

Monitoring Cognitive and Psychological Changes for Indigenous Australians Following Petrol and Alcohol Abuse

Submitted by

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Thesis Declaration

The articles presented in this thesis are the work of joint authorship. In all instances I am the primary author and have made the most substantial contribution to the work presented. Other authors have also contributed to the work presented and their contributions are detailed here: Dr Sheree Cairney provided research supervision and contributed significantly to the design and implementation of the studies, data collection, statistical data analysis and interpretation, and to drafting and developing the final written reports. A/Prof. Paul Maruff is the chief scientific officer at CogState and was involved in designing the studies, statistical data analysis and interpretation, and drafting and developing the final written reports. Dr Matthew Lewis assisted with in the statistical data analysis and interpretation and in drafting a number of the final written reports. Other authors are acknowledged on the title page for each chapter. Ms Nicole Berkhout, Ms Jodie Gunderson, Ms Jessica Benitez, and Ms Leigh-Ann Onnis provided co-ordination of data collection in the Top End.

I hereby declare that the work herein, now submitted as a thesis for the degree of Doctor of Philosophy by research of the Charles Darwin University, is the result of my own investigations and all references to ideas and work of other researchers have been specifically acknowledged. I hereby certify that the work embodied in this thesis has not already been accepted in substance for any degree and is not being currently submitted in candidature for any other degree.

Kylie Dingwall

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List of Abbreviations

ABC	Aboriginal Birth Cohort
AIHW	Australian Institute of Health and Welfare
ALAD	delta-aminolevulinic acid dehydrase
ANCOVA	analysis of covariance
ANOVA	analysis of variance
ARIA	Accessibility/Remoteness Index of Australia
AVGAS	aviation gasoline
CANTAB	Cambridge Neuropsychological Test Automated Battery
CNS	central nervous system
CPAL	Continuous Paired Associate Learning
CSF	cerebral spinal fluid
CT	computed tomography
DV	dependent variable
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders 4 th Edition
EEG	electroencephalogram
EMG	electromyogram
ENG	electronystagmogram
F	F-statistic
GMCT	Groton Maze Chase Test
GMLT	Groton Maze Learning Test
GP	general practitioner
HRB	Halstead Reitan Battery
ICD-10	International Classification of Diseases 10 th Revision
IHD	ischemic heart disease
IV	independent variable
k	number of groups
K10	Kessler Psychological Distress Scale – 10
KICA	Kimberley Indigenous Cognitive Assessment
LMM	linear mixed model
log	logarithmic transformation base 10
M	mean
mps	moves per second

MRI	magnetic resonance imaging
N	sample size
NATSIHS	National Aboriginal and Torres Strait Islander Health Survey
NATSISS	National Aboriginal and Torres Strait Islander Social Survey
NHMRC	National Health and Medical Research Council
NLES	Negative Life Events Scale
NS	not significant
NT	Northern Territory
OR	odds ratio
PHQ-9	Patient Health Questionnaire – 9
RR	relative risk ratio
s	seconds
SD	standard deviation
SDQ	Strengths and Difficulties Questionnaire
SEWB	social and emotional wellbeing
SPECT	single-photon emission computed tomography
STI	sexually transmitted infection
UK	United Kingdom
USA	United States of America
VSA	volatile solvent abuse
VSAP	Volatile Substance Abuse Prevention
VSU	volatile solvent use
WASC-Y	Westerman Aboriginal Symptom Checklist for Youth
WAACHS	Western Australia Aboriginal Child Health Survey

Journal Publications and Presentations Associated with the Thesis Content

Journal Publications

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Dingwall, K. M., & Cairney, S. (2009). Measuring Cognitive and Social Emotional Wellbeing Outcomes for Indigenous Substance Abusers [Abstract]. *Drug and Alcohol Review*, 28(S1), A14.

