person has residue alcohol in the mouth. According to the Victoria Police's Informant's Training Manual (1998), a person having just consumed a drink containing alcohol will result in residue alcohol being left in the mouth which will in turn have a direct influence on a breath analysis result. When testing by way of breath alcohol analysis, breath samples contaminated with mouth alcohol can cause the breath alcohol concentration to be grossly over stated because the alcohol concentration in a drink is much higher than the alcohol concentration in blood would ever be (Cooper, 1976). To perform a representative breath alcohol analysis it is vital that only deep lung air is obtained. To prevent a mouth alcohol situation influencing an analysis it is necessary to be satisfied that the person to be tested has not consumed alcohol for at least 15 minutes prior to a breath sample being obtained. Residue alcohol in the mouth will fully dissipate within a 15 minute period (ibid.).

## 14. CONCLUSION

Results discussed in the literature in this section (albeit often problematic), suggest that hangover does have a detrimental effect on human neuropsychological performance. Taken together, findings indicate that if appropriate measures are utilised, hangover-induced attentional difficulties can be detected several hours following acute alcohol consumption (Anderson & Dawson, 1997). To this extent, the nature of the impairment

appears to have significant impact on both focussed and divided attention. This concurs with the opinion that hangover induced driving impairment may be a consequence of a reduced ability to allocate cognitive resources to various competing stimuli (Anderson & Dawson, 1997; Finnigan & Hammersley, 1992). Studies investigating the effects of post-alcohol impairment indicate that a return of BAL to zero after alcohol does not mean that the individual will return to an immediate state of sober cognitive competence or have an accurate sense of performance confidence (Anderson & Dawson, 1997). This study is concerned with the previously intoxicated individual who requires attentional resources in the pursuit of occupational or recreational demands. The implication being, that such a person could remain compromised for 16 hours or more succeeding the cessation of alcohol intake and that even a mild neuropsychological impairment could have serious consequences under certain situations such as driving or operating machinery.

**CHAPTER 3:****METHODOLOGY**

The study aims at investigating the possible neuropsychological effects of alcoholic hangover on human cognitive and psychomotor performance. The research focuses specifically on simple and choice reaction times, divided attention tasks and driving skills, examining the residual effects of an acute dose of alcohol 14-16 hours after ingestion. The hypothesis is that cognitive functioning will be impaired for several hours after the BAL has returned to zero and an univariate analysis of individual tests will discriminate between the hangover and control groups. A within subjects pre-/post-test design was used to compare test performance before and during the hangover state and a between groups design was used to assess differences between the hangover and control groups.

The pre-test / post-test design provides baseline measures of performance allowing for individual differences and practice effects. Any significant practice effects found on the tests will suggest that attentional problems are evident in individuals suffering from alcoholic hangover and, therefore, indicating that alcohol results in some degree of brain dysfunction leading to cognitive-perceptual inefficiencies.

## 1. SUBJECTS

A computerised test of simple and complex reaction times and a driving skills test were administered to two groups of volunteers, between the ages of 18 – 29 years. All subjects were selected from a predominantly student population via active recruitment from advertising by posters and by word-of-mouth, and assigned to either the experimental or control group. Although the literature does not provide evidence of gender differences in alcoholic hangover, there is a serious gap in available research including women, and therefore, the author tried to recruit as many female volunteers as possible (23 female subjects out of a total of 63 subjects).

To prevent any subject from either having traces of alcohol in their systems or the effects thereof, all subjects agreed to refrain from ingesting alcohol in any form whatsoever for 48 hours before the pre-test was administered. All subjects were required to be present at the social pub evening, the only provision being that the subjects from the control group drank soft drinks and no alcohol, whereas the hangover group drank alcohol.

All participants had to be in possession of a valid driver's license and were required to adhere to the same rules and regulations both prior to and during testing, the only difference being that the experimental group ingested alcohol, whilst the controls did not.

Data was discarded from:

- Subjects who did not complete all the required tests (3 cases);
- Those individuals from the hangover group who failed to reach the stipulated minimum level of 0,1g/dl of alcohol by 12p.m. on the night of testing (2 cases);
- Those subjects who took longer than 40 minutes to complete the CALCAP programme (1 case).

## **2. MATERIALS AND MEASURES**

### **2.1. Screening Questionnaire**

Initially all subjects in both the hangover and control groups were pre-screened on the basis of a confidential questionnaire (Appendix 1.). This document was primarily aimed at identifying any volunteer who may have had a history of psychiatric illness or related condition, those who may have ingested psychiatric medication of any sort and regular drug users, all of which might offer different reasons for results achieved in testing.

Furthermore, in order to ensure that the sample and control groups were as homogenous as possible, it was necessary to investigate drinking histories, selecting only those subjects with reported moderate drinking histories (defined as drinking less than seven drinks in a sitting, and less than four occasions a week). It was also imperative that all

volunteers fell within the age range with as similar profiles as possible. Details included in the questionnaire were as follows: -

- (1) Age, sex, occupation, weight and proof of drivers license.
- (2) General medical history. Subjects were asked if they had ever been treated for a neurological illness or diagnosed with a learning or attention deficit disorder. In addition, they were asked about the use of psychiatric medication in the preceding six months.
- (3) Subjects were requested to provide information of the recent ingestion of illegal substances (i.e. within two weeks of completing the questionnaire), and whether or not they had ever been a habitual drug user.
- (4) Drinking history. This provided information on the number of years the subject had been drinking alcohol, the types of alcoholic beverages preferred, the amount generally drunk on an average social occasion and whether and what alcoholic beverages they might mix whilst drinking. In addition, they were requested to subjectively rate themselves as a social drinker, moderate drinker, heavy drinker or binge drinker.

Not all the information was used in the study, but it was thought that a full history might be useful for certain aspects of the data analysis.

## 2.2. Hangover Symptom Rating Scale

A 19-item hangover rating scale based on physiological and psychological hangover symptoms reported in the literature and initially pilot-tested by Anderson and Dawson (1999) was constructed for use in the study (Appendix 2). Subjects were requested to rate the severity of their symptoms on a 5-point Likert-type scale varying in response from "not at all" to "extremely". Symptoms included: nausea, tinnitus, headache, tachycardia, excessive thirst and hunger, anxiety, insomnia, sore eyes, unsteadiness in standing or gait, profuse sweating, shakiness, motivational disturbance, absent-mindedness, fatigue, diarrhoea, dry mouth, mood change and general discomfort. A total severity score, based on the summated ratings was computed for use in the statistical analysis.

## 2.3. Driving Skills Tests

Most available research in the field incorporating driving skills tests and alcohol concentrate only on the effects of drinking and driving, and do not focus on post-alcohol impairment. Thus, previous examples of driving tests used in terms of hangover are extremely rare and specific tests designed for this purpose are non-existent. Guided by the apparent validity of the Swedish study reported by Franck in the Medical News (October, 7, 1983) a search for similar, locally available driving skills tests was made. The Swedish design incorporated only one driving skills test administered before and after drinking. In an effort to enhance the reliability of final test results, five of the most appropriate tests for the purpose of this study were selected from the KwaZulu Natal

Road Traffic Inspectorate's (1998) "Driver of the Year Competition", which was originally aimed at the selection of the best heavy motor vehicle driver in various categories. Following consultation with the traffic authorities on the applicability to light motor vehicle use, the original tests were adapted for use in the current study. Based on the literature search discussed in Chapter 2, each of the five tests chosen tested judgement, precision and driving skills. Sub-tests called for precision, accuracy, visuo-spatial estimation, control in perception, tracking, memory, co-ordination, decision-making, and reaction times. Because of the need to accommodate data collection within a two hour window, the entire course comprising all five subtests, was designed for completion within a five minute time period for each subject. Examiners recorded results on a score sheet (Appendix 3). Other materials needed included two identical motor vehicles, 10 tennis balls, 10 rubber hubcaps, two moveable upright poles, a ground target, a plumb line and two stopwatches.

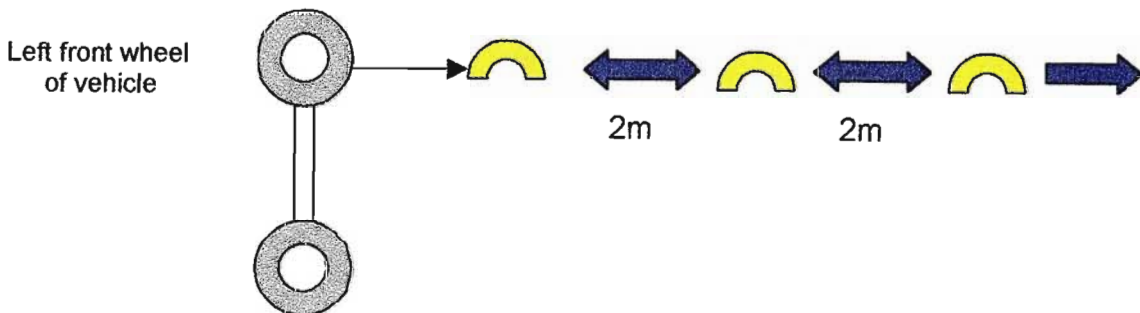


**Figure 2 : Subjects gathered at the Road Traffic Inspectorate Motor Vehicle Testing grounds waiting to undergo the driving tests.**



The selected tests were as follows:

- (1) **Forward Movement.** This test (which requires precision, control and accuracy) looks at the driver's ability to judge the position of the left front wheel of the vehicle along a straight line and without stopping. The test aims at simulating conditions where it is necessary for the driver to keep as far left as possible in a narrow street and still be able to judge the distance of the pavement. A course is set in which 10 tennis balls are placed two metres apart in a straight line. The driver is then required to drive without stopping (and still maintaining a continuous speed), touching each tennis ball with the left front tyre of the vehicle (Figure 3). Points out of 50 are allocated for every marker touched. This test requires precision, control and accuracy



**Figure 3 : Forward Movement Driving Task**

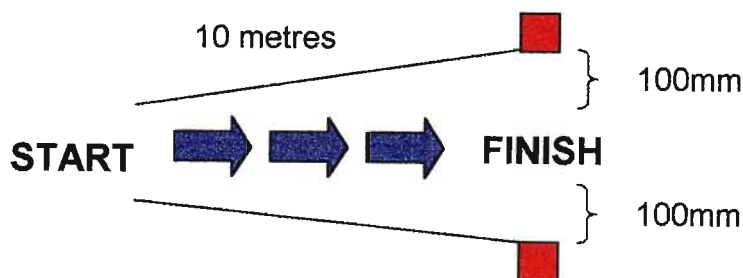
**Figure 4 : Supervising and testing the Forward Movement Driving Task**



**Figure 5 : Measuring the distance from inside the poles in the Width Estimation Driving Task.**

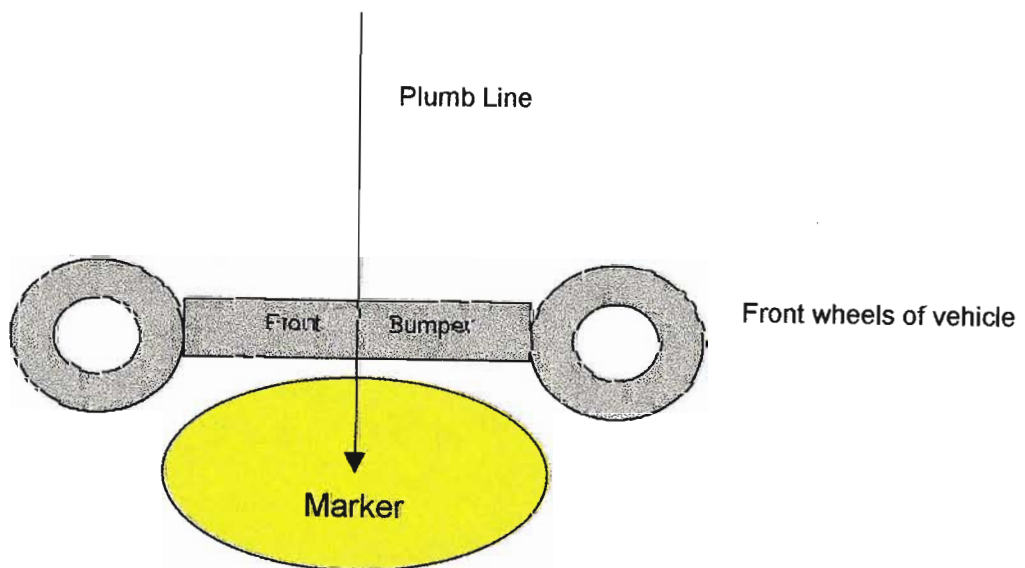


- (2) **Width Estimation.** This test aims at examining the driver's ability to judge the width of any section of the vehicle. This test simulates conditions in which thoroughness is limited. From a distance of 10 metres from two upright poles (the one being fixed the other not), the driver must indicate with his/her hand to the examiner where the moveable pole should be in order to fit the vehicle through the two markers without touching either and within a 100mm distance from the insides of the poles. A maximum score of 50 points is measured on a rating scale from between 100mm (50 points) and 500mm (10 points). If the driver falls outside this measurement or touches either marker, zero points are scored (refer to Figure 6).



**Figure 6 : Width Estimation Driving Task**

- (3) **Target.** The "Target" test (Figure 7) is essentially a measure of precision driving and visuospatial estimation and judges the driver's ability to position the front wheels of the car in relation to a fixed line. This simulates conditions where a vehicle needs to be stopped with its wheels in a pre-determined spot or on a marker. Subjects have to drive the vehicle up to a stop line on the ground while maintaining a normal driver position. Speed can be controlled as required, or until the driver is satisfied that s/he has reached his/her objective. In the case of this study, drivers were asked to drive their vehicle so that the centre of the front bumper fell directly above the central line of a disc-shaped marker placed on the ground. Examiners used a plumb line to assess accurate measurement. Ten points out of a possible 50 are deducted for each stop or realignment made by the driver and all points are deducted if the plumb line hangs outside the marker, or if the vehicle moves whilst being measured.

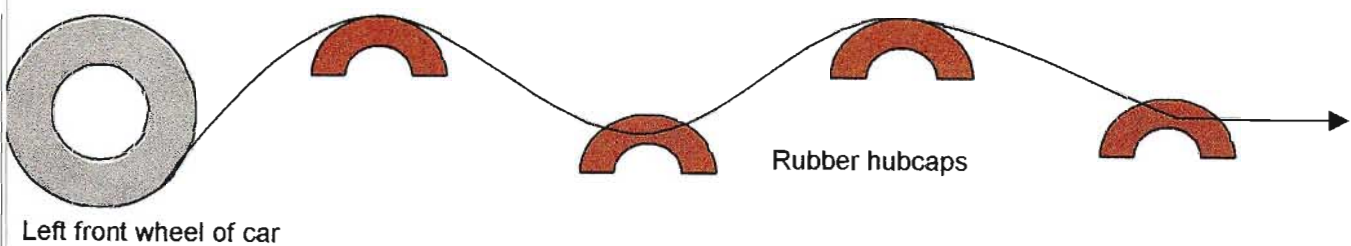


**Figure 7 : Target Driving Task**



- (4) **Winding Line.** This test is identical to Task 1, except that rubber hubcaps are used instead of tennis balls, and the course is a winding one (Figure 8). Visual perception and control are required and, once again, the driver scores points for every marker touched by the left front wheel of the vehicle.

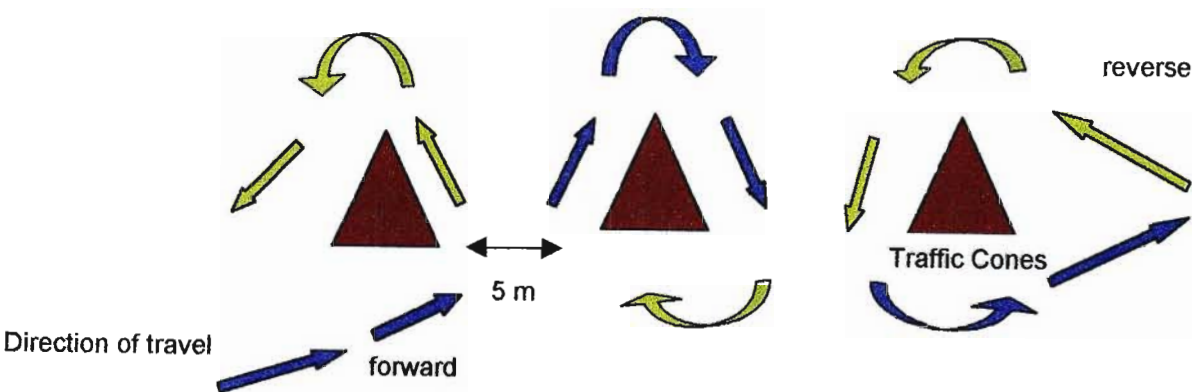
**Figure 8 : Winding Line Driving Task**



**Figure 9 : A subject negotiating the traffic cones in the Serpentine Driving Task.**



- (5) **Serpentine.** This tests the driver's ability to manoeuvre the vehicle backwards and forwards through confined spaces. The test was designed to simulate conditions where a driver needs to negotiate detours, heavy traffic etc. Without stopping, subjects had to weave their vehicle around a set of obstacles (in this case road traffic cones), placed in a figure-of-eight and five metres apart (Figures 9 and 10). The test was divided into two parts. Subjects had to first complete the task moving forwards, and then repeat the procedure using reverse gear. The only authorised stop being that in which the driver needed to change direction to complete the test. Points out of a possible 50 were deducted for any cones touched (i.e. ten points for every cone touched).



**Figure 10 : Serpentine Driving Task**

Although stopwatches were used in calculating an overall time score, there were no time constraints for individual sub-tests and all subjects completed the various tasks well within the 5 minute time frame.

#### **2.4. California Computerised Assessment Package (CALCAP)**

The CALCAP computer software programme (Miller, 1986) was modelled after the Continuous Performance Task, a measure of sustained attention and reaction time using age and education specific norms. The CALCAP package presents a broad range of stimulus materials on a computer display with exposure times precisely controlled and reaction time responses to the stimulus measured and recorded. Measures include mean and median reaction times, total numbers of true and false positive responses and estimates of the signal detection parameters  $d'$  and beta (Miller, 1986). Thus, in addition to reaction time measures, the level of performance on each task is assessed by evaluating the number of actual "correct hits" (true positive responses made by the subject) and actual "misses or incorrect hits" (false positive responses made by the subject). The higher the True Positive score the better the subject's performance on the task of identifying target stimuli. A high False Positive score indicates subject bias by incorrectly responding to distracter stimuli. Therefore, the test measures the subject's ability to discriminate between the true items and distracter items, as well as the degree to which the subject deviates from the optimal likelihood ratio. The CALCAP programme classifies subjects as "outliers" if they perform two standard deviations or lower on two or more of the tasks.

The CALCAP programme was selected because of the reliability and validity of the programme based on the task primarily development and normative data described in the programme manual (Miller, 1986). Within the testing, individual reaction time measures are designed to assess a number of cognitive domains, including speed of processing

(reaction time), language skills, rapid visual scanning, form discrimination, recognition memory, and divided attention (ibid.). The range of tasks make it an ideal instrument for use in the longitudinal study of cognitive changes due to the effects of hangover.

The programme itself consists of ten Simple and Choice reaction time measures administered by the computer (thus, reducing the variability in test administration). The tasks are designed to be self-explanatory and need only minimal supervision from the examiner. Stimuli are presented visually on a blue and grey computer monitor, viewed by subjects from a line-of-sight distance of approximately 45cm. Subjects are required to focus on a display field and respond only to specific visual stimuli. The procedure takes approximately 20-25 minutes to complete. Although an abbreviated version is available, the programme was administered to the subjects in its entirety.

The first data entry in the programme consists of identification numbers, demographic and medical information. To ensure accurate data entry, the subject is required to enter subject numbers twice.

The CALCAP programme displays a brief set of instructions at the beginning of the reaction time task and at the beginning of each individual measure. The tasks are designed to be self-explanatory, and include practice trials. Where the subject is unable to complete the practice trials on the simple reaction time measures, the programme will display a message to the subject advising him/her to ask the examiner for assistance. The examiner will then re-start the practice trial. For choice reaction time measures, the programme allows the subject up to three practice trials and then proceeds to the actual



task, even when the subject fails all three practice trials. For all tasks, the computer suggests that the subject contact the examiner for any necessary help or assistance.

A more detailed breakdown of the sub-tests is as follows:

- (1) **Simple Reaction Time.** Subjects are asked to press the space bar key as soon as they see anything on the screen. This procedure provides a basal measure of reaction time. The task is presented at the beginning, the middle and at the end of the computerised procedures to allow for the assessment of fatigue effects.
- (2) **Choice Reaction Time for Single Digits.** Subjects are asked to press the space bar key as soon as they see a specific number such as '7', otherwise they are to do nothing. This task adds a simple element of vigilance to the task.
- (3) **Serial Pattern Matching (Sequential Reaction Time).** Subjects are asked to press the space bar key only when they see two of the same number in sequence, e.g. if they see the number 5 followed by a second occurrence of the number 5. This adds a more complex element of memory since the subject must keep in mind the last number seen.
- (4) **Lexical Discrimination.** Subjects have to press the space bar key whenever they see a word that fits into a specific category such as animal names (e.g. COW), but not when they see a word which fits into a category that is other than animals (e.g.

DESK). This introduces an additional level of language skills by requiring meaningful differentiation between semantic categories. The task requires rapid language processing and should be sensitive to any disruption in language skills.

- (5) **Visual Selective Attention.** Subjects have to press the space bar key whenever they see a specific word, e.g. 'SEVEN' in the centre of the screen. Other words are displayed around the periphery of the target stimulus located in the centre of the screen. These distracters require that the subject focus on attention more narrowly.
- (6) **Response Reversal and Rapid Visual Scanning.** This task is identical to the previous except that the subject must ignore the stimulus presented in the middle of the screen while responding to target stimuli displayed around the periphery of the computer screen. This taps into the subject's ability to change cognitive set from the previous task, requiring more rapid visual scanning across the entire display screen.
- (7) **Form Discrimination.** Subjects are shown three geometric figures simultaneously and asked to press the space bar key only when two of the figures are identical. The task requires rapid comparison of non-nameable forms, and, because of the brief exposure of time, may measure the subject's ability to retain an iconic memory of the figures.