Dingwall, K. M., & Cairney, S. (2010). Psychological and cognitive assessment of Indigenous Australians [Review]. *Australian & New Zealand Journal of Psychiatry*, 44(1), 20-30.

Lewis, M. S., Dingwall, K. M., Sawyers, S., Berkhout, N., & Cairney, S. (2010). The assessment of cognition in an adolescent Indigenous population. *Australian Psychologist*, 45(2), 123-131.

Dingwall, K. M., Lewis, M. S., Maruff, P., & Cairney, S. (2010). Assessing cognition following petrol sniffing for Indigenous Australians. *Australian and New Zealand Journal of Psychiatry*, 44(7), 631-639.

Dingwall, K. M., & Cairney, S. (2011). Detecting psychological symptoms related to substance misuse among Indigenous Australians. *Drug and Alcohol Review*, 30(1), 33-39.

Cairney, S., & Dingwall, K. M. (2010). The mysterious practice of petrol sniffing in isolated Indigenous groups [Review]. *Journal of Paediatrics and Child Health*, 46(9), 510-515.

Dingwall, K. M., Maruff, P., Clough, A., & Cairney, S. (2011). Factors associated with continued solvent use in Aboriginal petrol sniffers following treatment [Electronic Version]. *Drug and Alcohol Review*. Retrieved 11 January 2011 from <http://onlinelibrary.wiley.com/doi/10.1111/j.1465-3362.2010.00279.x/abstract>

Dingwall, K. M., Maruff, P., & Cairney, S. (2011). Neuropsychological problems and alcohol availability key factors in continued heavy alcohol use for Aboriginal Australians [Letter to the editor]. *Medical Journal of Australia*, 194(1), 50-51.

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Presentations

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Dingwall, K. M. & Cairney, S. Cognitive Assessment Following Substance Abuse in Indigenous Populations. Oral presentation at the *Creating Futures: Research, Practice and Policy for Indigenous Rural and Remote and Island Peoples Conference*, Centre for Rural and Remote Mental Health and the Royal Australian and New Zealand College of Psychiatrists, Cairns, September 2008.

Dingwall, K. M., Berkhout, N. & Cairney, S. Culturally Appropriate Assessment of Cognitive Function in Indigenous Australians Following Volatile Substance and Alcohol Abuse. Oral presentation at the "Two Nations, Ten Cultures?" *Combined APSAD and Cutting Edge Addiction Conference*, Auckland, New Zealand, November 2007.

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Thesis Format and Presentation

This thesis is presented as a series of papers that are either submitted, ‘in press’, or published in internationally peer-reviewed journals. In accord with the Charles Darwin University Guidelines for the Presentation of Theses, it has uniformity of format beginning with a general introduction (Chapter 1) and concludes with a general discussion (Chapter 12) that summarises the findings of the body of research. Apart from Chapters 1 and 12, each chapter is presented as a stand-alone article. A table outlining the status of each article is presented in Appendix A, with reprints of published articles, acceptance letters for those ‘in press’ and acknowledgement of receipt for articles under review at the time of submission of this thesis. The general introduction and discussion have not been submitted for publication, but contain extracts that are taken from another published peer-reviewed journal article which is also included in Appendix A.

The thesis comprises two parts with Part A describing the psychometric properties of the selected assessment process and opening with one review chapter and concluding with three empirical chapters. Part B investigates the cognitive psychological changes associated with petrol and alcohol abuse and begins with two review chapters followed by four empirical chapters. While Part B addresses both petrol and alcohol abuse, the review articles focus on petrol and other solvent abuse, as the neuropsychological consequences of solvent abuse are relatively poorly understood in any population while they are relatively well established for alcohol. Although submitted to different national and international journals each with different formatting requirements, for the purpose of this thesis, each chapter has been formatted consistently with one reference list presented at the end, as per university

guidelines, in the format specified by the American Psychological Association (6th edition).