Following completion of the computerised tasks a summary of the test results is immediately available with individual times and other data being displayed. The CALCAP programme provides three types of printed output. One displays the individual's range of scores and median values, one displaying normative ranges and one showing these data in a graphical representation using T-score values where a score of 50 is average. The standard deviation for a T-score is 10. Higher T-scores correspond to better performance, and lower T-scores to lower performance.

### **CALCAP Task Development and Normative Data**

The CALCAP programme itself was designed and developed on the basis of normative data collected on a sample which included 641 HIV-1 seronegative gay men drawn from the Multicenter AIDS Cohort Study (MACS). Subjects received a test battery consisting of six conventional neuropsychological tests and nine computerised reaction time measures at the time of their regular six-month visit conducted as part of the MACS protocol. The conventional screening battery consisted of the Trail Making Test (parts A and B); Digit Span sub-tests (forward and backward) of the WAIS-R; Controlled Oral Word Association Test (verbal fluency); Grooved Pegboard Test; Symbol Digit Modalities test, and the Rey Auditory Verbal Learning Test (RAVLT). These tasks were selected because of the sensitivity to most areas of cognitive functioning. More specifically these include:

- Language (Verbal Fluency; Rey Auditory Verbal Learning Test),
- Memory (Rey Auditory Verbal Learning Test; Digit Span; Symbol Digit Modalities),
- Attention (Digit Span; Trail Making Test Part A),
- Motor Speed and Manual Dexterity (Grooved Pegboard), and
- Psychomotor Functioning (Trail Making Test Part B; Symbol Digit Modalities).

In the description of task development, normative data provided in the manual is broken down by age and education and includes information on internal consistency reliability, test-retest reliability, and intercorrelations of the CALCAP and conventional test measures (*ibid.*).

The CALCAP Reaction Time measures have a very high internal consistency reliability, which indicates that the constructs measured are assessed in a uniform manner across the multiple trials of each reaction time task. Generally the simple reaction time measures have a very low test-retest reliability (0.20 - 0.29), but very high internal consistency reliability (0.77 - 0.95). This suggests that the motor skills measured by the simple reaction time tasks vary considerably depending on state variables such as mood, attention, fatigue, time of day etc. This hypothesis is further supported by the modest intercorrelations observed between the first, second and third iterations of the simple reaction time task (0.41 - 0.68) during the standard CALCAP test battery.

The choice reaction time measures show six month test-retest reliability (0.43 - 0.68) that is comparable to that seen in conventional neuropsychological procedures (0.47 - 0.77). However, it is likely that, as with the simple reaction time measures, choice reaction time is somewhat more state dependent than conventional neuropsychological procedures. Internal consistency reliability for the choice reaction time measures is quite high (0.81 - 0.96).

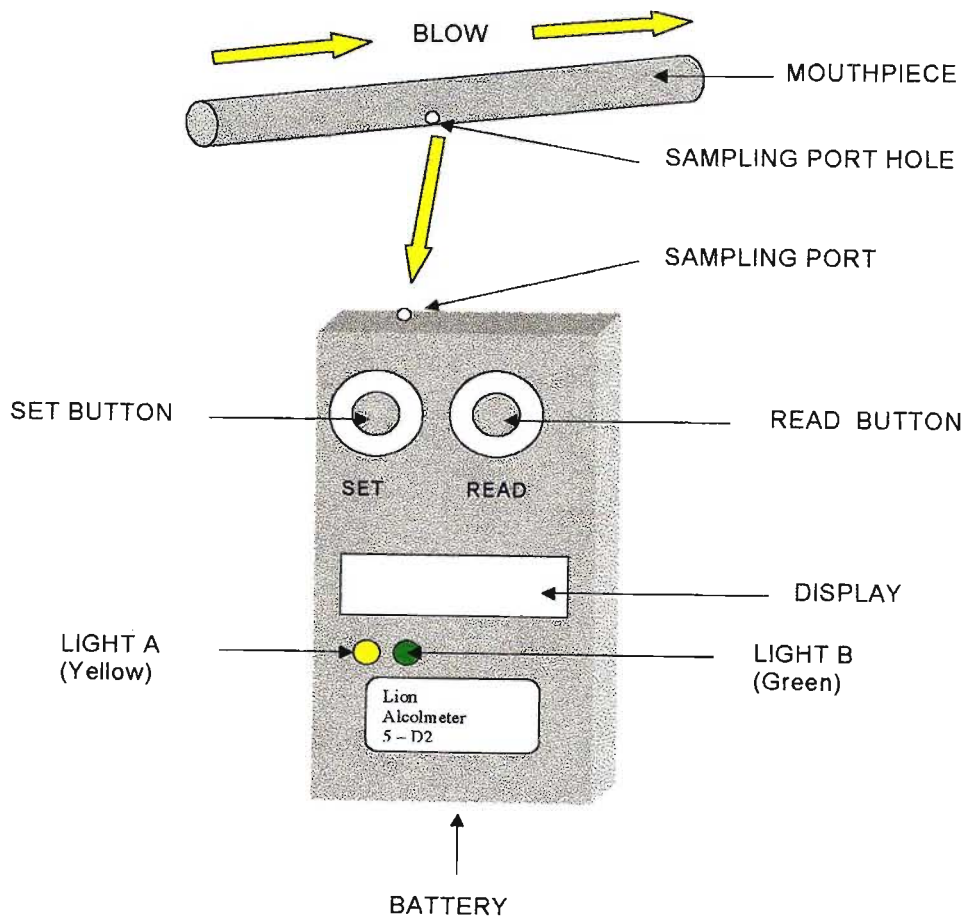
In the intercorrelations of reaction time and conventional neuropsychological measures (where  $N = 1023$ ), multiple iterations of the same simple reaction time task administered at four separate times during the standard CALCAP procedure showed a correlation from 0.41 to 0.68 with each other. Choice reaction time measures correlated from 0.31 to 0.60. Form Discrimination showed the lowest intercorrelation with other choice reaction time measures. Conventional procedures correlating most highly with reaction time are Symbol Digit Substitution (0.19 - 0.37), Verbal Fluency (0.13 - 0.25) and Trail Making Part B (0.17 - 0.32). Descriptive statistics for the CALCAP measures obtained during testing are presented in Table 5.

## **2.5. The Lion Alcolmeter**

Breath alcohol was measured using the The Lion Alcolmeter, Model s-D2 (Figure 7) which is the prescribed device used in South Africa in accordance with Regulation 301 of the Road Safety (Procedures) Regulations 1988, for the purposes of Section 53 of the Road Safety Act 1986 (Victoria Police, 1998), and is used for breath alcohol screening in the fields of traffic law enforcement, medicine and industrial safety. The device is

reputed to be robust and reliable (KwaZulu Natal Road Traffic Inspectorate, 1998) with a reported true and satisfactory level of accuracy for alcohol screening. The process of operation is simple which makes for easy use.

**Figure 11 : Lion Alcolmeter**



The device operates on an electrochemical fuel cell to detect and measure the concentration of alcohol vapour in expired breath. When breath is drawn into this cell a

small voltage is generated which is directly proportional in magnitude to the breath alcohol concentration, and therefore, the estimated BAL of the subject. The fuel cell voltage is fed to an electronic amplifier and displayed on a digital monitor of liquid crystal.

For hygienic reasons a new, disposable mouthpiece is attached to the alcolmeter for each new reading. Subjects are requested to fill their lungs and then blow one continuous breath through the lipped edge of the mouthpiece. A yellow light on the instrument serves as an indicator when the person providing the sample has blown hard enough, and a green light indicates whether they have blown long enough to provide a deep lung air sample. In order to ensure accuracy and reliability, the three alcolmeters used were all calibrated before testing. Three BAL readings were taken on the hangover group during the drinking phase, and a fourth BAL reading was taken on the second day of testing to ensure that all subjects were alcohol free at the posttest data collection.

## **2.6. Measurement of Blood Glucose**

Alcohol is known to affect blood sugar levels. Therefore, to control for alcohol-induced hypoglycaemic effects at the time of testing, every individual underwent a pinprick blood glucose test at the start of the pre- and posttest periods.

The SureStep Blood Glucose monitoring system used is designed as a reliable self-monitoring device for diabetics. A drop of blood is taken by pinprick from the finger and placed on a Test Strip, which is then inserted into the blood glucose meter. The meter

measures the blood glucose level and displays the result on average in 30 seconds. The system is calibrated to give a plasma value, which is the measurement used by most clinical laboratories (SureStep Owner's Booklet, 1995). Easy-to-understand symbols guide the user through the test procedure with advice related to normal range responses and possible problem areas.

### **3. PROCEDURE**

Following subject recruitment, a meeting was held in which the aim and method of the study was explained to all volunteers and informed consent obtained (Appendix 4). Confidential questionnaires (Appendix 1) were completed and final instructions were given (Appendix 5). Subjects were then selected according to suitability (from information gleaned from the questionnaire) as well as the availability of individuals on the specified days of testing. A relatively large sample size (63 subjects) necessitated dividing the participants into three testing groups. With no specific criteria involved (apart from the availability of the subject), individuals were then further assigned to either the experimental or control groups. Prior to testing, every subject was contacted telephonically in an attempt to monitor and maintain the required 48 hour alcohol-free period and to confirm arrangements. Trained research assistants were used in the data collection.



Each subject was then tested over two consecutive days. Data collection took a total of six days to complete. Control and experimental groups were pre- and post-tested during the course of the study. Pre-testing provided a baseline measurement for each subject from which the magnitude of change due to alcohol could be determined. In addition, the pre- and post-test design allowed for the consideration of possible practice effects when using repeated measures over time.

On the eve of all subjects' pre-test day, subjects from both the hangover and control groups attended a party held in a local pub. In order to simplify the estimates of alcohol required for a BAL reading of 100 mg/dl, participants from the hangover group were restricted to two types of alcoholic beverage.

To assist in stimulus presentation and data collection, ten IBM compatible machines with Intel 80386 microprocessors, 512K minimum memory, Hard Disk Drives with 2MB of free space, an 80 column display and MS-DOS Prompt were loaded with the CALCAP software programme.

The driving skills course was set out at the local Road Traffic Inspectorate Motor Vehicle Testing grounds approximately 3 k.m. from the school and supervised by qualified personnel. Half the subjects began testing with the CALCAP computer programme and half with the driving test. When the subjects had finished (e.g. the CALCAP test) they would crossover to the alternate venue and complete the rest of the required tests (e.g. the driving skills test), and vice versa. This pattern was repeated on the post-test day of data

collection. Time of day in terms of data collection was restricted in that post-tests had to be administered between 14 -16 hours after the hangover subjects had stopped drinking (12 p.m. of the night before). This meant that testing had to take place between 2 p.m. and 4 p.m. on the day following drinking and all data was, therefore, collected within a 26 hour window.

In order to control for hangover symptoms being exacerbated by hypoglycaemia in the individual, glucose tests were administered to all subjects before testing and results were recorded. Each subject was then seated at a computer and instructed to position himself so that he could see the screen comfortably and press the space bar on the keyboard. The subject was further informed that he would need to use the space bar for all responses. Subjects were assisted with the coding of demographic information, and given a brief explanation of what was expected from them. Because of the self-explanatory nature of the software programme, subjects were told to follow instructions presented to them on the screen and ask for assistance where necessary. Once the test had been completed test results were automatically saved and the examiners would reset the machine for the next subject. One subject failed to complete the CALCAP programme after 40 minutes and was excused from further participation in the study.

Subjects then proceeded to the motor vehicle testing grounds to participate in the driving tests. On arrival, staff of the Road Traffic Inspectorate accompanied the subjects around the pre-set course explaining in detail exactly what was required from them during each of the sub-tests. Subjects were encouraged to ask questions to eliminate possible doubt as

to what was required. In order to put all subjects through their paces within the restricted time allowed, i.e. between 2-4 p.m. it was necessary to utilise two motor vehicles. All subjects used one of two identical Mazda 323 cars for testing. This aimed at giving all subjects a fair and equal chance at success. Furthermore, as a means of motivating subjects to perform as well as they possibly could, a monetary bonus of R30.00 was offered to the subject who had scored the highest points at the end of each day's driving tests.

Once the subjects had completed both the CALCAP and driving tests they were instructed to return to the designated pub at 8.30 p.m. In addition, they asked to eat a normal meal at least an hour before arriving, and to avoid excessively fatty foods which might affect the rate of absorption of alcohol in the digestive system.

Prior to arrival, the subjects from the experimental group had already been asked to state their preference for either wine or beer. Together with their body weight at the time of testing, the experimenters calculated how many drinks each subject would need to drink over a three hour period to reach a BAL of 100mg/dl. Calculations were done in accordance with subject's choice of either wine (8g/100ml) or beer (17g/340 ml).

Estimates of projected blood alcohol levels were computed using the Widmark Formula (Cooper, 1979) in which alcohol concentration in the body as a whole is equal to the ratio

between the amount of alcohol in the body, expressed in grams (A), and the mass of the body (P), expressed in kilograms. Therefore:

$$\frac{\text{Amount of alcohol in body in grams}}{\text{Mass of body in kilograms}} = \frac{A}{P} \text{ grams alcohol per kilogram body mass (g/kg)}$$

On arrival, subjects from the control group were issued with vouchers which they could exchange for soft-drinks, whilst the experimental group were presented with a restricted number of vouchers (calculated according to body weight and choice of alcoholic beverage) which they could exchange for either wine (100ml glasses) or beer (4.5%, 340ml cans). The ecological validity of the naturalistic pub setting was important, and therefore, the pub event occurred in a venue open to the public, controlled only in terms of the allocation and distribution of alcohol to the participants of the study.

**Figure 12 : Control and Hangover subjects during the drinking phase in the pub.**



Because of individual differences in the metabolism and rates of elimination of alcohol during drinking, the evening was divided into three drinking sessions of 40 minutes in duration. The aim was to ensure that each subject attained a BAL of approximately 0.1g/dl as close to midnight as possible. This allowed the experimenters to monitor each subject by way of alcohol breathalyser tests. At the end of each 40 minute period, subjects were required to stop drinking alcohol for a period of 20 minutes in preparation for the alcohol breathalyser test. Following the test, each subject was then instructed as to how many drinks he or she would need to consume in the next 40 minutes and more tickets were issued accordingly. Each reading was noted on a recording sheet. The predictions based on the Widmark formula were accurate in 80% of the cases, the remaining 20% of subjects requiring slight adjustment to their rate of alcohol consumption.

All drinking stopped at midnight and final breathalyser tests were administered. Any hangover subject who had not managed to reach a final BAL of 0.1 g/dl was excused from further participation in the study and all data discarded. All subjects were escorted home by way of the Rag Buddy Bus with strict instructions to go immediately to bed and attempt at getting as normal a nights sleep as possible (i.e. no more than one hour in excess or less than usually required). In addition, all subjects ( $N = 63$ ) were instructed not to self-medicate possible hangover symptoms with any drugs, because of the possible psychoactive effects that could effect driving skill and reaction time.

Subjects reported back to their designated venue (i.e. either the school premises or motor vehicle testing grounds) at 2 p.m. the following day. All subjects were required to complete the Hangover Symptom Rating Scale. Post-testing then took place following the exact same procedure as the previous day. Once all tests had been completed, subjects were thanked and paid a nominal amount (R30.00) for their participation in the study.

**CHAPTER 4.****RESULTS****1. DATA ANALYSIS**

Study results were analysed using SPSS/PC+<sup>1M</sup> (Norusis/SPSS Inc., 1989-1997), and the significance level set at 0.05. Multivariate analysis was applied to compare hangover and control groups, while a within-subject factors multivariate analysis of variance was used to determine the difference between pre- and post-tests. Analysis of Covariance (ANCOVA) was conducted on significant results in order to eliminate the possible covariants with regards sex, hangover and drinking history. Certain of the variables did not meet the assumptions of the Analysis of Variance (ANOVA) test in terms of homogeneity of variance and normality. Specifically, repeated measures ANOVA for the *CALCAP Degraded Words with Distraction* and *True Negative* measures failed both the univariate homogeneity of variance tests (Cochrans C and Bartlett- Box) and the multivariate test of homogeneity of dispersion matrices (Boxes M). Assumption of normality was tested using the Levene's Test for Equality of Variance. However, it can be argued that this failure to meet the assumptions does not significantly affect the results as repeated measures ANOVA's have been shown to be robust even when some of the assumptions have not been met (Howell, 1997). Reliability analysis (Cronbach Alpha) was computed for the Hangover questionnaire. SPSS out put is voluminous, and therefore only the key summaries have been included in this dissertation. For further examination full results are available on file and stiffy disk.

## 2. DEMOGRAPHIC DATA OBTAINED FROM THE INTAKE QUESTIONNAIRE

Analysis of the intake questionnaire, using one-way ANOVA, showed that the hangover and control groups did not differ significantly with respect to age  $F(1,60) = 8.16, p = 0.20$ , nor did the groups differ with respect to education  $F(1,60) = 3.08, p = 0.72$ .

Demographic data for the entire sample are presented in Table 1.

**Table 1. : Demographic profiles of Subjects Used in the Current Study ( $n = 62$ )**

Variable	Hangover Group ( $n = 36$ )	Control Group ( $n = 27$ )
Mean age in years	21.22 (2.00)	22.13 (3.42)
Age range in years	19 - 29	18 - 29
Mean education in years	14.78 (1.02)	14.65 (1.71)
Male : Female ratio	64% vs 36%	59% vs 40%

Note: age and education figures are presented as a mean with *SD* in parentheses.

Pearson's Chi – Square Probability Test shows that no significant difference exists with respect to gender compositions in the two groups ( $\chi^2[1] = 0.04, p = 0.85$ ). In addition, no significant differences were found in number of drinking years  $F(1,60) = 0.71, p = 0.79$ . However, a significant difference was found between the groups in terms of drinking



frequency, i.e. the number of times per week a subject would imbibe alcohol  $F(1,60) = 8.95, p = 0.004$ . Demographic information related to the drinking history of all participants is presented in Table 2.

**Table 2. : Intake questionnaire data by group (Hangover and Controls)**

<b>Variables</b>	<b>Hangover Group (<i>n</i> = 36)</b>	<b>Control Group (<i>n</i> = 27)</b>
Number of years drinking	5.33 (1.91)	5.50(3.02)
Drinking frequency (Number of times per week)	2.33 (0.99)	1.61 (0.85)

Note: number of years drinking, drinking frequency and drinking amount are presented as a mean with *SD* in parentheses.

### **3. HANGOVER SYMPTOMS**

Reliability analysis of the Hangover Questionnaire resulted in a Cronbach Alpha of 0.91. This indicates satisfactory reliability in that it demonstrates high internal consistency or inter-item correlation.

Subjects consumed an average of 106g of alcohol, which is approximately the equivalent of six cans of beer. Differences in body weight resulted in females consuming less alcohol on average (76g /4.5 beers) than the males (123 g/7 beers) to reach a BAL of approximately 0.1g/100ml. Table 3 represents subjects' reported rating of hangover

symptoms indicating that alcohol intake in excess of 100g leads to a subjective sense of distress. Statistical analysis reflects a tendency of 13 hangover symptoms to cluster together, suggesting that most subjects complained of a “syndrome” of hangover in that certain symptoms tended to occur together. For identification purposes these clusters are marked with an asterisk.

**Table 3. Frequency of reported hangover symptoms in Hangover group ( $n = 36$ )**

<b>Hangover symptom – (ranked by perceived level of distress)</b>	<b>Percentage of subjects reporting symptom</b>
Excessive thirst *	92
Dry mouth *	84
Fatigue *	84
Lethargy/reduced motivation *	75
Headache *	61
General discomfort *	81
Excessive hunger	59
Absent-mindedness *	61
Shakiness	64
Sore eyes *	53
Insomnia	36
Nausea *	56
Unsteadiness in standing / gait *	47
Rapid heart rate *	44
Mood change *	25
Excessive sweating	30
Anxiety / nervousness *	17
Tinnitus	25
Diarrhoea	14

\* Denotes cluster of hangover complaints as identified by factor analysis

The following table, presents the means of the 13 symptoms of hangover that clustered together. Following factor analysis, the remaining six symptoms were extracted from the

data. The information was obtained by way of a 5-item Likert - type scale ranging from 0 (Not at all) to 4 (Extremely).

**Table 4. Hangover symptoms clustering together to form a ‘syndrome’ reported in the Experimental group ( $n = 36$ )**

Hangover symptom	Hangover Group ( $n = 36$ )
Excessive thirst	2.28 (1.37)
Dry mouth	2.00 (1.42)
Fatigue	1.81 (1.19)
Lethargy/reduced motivation	1.58 (1.21)
Headache	1.31 (1.33)
General discomfort	1.25 (1.00)
Absent-mindedness	1.17 (1.23)
Sore eyes	1.08 (1.25)
Nausea	0.83 (0.97)
Unsteadiness in standing / gait	0.72 (1.00)
Rapid heart rate	0.72 (1.00)
Mood change	0.44 (1.00)
Anxiety / nervousness	0.25 (0.60)

Note: Hangover symptoms are presented as a mean with *SD* in parentheses.

Data from the control group have not been reported due the fact that besides the symptom of *fatigue* (understandable after the late night experienced by all subjects), few other symptoms were reported.

#### 4. DRIVING MEASURES

Repeated measures (pre- and post-test) data was collected for each group. The mean and standard deviation of the entire sample are described in Table 5.

**Table 5. Descriptive Measures on the Driving tests.**

VARIABLE	HANGOVER PRE-TEST	HANGOVER POST-TEST	CONTROL PRE-TEST	CONTROL POST-TEST
	<i>n</i> = 36		<i>n</i> = 27	
Forward Movement	19.44 (25.88)	16.94 (24.94)	30.2 (23.40)	34.81 (17.46)
Width Estimation	15.83 (15.58)	16.29 (15.07)	20.8 (15.21)	13.85 (15.51)
Target	13.61 (15.52)	10.56 (16.72)	4.23 (8.09)	13.46 (18.75)
Winding Line	31.11 (13.94)	30.00 (15.02)	29.62 (12.16)	30.37 (13.37)
Serpentine	45.83 (14.01)	46.67 (11.71)	45.77 (13.62)	45.77 (13.62)
# Time Taken to Complete All Tests	125.56 (39.04)	121.66 (45.42)	130.58 (27.22)	138.27 (38.60)
Total Score	2.16 (0.50)	1.88 (0.53)	2.10 (0.48)	1.92 (0.45)

Note : Driving measures pre- and post-test are presented as a mean with *SD* in parenthesis.