As the thesis is presented as a series of individual articles, there is some repetition throughout in terms of background information and methodology. While the same methodological techniques and population were utilized throughout the thesis, the ways in which techniques or inclusion and exclusion criteria were applied varied slightly to address the specific aims of each study. As a result it was considered necessary to include the methods section for each chapter as is required for publication. Short prefaces precede Chapters 2 to 11 that introduce each chapter's relevance to the overall thesis in order to link chapters and improve readability.

Terminology

Although efforts have been made to maintain consistency in presentation, some variation in the terms used could not be avoided. Petrol is just one type of volatile solvent that is inhaled for its intoxicating effects however, the findings from studies on petrol abuse are also relevant to the broader area of volatile solvent abuse.

Therefore in order to appeal to a broader range of readers, some articles used the more generic term ‘volatile solvents’ in place of the more specific term ‘petrol’. In addition, the articles presented in Chapters 7 and 8 were prepared for publication in American journals, and the term ‘gasoline’ was used in place of ‘petrol’ in the submitted versions. However, for consistency, the thesis versions use the term ‘petrol’. The Diagnostic and Statistical Manual of Psychiatric Disorders (DSM-IV) classifies the abuse of volatile solvents as ‘inhalant abuse’, however, as explained in Chapter 6, inhalants can also refer to anaesthetic gases that can have different psychoactive effects and are typically used by a group possessing different characteristics to those who typically use volatile solvents. Therefore the term ‘volatile solvents’ was preferred over ‘inhalants’ throughout this thesis.

In addition, the related terms ‘mental health’, ‘social and emotional wellbeing’ (SEWB), ‘psychiatric’, ‘psychological’ and ‘cognitive’ were all used in this thesis. ‘Mental health’ was used to refer to the broad area of mental functioning including both psychological and cognitive functioning. ‘Psychological’ and ‘social and emotional well-being’ (SEWB) refer more specifically to psychiatric or psychological disorder and mental well-being. The concept of SEWB has been used in Australia to incorporate Indigenous people’s holistic view of health and mental health and these concepts are described in greater detail in Chapter 2. However, the

assessments used in this thesis measure constructs reflective of traditional psychological or psychiatric symptoms, albeit in a culturally appropriate way, therefore the term psychological was generally preferred in reference to the assessment of these symptoms. ‘Cognitive’ on the other hand refers to brain function and incorporates the range of mental processes needed to conduct the activities of daily life.

The term ‘Indigenous’ is used internationally, and in this thesis, to incorporate a wide range of Indigenous groups, which in Australia include both Aboriginal and Torres Strait Islander people. However, it is recognised that there is incredible cultural diversity amongst Indigenous groups, even across Australia, and the term ‘Aboriginal’ can be used to describe a population somewhat more specifically. Therefore, in Part A and the first review chapter of Part B the term ‘Indigenous’ was preferred in order to introduce the issues as they relate to Indigenous people more broadly. Chapters 8, 9, 10 and 11 in Part B all use the term ‘Aboriginal’ however, to more precisely describe the specific group that was assessed. In addition, the colloquial terms ‘Western’ and ‘mainstream’ are used in this thesis in reference to the dominant, English speaking, Anglo-Saxon culture or health care practices of developed nations including Australia, United Kingdom and United States of America.

Finally, this thesis recognises the related but differential meanings of the terms ‘use’, ‘abuse’ and ‘misuse’ as they relate to intoxicating substances. Therefore, all three of these terms are used throughout this thesis with ‘use’ referring to the general consumption of an intoxicating substance, ‘misuse’ referring to hazardous or harmful

use of an intoxicating substance (without clinical diagnosis) and ‘abuse’ referring to the clinical diagnosis of a maladaptive pattern of harmful use based on established diagnostic criteria.

Thesis Abstract

The current research aimed to assess and monitor the incidence and recovery of cognitive and psychological changes associated with the abuse of petrol and alcohol among Indigenous Australians. Study participants included 224 Indigenous Australians recruited from educational or rehabilitation facilities in the Northern Territory, who were classified as petrol or alcohol abusers or healthy controls on the basis of detailed substance use histories. Baseline cognitive and psychological assessments were completed on admission to rehabilitation, and then fortnightly for the duration of treatment. Community follow up assessments were also conducted approximately one year after treatment. The cultural and psychometric validity of the selected assessments were first established by evaluating test-retest reliability, practice effects, and any demographic factors that impact on test performance for this group. Impairments were then identified for each of the petrol and alcohol groups across the study timeframe using cross sectional and longitudinal comparisons with matched control groups. At baseline, petrol sniffers aged 11-25 years with an average of five years chronic use demonstrated impairments on tasks of visual motor, attention, memory, learning and executive functions. Importantly, the majority of these impairments normalised within two months of abstinence by the end of treatment, however speed deficits on visual motor, memory and executive function tasks persisted after 12 months. Similarly, impairments in visual motor, attention, memory, learning and executive functions were observed among both chronic and episodic alcohol users aged 18-60 years with an average of 16 years use. Most resolved within four weeks of abstinence, although visual motor deficits recovered within 11 months. The impairment and recovery profiles of both chronic and episodic users were similar, suggesting that episodic alcohol use may be as damaging

as chronic use. Cognitive deficits, psychological symptoms and continued petrol and alcohol availability were key factors that led to their continued abuse following treatment discharge.

Chapter 1

General Introduction

1.1 SUBSTANCE ABUSE AMONG INDIGENOUS AUSTRALIANS

Many Indigenous people experience unacceptable levels of disadvantage in living standards, life expectancy, education, employment and physical and mental health, which are all potential risk factors for substance abuse (Commonwealth of Australia, 2009). Coupled with a history of marginalisation, cultural oppression, dispossession, dislocation, and forced removal of children, it is unsurprising that Indigenous groups appear disproportionately affected by the health and social impacts of substance abuse compared to other Australians (Gracey, 1998). The dislocation experienced by Indigenous people post colonisation disrupted traditional connections with family, community, land and culture, which are central to Indigenous spirituality and sense of wellbeing (Grieves, 2009). For this population, disruption or disintegration of these interconnections typically leads to physical and mental ill health (Reser, 1991). While social and psychological factors may also contribute to the incidence of substance abuse, harmful levels of substance abuse can in turn prompt social discord that emerges as interpersonal violence and homicide, child abuse and neglect, suicide and self inflicted harm (Begg et al., 2003). Consequently substance abuse is both a product of and a contributor to the social, psychological and political status of Indigenous Australians (Burdekin, 1993).

While few non-Indigenous Australians (39%) live outside of major cities, 69% of Indigenous Australians live in regional (43%) or remote (26%) regions (Australian Bureau of Statistics, 2006c). In the Northern Territory (NT), 79% of the Indigenous population lives in remote or very remote Indigenous communities (Australian Bureau of Statistics, 2006c). These communities are made up of small numbers of

Indigenous family groups and can often be accessed only via four wheel drive or light aircraft, so appropriate health and other services can be difficult to access (Australian Bureau of Statistics, 2006c; Cairney & Maruff, 2007a). Basic resources are often lacking, with a recent report suggesting that 2% of Indigenous communities had no organised water supply, 7% had no organised sewerage system and 13% were located 100 kilometres or more from the nearest primary school (Australian Bureau of Statistics, 2002). The Indigenous people living in rural and remote regions often live semi-traditional lifestyles and may have had little contact with Western or mainstream systems. Thus, for these Indigenous people, education, employment, housing and recreational opportunities can be limited, poverty can be high, and overcrowding can be common (Commonwealth of Australia, 2009).