# Denotes time taken to complete all 5 tests measured in minutes and seconds.

Except for the Target Driving Task, results did not show any significant difference between the groups. The following table outlines the outcome of the statistical process with regards to group differences measured within and between groups.

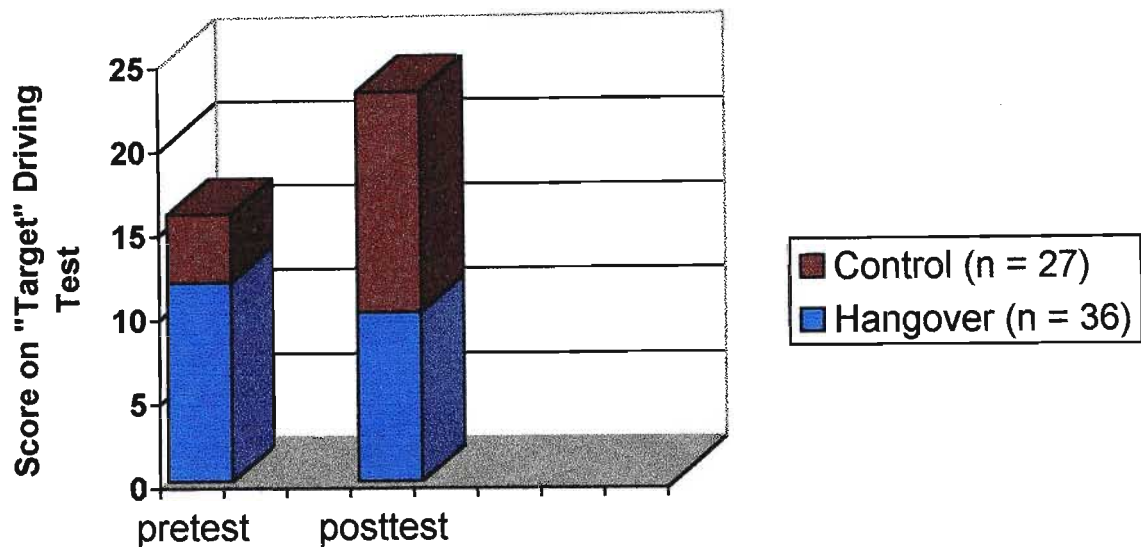
**Table 6. : Repeated Measures ANOVA on the Driving Tests (i.e. pre-test / post-test comparison)**

VARIABLE	ANOVA ( <i>df</i> = 1,60)	
	<i>F</i>	<i>p</i>
Forward Movement	1.58	0.214
Width Estimation	2.49	0.120
Target	6.06	*0.017
Winding Lane	0.31	0.583
Serpentine	0.04	0.852
Time Taken to Complete Test	1.13	0.292
Total Score	0.54	0.467

\* significant at  $p < 0.05$

These results indicate that the Target driving measure, showed a significant experimental effect. The improvement from pre- to post-test for this task between the control and experimental groups is illustrated in Figure 13. This figure shows that while the Control subjects were able to improve on their scores from pre-test to post-test, the Hangover subjects exhibited the opposite effect. This crossover effect reached statistical significance.

**Figure 13 : Showing Pretest and Posttest Mean Scores for the Hangover and Control Groups on the TARGET Driving Test**



Despite the fact that few significant differences were evident between the two groups, a definite trend emerged from the data where control subjects generally improved on the pre- to post-test tasks, whereas the Hangover group did not. In general, the Control subjects were able to improve on their pre-test Driving Skills scores at the post-test, whereas the opposite trend was manifested by the Hangover group. This trend was present for three out of the seven measures including the Overall Composite Driving Score. Figures 14 and 15 illustrate this trend, although it is important to note that there was no statistical group difference reached on either measure.

Figure 14 : Forward Movement Driving Score

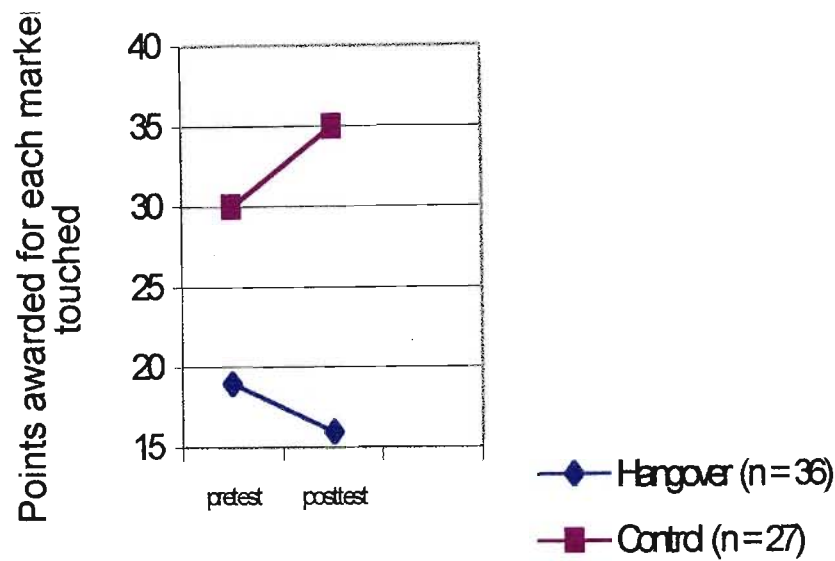
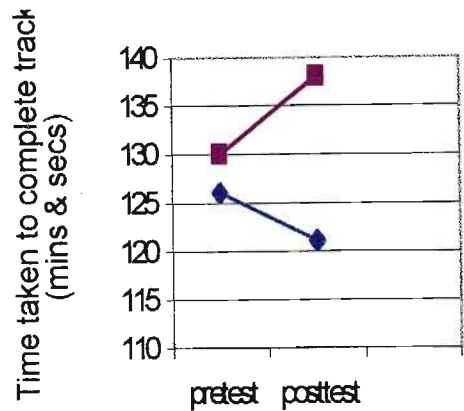


Figure 15 : Driving Composite Score



5. COMPUTERIZED REACTION TIME MEASURES (CALCAP)

Descriptive statistics for the CALCAP measures are presented in Table 6. Results indicate that the control group in contrast with the hangover group achieved a greater improvement score from pre-test to post-test. Reaction time measures revealed a general trend for poorer post-test performance in the hangover subjects, however, except for the True Positive score, none of these reached statistical significance.

**Table 7. Descriptive Statistics for CALCAP measures (Reaction Time measured in seconds).**

VARIABLE	HANGOVER PRE-TEST	HANGOVER POST-TEST	CONTROL PRE-TEST	CONTROL POST-TEST
	<i>n</i> = 36		<i>n</i> = 27	
SRT : Dominant Hand	299.17 (82.69)	288.67 (51.12)	298.77 (76.43)	283.69 (38.58)
SRT : Non-Dominant Hand	266.00 (37.21)	270.56 (43.55)	275.85 (49.83)	271.54 (38.63)
Choice Reaction Time Digits	378.67 (29.15)	384.90 (36.90)	389.84 (32.46)	385.58 (31.89)
Sequential Reaction Time	469.39 (82.06)	471.39 (87.22)	466.69 (71.15)	458.08 (64.24)
Language Discrimination	521.81 (58.06)	490.10 (43.53)	531.77 (58.41)	515.58 (46.00)
SRT 2 : Dominant Hand	290.39 (66.26)	278.78 (41.18)	325.23 (71.91)	281.23 (29.41)
Degraded Words with Distraction	455.81 (42.72)	446.44 (46.00)	517.96 (120.50)	474.08 (39.96)
Response Reversal / Words	591.56 (87.74)	561.42 (83.54)	619.58 (77.83)	590.88 (60.71)
Form Discrimination	652.44 (105.16)	619.28 (118.53)	698.04 (124.50)	638.65 (106.34)
SRT 3 : Dominant Hand	287.90 (50.26)	294.70 (47.37)	299.30 (43.00)	299.31 (52.52)
True Positives	99.81 (6.80)	102.22 (5.57)	96.35 (7.55)	102.04 (5.01)
True Negatives	11.58 (5.17)	7.83 (4.33)	13.69 (9.42)	8.42 (5.42)

SRT = Simple Reaction Time

Dominant Hand = Hand used to write with.

True Positives = Correct / true responses made by the subject.

False Negatives = Incorrect / false / missed responses made by the subject.

Note: CALCAP measures pre- and posttest are presented as a mean with *SD* in parenthesis.



Repeated measures ANOVA were also administered on the CALCAP within subject scores. The following table outlines the results of the statistical analysis and shows no significant differences found between the groups.

**Table 8 : Repeated Measures ANOVA (CALCAP Scores)**

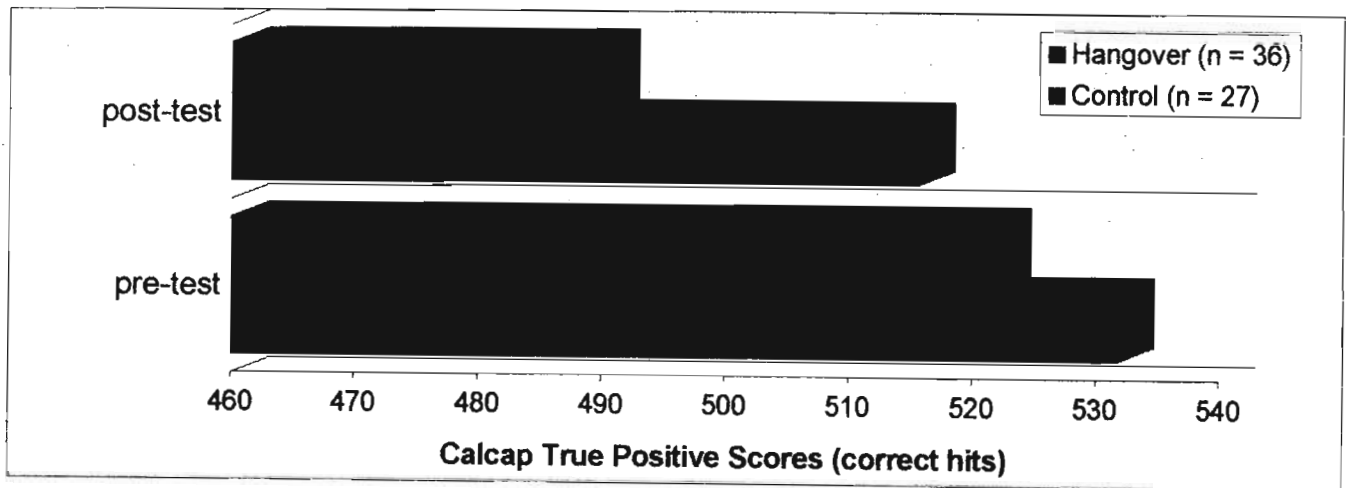
VARIABLE	ANOVA ( <i>df</i> = 1,60)	
	<i>F</i>	<i>p</i>
SRT: Dominant Hand	1.62	0.208
Choice Reaction Time Digits	1.78	0.187
Sequential Reaction Time	0.42	0.518
Language Discrimination	1.47	0.230
Degraded Words with Distraction	2.39	0.127
Response Reversal / Words	0.01	0.934
Form Discrimination	1.62	0.208
True Positives	4.05	*0.049

\* significant at  $p < 0.05$

The most sensitive index of the various computerised tests to the effects of alcoholic hangover, was an overall summary score. The score was based on the total number of correct target identifications over the complete 25 minute test, and can therefore, be regarded as an index of information processing accuracy.