Access to typical drugs of abuse can be restricted in remote regions due to geographical or social policy constraints. In this unique context, the specific substances and styles of use can differ from those practiced more widely in Australia (Clough, Guyula, Yunupingu, & Burns, 2002; Gray & Chikritzhs, 2000). Substances such as petrol (i.e., 'petrol sniffing') or the traditional plant beverage 'kava' that is imported from the Pacific islands, are used recreationally in some remote Indigenous communities for their intoxicating effects (Brady, 1992; Clough, Burns, & Mununggurr, 2000). However, in urban centres these practices are virtually unknown. Even when common substances such as alcohol or cannabis are used, the ways in which they are used can differ between populations or regions. Among some remote Indigenous groups alcohol use is described as heavy and episodic, reflecting the varying availability of alcohol and finances, particularly among communities with restricted access to alcohol (Cairney, Clough, Jaragba, & Maruff,

2007). Despite widely imposed alcohol restrictions, the rates of alcohol consumption among Indigenous people in the NT are almost double the national average (Gray & Chikritzhs, 2000). Although many Indigenous Australians abstain from alcohol use, those that do drink usually do so at hazardous levels and in fact, alcohol is the leading risk factor for mental disorders and injury for this group (Australian Bureau of Statistics, 2006a; Vos, Barker, Stanley, & Lopez, 2007). A similar polarisation of cannabis use has been observed among remote Indigenous groups where individuals either use cannabis heavily or not at all, with very little moderate use (Lee, Conigrave, Clough, et al. 2009). A recent report suggested 90% of cannabis users consumed greater than six cones daily, an amount around twice that of regular users elsewhere in Australia (Lee et al., 2009; Lee, Conigrave, Patton, & Clough, 2009). Furthermore, around 50% of Indigenous Australians smoke tobacco with prevalence rates over twice that of the non-Indigenous population (Australian Bureau of Statistics, 2007).

While there is ongoing concern around the use of each of these substances in Indigenous communities, alcohol and petrol abuse have the most profound effects on the central nervous system (CNS) (Cairney, et al., 2007; Cairney, Maruff, Burns, & Currie, 2002). Studies to date suggest that cognitive impairments in petrol or alcohol abusers may precede more serious neurological changes involving frontostriatal and cerebellar brain circuitry (Cairney, et al., 2007; Cairney, et al., 2002; Cairney, Maruff, Burns, Currie, & Currie, 2004a, 2004c, 2005; Maruff, Burns, Tyler, Currie, & Currie, 1998; Yucel, Lubman, Solowij, & Brewer, 2007). These substance induced brain changes indicated by deficits in inhibitory control, decision making and affect regulation, may contribute to the self-sustaining nature of substance

dependence (Rosenbloom & Pfefferbaum, 2008; Yucel, et al., 2007). A clear understanding of cognitive and psychological status, especially on admission to treatment, is therefore pertinent to achieving the best possible rehabilitation outcomes. Previous research indicates that individuals with more severe cognitive impairments are more likely to drop out of treatment programs and the course and prognosis for coexisting substance use and psychological disorders can be more chronic than for either disorder alone (Kessler et al., 1996; Teichner, Horner, Roitzsch, Herron, & Thevos, 2002). Adequate neuropsychological evaluation is therefore necessary to inform the development of appropriate case management, or treatment approaches (Takagi, Lubman, & Yucel, 2007).

1.2 MEASURING COGNITIVE AND PSYCHOLOGICAL FUNCTION AMONG INDIGENOUS AUSTRALIANS

The health of the brain can be understood in terms of how well it functions. Cognitive and psychological assessments provide objective indicators of the CNS and psychological impacts of substance abuse and other disease states (Cairney & Maruff, 2007a). In research studies, these assessments are used to improve understanding regarding the factors that alter normal brain function and behaviour. In settings where individuals require healthy or improved cognitive function to progress, learn, heal or rehabilitate, such as education, employment, prison or substance use rehabilitation, cognitive and psychological assessments can be used to detect abnormalities with respect to healthy standards. In these settings, individual outcomes may be improved by tailoring programs to accommodate any identified impairments (Dingwall & Cairney, 2009; Takagi, et al., 2007). Serial or repeated

assessments also enable the measurement of changes in brain function and behaviour over time and can be useful to detect disease progression or monitor recovery objectively following treatment (Straume-Naesheim, Andersen, & Bahr, 2005).