Although most of the CALCAP scores described in Table 7 fell from pre- to post-test and did not reach statistical significance, the Control group scores showed less deterioration than those of the Hangover group in the Language Discrimination Test. A graphical representation of this trend is presented in described in Figure 16.

**Figure 16. : CALCAP Language Discrimination Pre- and Posttest Scores**



A more specific comparison in terms of the magnitude of change in the significant results found on the CALCAP True Positive scores, the Target driving task and the Overall driving score is presented in Table 9. The control group improved by 5.91% on the

CALCAP True Positive task, whilst the experimental group only improved by 2.44 %. Further more, the table describes an improvement of 2.18 % by the control group in the Target Driving Test pre- and post-test scores, whilst the hangover group deteriorated by 22%. Similarly, the improvement on the Overall Driving Score again demonstrated a better result from the controls (13.64% versus 3.99).

**Table 9 : Improvement Scores for the Hangover and Control Groups based on the CALCAP True Positive Scores and the Target Driving Task.**

MEASURE	HANGOVER GROUP ( <i>n</i> = 36)			CONTROLS ( <i>n</i> = 27)		
	Pre-test Mean	Post-test Mean	% Improvement	Pre-test Mean	Post-test Mean	% Improvement
CALCAP True Positive	99.80	102.22	2.44	96.34	102.03	5.91
Target Driving Test	13.61	10.55	-22.0 Deterioration	4.23	13.46	2.18
Overall Driving Score	125.55	130.57	3.99	121.66	138.26	13.64

## 6. CORRELATIONS ANALYSIS

Correlational analysis was performed on all the Driving and CALCAP measures.

Although few pertinent correlations were shown except for the Target driving task and the CALCAP True Positive scores, a detailed outcome of these results is presented by way of interest in Tables 10 and 11.

**Table 10. : Correlations Analysis (Driving Tasks)**

	Hangover	Forward Movement	Width Estimation	Target	Winding Line	Serpentine	Time Taken to Complete Test	Total Score
Hangover	1.00	0.27	0.16	-0.07	0.04	-0.18	0.15	-0.04
Forward Movement	0.27	1.00	0.08	0.19	0.04	0.02	*0.68	0.30
Width Estimation	0.16	0.08	1.00	-0.04	-0.10	-0.12	*0.43	0.02
Target	-0.07	0.19	-0.04	1.00	0.21	-0.21	*0.54	-0.03
Winding Line	0.04	0.04	-0.10	0.22	1.00	-0.04	*0.37	0.02
Serpentine	-0.18	0.01	-0.12	-0.21	-0.04	1.00	0.15	0.22
Time Taken to Complete Test	0.15	*0.68	*0.43	*0.54	*0.37	0.16	1.00	0.09
Total Score	-0.04	0.03	0.02	-0.03	0.02	0.22	0.09	1.00

\* Denotes correlations significant at  $p < 0.05$

The only significant correlation appeared on the *Time taken to complete the test* measure versus four of the individual test scores themselves. Thus, as would be expected, the more time taken to complete these specific driving tasks, the better the score.

Table 11. : Correlations Analysis (CALCAP)

	Hangover	SRT: Dominant Hand	True Positives	True Negatives	Choice Reaction Time	Sequential Reaction Time	Language Discrimina tion	Degraded Words with Distraction	Response Reversal / Words	Form Discrimina tion
Hangover	1.00	0.21	0.11	0.14	0.47	0.01	0.09	0.03	0.34	-0.14
SRT: Dominant Hand	-0.20	1.00	-0.06	0.02	0.38	*0.56	0.15	*0.48	-0.01	0.24
True Positives	0.11	-0.06	1.00	-0.03	-0.03	-0.22	*0.57	-0.01	-0.29	-0.44
True Negatives	0.14	0.02	-0.03	1.00	-0.08	0.06	0.22	-0.08	0.12	-0.21
Choice Reaction Time	-0.05	0.38	-0.03	-0.08	1.00	*0.41	0.33	*0.47	0.19	0.12
Sequential Reaction Time	0.01	*0.56	-0.22	0.05	*0.41	1.00	0.29	0.43	0.24	0.34
Language Discriminat ion	0.10	0.15	*0.57	0.23	0.33	0.29	1.00	-0.03	0.40	0.11
Degraded Words with Distraction	0.03	*0.48	0.01	-0.08	*0.47	0.43	-0.03	1.00	0.14	0.29
Response Reversal / Words	0.34	-0.01	-0.29	-0.12	0.19	0.24	0.40	0.14	1.00	0.18
Form Discriminat ion	0.14	0.24	-0.44	-0.21	0.12	0.34	0.12	0.29	0.18	1.00

SRT = Simple Reaction Time

Dominant Hand = Hand used to write with.

True Positives = Correct / true responses made by the subject.

False Negatives = Incorrect / false / missed responses made by the subject

\* Denotes correlations significant at  $p < 0.05$ 

The above results show significant correlations between the *Sequential Reaction Time* and *Degraded Words with Distraction* measures; as well as *Choice Reaction Time* and *Simple Reaction Time (Dominant Hand)* scores.

## 7. ANALYSIS OF COVARIANCE (ANCOVAS)

The Target driving task and the CALCAP True Positive measures, being the only scores shown to be clearly significant, were then covaried with Sex, Hangover and Drinking History. None of the results reached statistical significance. The statistical outcome of this process is presented in Tables 12 and 13.

**Table 12. : ANCOVA (Target Driving Tasks Covaried with Hangover, Sex and Drinking History)**

Variable	t-value	Sig. of t
<b>Hangover</b>	-1.31	0.19
<b>Sex</b>	-0.12	0.99
<b>Drinking History</b>		
No. of years drinking	-0.63	0.95
Frequency (No. of times per week)	-0.69	0.49

**Table 13. : ANCOVA (CALCAP True Positive Test Covaried with Hangover, Sex and Drinking History)**

<b>Variable</b>	<b>t-value</b>	<b>Sig. of t</b>
<b>Hangover</b>	-1.41	0.16
<b>Sex</b>	1.54	0.13
<b>Drinking History</b>		
No. of years drinking	0.61	0.54
Frequency (No. of times per week)	-0.23	0.82

## **8. BLOOD ALCOHOL READINGS**

On the evening of testing, the sequential blood alcohol readings taken at the end of each 40 minute drinking session by way of breathalyzer testing are represented in Table 14.

Each of the subjects in the Hangover group was to have reached a BAL of not less than, and as close to 0.1 g/dl as possible by the time the third measurement was taken.

Drinking began at 21:00. All Hangover subjects ceased drinking at 21:40 hours for a period of 20 minutes. The first reading followed at 22:00 hours. This procedure was then repeated twice with further readings taken at 23:00 hours and 24:00 hours.

**Table 14 : Sequential BALs by way of Breathalyzer Testing**

<b>GROUP</b>	<b>FIRST READING (22:00 hours)</b>	<b>SECOND READING (23:00 hours)</b>	<b>THIRD READING (23:00 hours)</b>
HANGOVER	0.05 (0.02)	0.10 (0.02)	0.12 (0.02)

Note: Blood alcohol figures are presented as a mean with *SD* in parenthesis.

## 9. GLUCOSE TESTS

These tests served to control for hangover symptoms in the experimental group being exacerbated by hypoglycemia. All subjects fell within the normal range of testing, and although the statistical analysis was of no significance the Glucose pre- and post-testing results are presented in Table 15 by way of interest.

**Table 15. Descriptive Statistics on the Glucose Pre- and Post-testing.**

<b>GROUP</b>	<b>GLUCOSE PRETEST</b>	<b>GLUCOSE POSTTEST</b>
HANGOVER	5.14 (0.67)	4.95 (0.95)
CONTROL	4.55 (1.20)	5.25 (1.68)

Note: Glucose figures are presented as a mean with *SD* in parenthesis.



10. GENDER DIFFERENCES

Given the intrinsic value of female composition in this study, statistical analysis was carried out on possible gender differences measured in the drop from pre- to post-test scores. The only interesting results were found on two of the CALCAP measures. The difference measure on the CALCAP Sequential Reaction Time Task (measuring Divided Attention), is described in Table 16, where males outperformed females in that they showed an overall improvement by 0.717, whereas the females dropped by 7.8261.

Although t-tests on this difference proved not significant, ( $p = 0.605$ ) this score displayed the largest drop in pre- to post-test CALCAP measures.

**Table 16.      Difference measure with regards Gender on the pre- to posttest CALCAP Sequential Time Reaction Measure**

VARIABLE	NO. OF CASES	MEAN	SD
MALES	39	0.72	64.8
FEMALES	23	7.826	61.1

**Table 17.      Difference measure with regards Gender on the pre- to posttest  
CALCAP Language Discrimination Measure**

VARIABLE	NO. OF CASES	MEAN	SD
MALES	39	35.90	57.41
FEMALES	23	7.04	25.32

Conversely, in the CALCAP Language Discrimination Task measuring verbal fluency (Table 17), females performed much better than their male counterparts in that there the drop from pre- to post-test scores was much greater in the males than in the females.

## CHAPTER 5: DISCUSSION AND CONCLUSION

### 1. DEMOGRAPHIC DATA OBTAINED FROM THE INTAKE QUESTIONNAIRE

The information gathered from the intake questionnaire, served primarily as a screening device in the initial phase of subject selection. Results from the statistical analysis confirmed that there were no significant differences between the experimental group and the control group in respect of age and education. However, data analysis was restricted in terms of drinking history in that the only suitable variables for statistical analysis were those of *Number of Years Drinking* and *Drinking Frequency*. Although an attempt was made at measuring *Drinking Amount* (in terms of number of drinks consumed in one sitting), the design of the questionnaire proved too vague, as alcoholic beverages differ in alcohol content, and specifics such as type of beverage, number of tots and size of glass (in the case of beer, wine and ciders) were omitted (Appendix 1), thus rendering the data unfit for statistical analysis. Future research needs to pay much more attention to how such information is gathered in terms of structuring questions in such a way that data collected is clear and precise.

## 2. HANGOVER SYMPTOMS

The subjective symptoms most often reported by the subjects in the Hangover group, depicts aspects of perceived level of physiological distress measured 14 – 16 hours after cessation of drinking. These results are accordant with theoretical models described by Gauvin et al. (1993) in which the nature of this distress suggests that symptoms arise from a toxic reaction to alcohol and its metabolic by-products thereby resulting in symptoms of hangover. It is important to note that *fatigue* is the third most commonly reported hangover symptom (endorsed by 84% of subjects in the experimental group). This is significant in that previous studies examining alcoholic hangover and human performance (Anderson & Dawson, 1999; Begleiter & Platz, 1972; Finnigan and Hammersley, 1992), have not given much consideration to the fatigue effects of alcohol on human performance even though *insomnia*, *lethargy* and *sleepiness* as have often been mentioned in studies looking at the effects of alcohol on neurological and physiological functioning (Gauvin et al., 1993; Harburg, Davis & Gunn, 1981). The effects of fatigue on human performance may offer some explanation for the deficits in mental efficiency on tasks requiring focus, concentration and accuracy (e.g. reaction time and precision driving).

As was expected, few hangover symptoms, with the exception of *fatigue*, were reported from the control group. It may be argued that the late night party the evening before, together with the fact that most of these subjects drank Coca-Cola which has a known

high caffeine content (a stimulant), could have contributed to poor sleep patterns experienced by these participants. Although a minor consideration, the high instance of *fatigue* reported in the hangover group, may have been of more consequence had the subjects from the control group ingested soft drinks that were stimulant free.

Statistical analysis showed that 13 of the hangover symptoms tended to cluster together. This is compatible with studies such as Gauvin et al., (1989, 1992 & 1993) in that it suggests that most subjects from the hangover group complained of a “syndrome” of hangover, with the reported symptoms tending to occur together.

Studies by Lukas et al. (1986), Millar et al. (1992) and Portans et al. (1989) have demonstrated that human beings have difficulty in using internal cues to measure their level of intoxication and, similarly, hangover effects can be measured even when the person does not ‘feel’ subjectively hungover (Finnigan & Hammersley, 1992). It is interesting to note that in this study the subjective experience of hangover did not correlate significantly with the degree of performance decrement on the post-test scores of the measures of driving ability and computerised reaction time tests. Although symptoms recorded by subjects indicate that alcohol in excess of 100 grams leads to a subjective sense of distress, individual perception of the level and severity of hangover proved an unreliable predictor in terms of performance on these tasks. Therefore, the assumption cannot be made that the worse the individual feels as a result of hangover, the worse he/she will perform. This discrepancy between subjective distress and measured performance has been previously reported in the literature (Anderson & Dawson, 1997;

Seppala et al., 1976; Watson et al., 1990; Ylikahri et al., 1974;) and has important implications in that it suggests that, even if the individual does not experience any subjective feelings of hangover, this does not necessarily mean that one has returned to the pre-hangover level of mental efficiency. In addition, concentration deficits and judgement inaccuracies brought about by hangover may still be present.

### **3. DRIVING MEASURES**

The "Target Driving Task" is essentially a measure of precision driving and visuospatial estimation. Hangover induced performance decrements detected in this study on this kind of task, indicate that although basic driving skills in general are unlikely to be affected, the presence of hangover has the potential to interfere with the more refined aspects of driving ability involving visuospatial judgement and precision. Therefore, it may be argued, that while a driver might be successful in controlling a vehicle while engaged in familiar situations, it is possible, that when faced with novel or unexpected circumstances and in conjunction with speed, the presence of hangover may result in a potential deterioration in driving precision which could increase the risk of that individual being involved in an accident. This is supported in the literature where experimental research also found that even when repeated performance of certain tasks under the influence of alcohol resulted in learned tolerance, when faced with new and different situations, drivers showed a marked deterioration in performance (Brewer & Sandow, 1980; Cook, 1997). Although speculative, these findings suggest that the proficiency to handle a

vehicle successfully in an emergency situation whilst driving, could be compromised if the driver was suffering from a hangover. Given that these effects may be suppressed in closed – course tests (Medical News, 1983), it could be argued that the potential disruption to driving ability could be even more pronounced in real situations.

Furthermore, even though the data analysis showed few overall significant differences between the groups, it is interesting to note that there was a definite trend for subjects from the control group to improve on the post-test scores, whilst the opposite trend was apparent in the hangover group. Even though studies have been fraught with difficulties, there is enough evidence to indicate that the hangover phase has a significant impact on simple psychomotor performance resulting in a deterioration of psychomotor skills (Brewer & Sandow, 1980; Finnigan & Hammersley, 1992; Seppala et al., 1976). This is verified in flight simulator research which strongly suggests that performance may be impaired for several hours even after BAL's have returned to zero (Cook, 1997; Morrow, Leirer & Yesavage, 1990; Yesavage & Leirer, 1986). Although hypothetical, an emerging trend towards any degree of decrement in post-test driving scores, again suggests the possibility of decreased efficacy on the part of a hungover driver in situations demanding acute reaction time, precision and control, which may ultimately increase the likelihood of an accident.

#### 4. COMPUTERISED REACTION TIME MEASURES

The CALCAP findings suggest that the subjects suffering from hangovers proved to be less accurate in target identification than those who had not consumed alcohol. Subjects from the control group appeared better able to discriminate between the true items and the distracter items, than those of the experimental group. These results imply that cognitive efficiency seems, therefore, to be a component of alcoholic hangover as the effects are still detectable 14-16 hours after cessation of drinking. Moreover, given that Finnigan and Hammersley (1992) suggest that neuropsychological manifestations are likely to be subtle and affected by individual differences, these findings indicate that with alcoholic hangover one might expect degraded attentional resources and concentration deficits. It is significant to note that once again these results are supported in current research which show that these problems occur independently of subjective evaluation of how hungover an individual might feel (Anderson & Dawson, 1997; Finnigan & Hammersley, 1992).

#### 5. CORRELATIONS ANALYSIS AND ANCOVAS

Few important correlations were established except on the already ascertained measures of the *Target Driving Task* and the *CALCAP True Positive Score*. A positive correlation was established on the driving measure, *Time Taken to Complete the Test*. However, this offers little to the study in that it is expected that the longer one takes to complete a



driving task, the better the score will be. Similarly, although significant correlations were detected between the *Sequential Reaction Time* and *Degraded Words with Distraction* measures; as well as *Choice Reaction Time* and *Simple Reaction Time (Dominant Hand)* scores, given the nature of the measures concerned, these results are also fairly obvious and add little in the final analysis.

The analysis of covariance in which the only two important measures (*Target Driving Task* and *CALCAP True Positive Scores*) were covaried with Sex, Hangover and Drinking History failed to reach any statistical significance.

## 6. GENDER DIFFERENCES

Looking at gender as a modifying variable, statistical analysis of the data showed that the post-test improvements could not be attributed to a gender effect in that females performed no better or worse than their male counterparts during hangover. However, sex differences were evident in the pre-test computerised reaction time measures. Males outperformed females on the *Sequential Reaction Time Task* that measures divided attention, whereas, females outperformed males on the *Language Discrimination Task* which requires semantic matching. The latter is in keeping with research showing that females generally have superior language ability (Baylor et al., 1989; Delin, & Lee, 1992). Although males had a slightly higher overall composite score than females on the

pre-test driving measures (130 versus 122), this difference did not reach statistical significance.

## **7. LIMITATIONS OF THE CURRENT STUDY AND FURTHER RECOMMENDATIONS**

Problems outlined in this dissertation make an objective review of the literature difficult. Any attempt at meta-analysis or tabulation of different studies findings is restricted by the fact that most studies are unique in terms of at least one of: - alcohol dosage; methodology of testing; or specific tests of performance used. Therefore, much of the findings in areas of related research are inconsistent.

An important weakness in the design of the study lies in the selection of subjects to groups. Although the statistical analysis showed no significant group differences, the results of the study might have been strengthened had the samples been better matched in terms of the demographic information collected in the intake questionnaire relating to age, sex and drinking history (i.e. an improved evenness within the groups). In addition, equal ratios of men and women, as well as equal and even larger sample sizes might have reinforced the end results. It is suggested that future studies take this into account. Furthermore, the introduction of a placebo controlled experiment with double-blind administration may be useful in controlling expectancy effects.

Although the use of a naturalistic setting is regarded as a strength in this study, the researchers were heavily reliant on the co-operation of the subjects. Therefore, requests to, for example: - abstain from alcohol for a certain period before testing; to eat a non-fatty meal one hour before drinking; to “get a normal night’s sleep” following the cessation of drinking, and not to self-medicate any symptoms of hangover, were totally dependent on the integrity and commitment of each subject. Controlling these variables outside a laboratory environment is difficult. Perhaps a design that incorporates both the naturalistic setting and monitors eating and sleeping before and after testing, may help strengthen the efficacy of the results.

It has already been mentioned that the demographic information gleaned from the intake questionnaire lacked detail and clarity in the category of *Drinking History*. In order for statistical analysis to be more proficient, this section could have been more detailed and accurate.

It has been well established in the literature that BAL’s take up to eight hours to return to zero (Cook, 1997; Finnigan & Hammersley, 1992). Given that this study used a 14 – 16 hour window, more significant results may have been established within a lesser hangover time period. Therefore, it is suggested that future research, either reconsider the length of this test – retest interval, or include more variations.

Finnigan and Hammersley (1992) have argued that, in studies where impairment after alcohol is found on one or two measures but not on several others, in the absence of

coherent theory to predict when impairment should or should not be found, a 'significant' difference on one or two measures out of several may be due to variables of another sort. e.g. negative emotional states like anxiety and depression are known to interfere with cognitive performance. However, most of the literature reports studies with small sample size and with an  $n = 62$ , the results from this research lends more confidence to the findings than previous studies.

## 8. CONCLUSION

The aim of this dissertation was two-fold. The first was to report on previously published and new data concerning the long-term after-effects of acute high dose alcohol administration. The second was to examine the acute effects of post-alcohol impairment on human performance. With regards the latter, the findings described in the study indicate that individuals with hangover perform less well than control subjects on measures of reaction time and driving precision. Although the effects are subtle in that they are restricted to only one driving measure and one composite reaction time measure, they are, nevertheless detectable 14-16 hours following the consumption of alcohol in excess of 1g/kg.

From a neuropsychological perspective, the findings suggest that alcoholic hangover is associated with reduced mental efficiency. This could have important repercussions for driving behaviour and other activities that make heavy demands on attentional resources.

The study findings also indicate that the subjective experience of hangover is not a good predictor of reaction time or driving performance, and therefore, individuals should be aware that drinking may leave a residual impairment on sober performance for at least 14-16 hours after cessation of drinking. In addition, the absence of hangover symptoms does not guarantee that they are fully recovered, and impaired neuropsychological functioning may still be present.

Thus, the message of the study is clear: with enough consumption of alcohol to invoke hangover, such individuals may be operating with less than 100% mental efficiency, making driving and other activities where reduced concentration is required, potentially dangerous. Although speculative, it may be argued that if enough people drive a motor vehicle while impaired, there will be an increased possibility of this leading to a substantial number of surplus accidents.

Although there is a need for further studies on the individual differences and responses to alcohol, the "Don't Drink and Drive" rule should perhaps be reinforced with a simple legal limit which functionally prevents any consumption of alcohol for some time prior to driving.

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**APPENDIX 1: INTAKE QUESTIONNAIRE****STRICTLY CONFIDENTIAL****RESEARCH QUESTIONNAIRE**

IT IS IMPORTANT THAT YOU ANSWER THE FOLLOWING AS TRUTHFULLY  
AS POSSIBLE

NAME : \_\_\_\_\_

ADDRESS : \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

TELEPHONE: \_\_\_\_\_

MALE / FEMALE : \_\_\_\_\_

DATE OF BIRTH : \_\_\_\_\_

OCCUPATION : \_\_\_\_\_

WEIGHT : \_\_\_\_\_

DRIVER'S LICENSE OBTAINED : \_\_\_\_\_

**GENERAL MEDICAL QUESTIONS:**

HAVE YOU EVER SUFFERED FROM ONE OF THE FOLLOWING:

(If the Answer is "YES" please give details of when; how often etc..)