While specific associations between substance abuse, cognitive and psychological functions are increasingly recognised, these relationships are poorly defined, particularly among Indigenous Australians (Clough et al., 2005; Clough et al., 2006; Yucel, et al., 2007). Improved understanding of these relationships would aid the development of appropriate and responsive prevention and intervention strategies for substance abuse (Takagi, et al., 2007). A major obstacle has been the lack of culturally appropriate tools for measuring cognitive and psychological function in this group (Dingwall & Cairney, 2010b). Mainstream tests that are commonly used in Australia, even inappropriately amongst Indigenous Australians, are based on English literacy and numeracy and Western conceptual frameworks. For many Indigenous people living in remote regions, English is a second or third language at best, and rates of formal education can be low (LoGiudice et al., 2006). Indigenous concepts of numbers, time and place can also differ profoundly from the mainstream views (Department of Education and Children's Services, 1995; Janca & Bullen, 2003). Detecting cognitive and psychological impairments reliably among Indigenous Australians can therefore prove difficult as mainstream tests based on Western conceptual frameworks, language and norms may be irrelevant and even incomprehensible, often leading to misdiagnosis among non-Western populations (Ardila, 1996). The literature review presented in Chapter 2 describes these issues in greater detail and reviews the few assessments that have been examined for their validity in assessing Indigenous Australians.

A recent review of the Australian Government's Aboriginal and Torres Strait Islander Primary Health Care Program (Gray, Sagers, Atkinson, & Stempel, 2004), recommended that "programs to address substance misuse related harms should be based within primary health care services" (p.p. *ix*), and "early intervention should be a major focus" (p.p. *x*). The development of brief cognitive and psychological assessments that are culturally appropriate and can be used and interpreted within a primary care setting is therefore pertinent to furthering our understanding of substance abuse related harms, and responding appropriately to individual health needs.

In response to the above issues, and in light of the literature review presented in Chapter 2, the cognitive assessment CogState and the psychological assessment Strong Souls were considered the most appropriate tools for use in this thesis. CogState is a computerised cognitive assessment that uses non-verbal stimuli to assess a range of cognitive functions in a short period of time and was developed specifically for use with Indigenous people (Cairney & Maruff, 2007a). Its portability, brevity, and ability to assess a range of functions in a short period of time also make it ideal for use in primary care settings. Strong Souls is a psychological assessment that was also developed specifically for use with Indigenous people in the NT (Thomas, Cairney, Gunthorpe, Paradies, & Sayers, 2010). However, as the main aim of this thesis was to monitor and understand cognition, and given the intended use within primary care settings, it was not considered necessary to include a comprehensive psychological assessment. Therefore an abbreviated version of Strong Souls was adopted for use in this research, and this is described in greater detail in Chapter 5.

With the development of appropriate screening procedures, service provision and health outcomes for Indigenous Australians may be significantly improved. For example, a better understanding of the aetiology, presentation, and treatment of cognitive and psychological problems for Indigenous people could be gained through the systematic collection of epidemiological data made possible by the availability of appropriate screening tools. The accurate identification of cognitive disability could positively impact police practices, court proceedings and sentencing options through improved support across the judicial process and recognition of impairment as a mitigating factor in sentencing (Simpson & Sotiri, 2004). For treatment providers, cognitive assessment is also an important tool to inform clients about the severity of their substance abuse, the importance of treatment and to monitor their recovery (Takagi, et al., 2007).