1. HAVE YOU EVER BEEN TREATED FOR A NEUROLOGICAL  
ILLNESS Eg. EPILEPSY ; FITS; SEIZURES; MIGRAINES; HEAD  
INJURY; MENINGITIS; ENCEPHALITIS etc.? - (YES) / (NO)

IF 'YES' GIVE DETAILS \_\_\_\_\_

- 
2. HAVE YOU EVER BEEN DIAGNOSED WITH A LEARNING DISORDER OR ATTENTION DEFICIT HYPERACTIVITY DISORDER? (YES) / (NO)

IF 'YES' PLEASE GIVE DETAILS \_\_\_\_\_

\_\_\_\_\_

3. HAVE YOU USED PSYCHIATRIC MEDICATION IN THE LAST SIX MONTHS, eg. SLEEPING TABLETS OR ANTI-DEPRESSANTS?

IF 'YES' PLEASE SPECIFY \_\_\_\_\_

\_\_\_\_\_

4. HAVE YOU EVER BEEN A DRUG USER? (YES) / (NO)

5. HAVE YOU USED ANY ILLEGAL SUBSTANCES IN THE PAST TWO WEEKS eg. MARIJUANA, ECSTACY? IF 'YES' SPECIFY. \_\_\_\_\_
- \_\_\_\_\_

### **DRINKING HISORY**

HOW LONG HAVE YOU BEEN DRINKING ALCOHOL? \_\_\_\_\_

WHAT KIND OF ALCOHOL DO YOU USUALLY DRINK? \_\_\_\_\_

\_\_\_\_\_

HOW OFTEN DO YOU DRINK ALCOHOL? (No of times per week / month)

\_\_\_\_\_

WOULD YOU DESCRIBE YOURSELF AS A:

SOCIAL DRINKER	( )
MODERATE DRINKER (Less than 7 drinks in a sitting)	( )
HEAVY DRINKER (More than 7 drinks in a sitting)	( )



BINGE DRINKER (Infrequent sessions of heavy alcohol consumption (\_\_\_\_))

HOW MUCH DO YOU USUALLY DRINK ON AN AVERAGE OCCASION?

(eg. How many tots or beers etc., in a sitting) \_\_\_\_\_

\_\_\_\_\_

DO YOU MIX YOUR DRINKS? (IF 'YES' EXPLAIN eg. what combination of alcoholic beverages you may consume) \_\_\_\_\_

\_\_\_\_\_

DO YOU USUALLY SUFFER FROM HANGOVERS? (YES) / (NO)

IF 'YES' LIST YOUR MOST PROMINENT SYMPTOMS \_\_\_\_\_

\_\_\_\_\_

IN YOUR EXPERIENCE, HOW MUCH ALCOHOL IS USUALLY REQUIRED TO  
INDUCE A HANGOVER? \_\_\_\_\_

\_\_\_\_\_

Thank you once again for being part of this project.

**APPENDIX 2:    HANGOVER QUESTIONNAIRE**

ID:  
CONTROL / SUBJECT

THIS MORNING WERE YOU MUCH DISTRESSED BY:

- 0 = NOT AT ALL
- 1 = A LITTLE BIT
- 2 = MODERATELY
- 3 = QUITE A BIT
- 4 = EXTREMELY

SYMPTOM	1	2	3	4	5
1. NAUSEA (Queasy)					
2. TINNITUS (Ringing in the head/ears)					
3. HEADACHE (Pressure feelings in the head)					
4. TACHYCARDIA (Rapid heart beat)					
5. EXCESSIVE THIRST					
6. EXCESSIVE HUNGER					
7. ANXIETY					
8. INSOMNIA (Disturbed sleep)					
9. SORE EYES					
10. UNSTEADINESS IN STANDING OR GAIT					
11. PROFUSE SWEATING					
12. SHAKINESS					
13. LETHARGY / MOTIVATIONAL DISTURBANCE					
14. ABSENT-MINDEDNESS					
15. FATIGUE					
16. DIAPHORESIS					
17. DRY MOUTH					
18. MOOD CHANGE / GRUMPY					
19. GENERAL DISCOMFORT					

**APPENDIX 3:     DRIVING TEST**

**LIGHT MOTOR VEHICLE TEST**

NAME \_\_\_\_\_ DAY \_\_\_\_\_

1.     **FORWARD MOVEMENT**

10 points AWARDED for each marker of Row "A" that is touched. \_\_\_\_\_

2.     **WIDTH ESTIMATION**

20 points for stopping or realigning.

- 0    - 100 mm = 50 points
  - 101 - 200 mm = 40 points
  - 201 - 300 mm = 30 points
  - 301 - 400 mm = 20 points
  - 401 - 500 mm = 10 points
- \_\_\_\_\_

3.     **TARGET**

10 points deducted for each stop / realignment  
50 points deducted if plumb line hangs outside the circle  
50 points deducted if the vehicle moves or realigns whilst being measured

\_\_\_\_\_

4.     **WINDING LINE**

50 points deducted if the driver follows the marker with the right front wheel

50	40	30	20	10
----	----	----	----	----

\_\_\_\_\_

5.     **SERPENTINE**

10 points deducted for touching border line  
10 points deducted for touching cone  
10 points deducted for stop or realignment  
50 points deducted for driving the wrong way round obstacle \_\_\_\_\_

TIME TAKEN ON TRACK \_\_\_\_\_ TOTAL POINTS \_\_\_\_\_

## APPENDIX 4:    CONSENT FORM

### A STUDY ON THE NEUROPSYCHOLOGICAL CORRELATES OF ALCOHOLIC HANGOVER.

#### CONSENT FORM

I \_\_\_\_\_ DECLARE THAT I GIVE MY  
INFORMED CONSENT TO PARTICIPATE IN THIS PROJECT. I UNDERSTAND  
THAT I MAY, OF MY OWN FREE WILL, IMBIBE ENOUGH ALCOHOL  
(DEFINED AS AN INTAKE IN EXCESS OF 1 g ALCOHOL / per 1 Kg BODY  
WEIGHT) TO INDUCE A HANGOVER.

I FULLY UNDERSTAND THE IMPLICATIONS OF THIS RESEARCH PROJECT  
WHICH INCLUDES AN AWARENESS OF THE DANGERS OF ALCOHOL  
CONSUMPTION.

I DECLARE MYSELF MEDICALLY FIT AND DO NOT HOLD THE  
RESEARCHERS IN ANY WAY RESPONSIBLE FOR ANY ILLNESS OR  
ACCIDENT WHICH MAY ARISE DURING OR AS A RESULT OF  
PARTICIPATING IN THIS PROJECT. I AM FULLY AWARE THAT I MAY  
WITHDRAW FROM PARTICIPATION IN THE PROJECT AT ANY TIME.

SIGNED \_\_\_\_\_ ON THIS DAY \_\_\_\_\_ OF \_\_\_\_\_ 19\_\_.

WITNESS : \_\_\_\_\_

## **APPENDIX 5: INSTRUCTIONS**

### **A STUDY ON THE NEUROLOGICAL CORRELATES OF ALCOHOLIC HANGOVER.**

#### **VERY IMPORTANT REQUIREMENTS**

IN THE INTERESTS OF RELIABLE RESEARCH IT IS **IMPERATIVE** THAT YOU ADHERE TO THE FOLLOWING.

1. ANSWER **ALL** QUESTIONS ABSOLUTELY TRUTHFULLY, REMEMBER THAT INFORMATION IS GATHERED ONLY FOR THE PURPOSE OF THE STUDY AND WILL REMAIN **STRICTLY CONFIDENTIAL**.
2. WHETHER YOU ARE PART OF THE SUBJECT OR CONTROL GROUP, YOU MUST **NOT** CONSUME ANY ALCOHOL WHAT-SO-EVER FOR THE **48 HOUR** PERIOD PRECEEDING THE PRE-TEST.

IN ADDITION, YOU CANNOT CONSUME ANY MEDICATION OR SUBSTANCES CONTAINING ALCOHOL OR THAT MAY HAVE AN AFFECT ON THE CENTRAL NERVOUS SYSTEM.

IF YOU ARE A MEMBER OF THE CONTROL GROUP, YOU CANNOT CONSUME ANY ALCOHOL OR EQUIVALENT SUBSTANCE , UNTIL AFTER THE POST-TEST PERIOD.

3. IN THE INITIAL 48 HOUR PRE-TEST PHASE, ALL PARICIPANTS ARE REQUIRED TO ENSURE THAT THEY EAT WELL-BALANCED NON – FATTY MEALS AND SLEEP AT LEAST 6 -8 HOURS PRIOR TO TESTING. PLEASE MAKE SURE THAT ON THE NIGHT OF TESTING, YOU HAVE EATEN AND COMPLETED DINNER BEFORE 7.30 pm.
4. THE TEST WILL RUN AS FOLLOWS:
  - **THE PRE-TEST PHASE:**  
BETWEEN 2-4 p.m. OF THE DAY OF TESTING, YOU WILL BE ASKED TO COMPLETE BOTH A DRIVING AND A COMPUTER TEST.

- **TESTING PHASE:** (9pm - 12 am)  
**Subject Group :** WILL BE PROVIDED WITH ALCOHOLIC BEVERAGES UNTIL THEY CONSUME ENOUGH ALCOHOL TO EXCEED 1g ALCOHOL / 1 kg BODY WEIGHT.

**Control Group :** WILL BE PROVIDED WITH NON-ALCOHOLIC BEVERAGES DURING THE SAME PERIOD OF TIME.

**BLOOD ALCOHOL WILL BE MEASURED THROUGHOUT THE NIGHT USING LINE SD 2 ALCOMETERS (BREATHALIZERS)**

**GLUCOSE TESTS WILL ALSO BE PERFORMED TO DETECT POSSIBLE HYPOGLYCAEMIA.**

- **THE POST-TEST PHASE:**  
THIS WILL TAKE PLACE BETWEEN 2-4p.m. ON THE DAY FOLLOWING TESTING AND WILL INVOLVE A REPEAT TEST OF BOTH THE DRIVING AND COMPUTER TESTS.

5. **ALL DRINKING WILL CEASE AT 12pm ON THE NIGHT OF TESTING, AND EACH SUBJECT IS ASKED TO SLEEP AS 'NORMALLY' AS POSSIBLE (i.e. NOT MORE THAN AN HOUR MORE OR LESS THAN USUAL).**

**IT IS VERY IMPORTANT THAT NO SUBJECT SELF-MEDICATE UNTIL AFTER THE POST-TEST HAS BEEN COMPLETED. THEREFORE, NO 'HANGOVER-CURES' UNTIL ALL TESTING HAS BEEN DONE.**

6. **TRANSPORT HOME WILL BE PROVIDED FOR THE SUBJECT GROUP AFTER DRINKING, AND IT IS THEREFORE REQUESTED, THAT ALL PARTICIPANTS FIND THEIR OWN WAY TO THE ST CHARLES COACHHOUSE PUB, AND THE CONTROL GROUP PROVIDE THEIR OWN TRANSPORT BOTH WAYS.**