1.3 MONITORING RECOVERY FOLLOWING PETROL AND ALCOHOL ABUSE

In order to improve prevention and treatment strategies for petrol and alcohol users, a thorough understanding of the complex CNS and psychological impacts of these substances is required. Recent research has demonstrated that a progressive decline in cognitive and neurological function that is directly related to the severity and duration of abuse is associated with chronic leaded petrol abuse, and some of these deficits are at least partially recoverable with abstinence (Cairney, et al., 2004a, 2004c, 2005; Maruff, et al., 1998). While recovery was demonstrated within two years of abstinence in these studies, the specific time course for cognitive recovery immediately following cessation of abuse still remains to be determined. Similarly,

among chronic alcohol users, impairments in psychomotor, attention, visuo-spatial, learning, memory and executive functions have been observed, with subsequent recovery following abstinence (Brandt, Butters, Ryan, & Bayog, 1983; Eckardt, Stapleton, Rawlings, Davis, & Grodin, 1995; Fein, Bachman, Fisher, & Davenport, 1990; Fein, Torres, Price, & Di Sclafani, 2006; Goldman, Williams, & Klisz, 1983). However, little research has examined the cognitive and psychological impacts of alcohol abuse for Indigenous Australians, and among both Indigenous and non-Indigenous populations, the cognitive impacts of episodic alcohol use (i.e. binge drinking) have not been thoroughly investigated. The impairment and timeline for recovery associated with heavy episodic alcohol use and the implications of chronic use among Indigenous Australians therefore remain unclear.

Knowledge of the specific timeline for cognitive recovery could help inform the design of more appropriate petrol rehabilitation programs, which often rely on cognitive abilities including memory, attention and complex cognition to achieve treatment outcomes (M. E. Bates, Bowden, & Barry, 2002; Fals-Stewart, Schafer, Lucente, Rustine, & Brown, 1994). If the course of recovery is clearly defined, treatment providers can delay introduction of complex material until cognitive function has improved. Rigorous evaluation of treatment outcomes may also be strengthened substantially by inclusion of the robust objective indicators provided by cognitive and psychological assessment.

In addition, among Indigenous petrol and alcohol users in treatment, concomitant cannabis use can be high (Dingwall & Cairney, 2010a). While few studies have examined the differential psychological effects of psychoactive substances for

Indigenous Australians, limited research indicates significant associations between cannabis use and psychological symptoms that may interact with other substance (i.e. petrol or alcohol) use (Clough, et al., 2005; Clough, et al., 2006). While the potential for worse outcomes among substance users with comorbid psychological disorders has been recognised, the impact of psychological symptoms on treatment and recovery for Indigenous users has not yet been investigated (Kessler, et al., 1996). Therefore to establish a sound scientific basis for treatment programs, the relationships between cognitive and psychological impairment, recovery and treatment outcomes must be clearly defined. With improved understanding of the potential outcomes for Indigenous substance users, governmental or treatment responses can be targeted appropriately, with anticipated improvements in treatment response and subsequent health outcomes.

1.4 SUMMARY

Substance abuse and its related harms currently devastate many Indigenous communities; however the relationship between cognition, psychological status and substance abuse remains unclear for this population. This situation is compounded by the complexities associated with measuring cognitive and psychological function cross culturally. Defining the relationships between substance abuse, cognitive and psychological function, recovery and treatment outcomes is necessary to improve service provision and health outcomes for this disadvantaged population. This thesis therefore responds to two specific contextual issues: (1) a lack of culturally appropriate assessments to measure cognitive and psychological impairment among Indigenous Australians and (2) a poor understanding of the nature of cognitive

recovery following petrol and alcohol abuse. The thesis is therefore presented in two parts to meet the following aims. The first is to establish an assessment process to measure cognitive and psychological function that is effective and accessible for use by primary care workers in an Indigenous health context (Part A). The second aim is to monitor the nature of impairment and subsequent recovery of cognitive function following petrol and alcohol abuse while considering the impact of psychological factors on the rehabilitation process (Part B).

Part A: Cognitive and Psychological Assessment of Indigenous Australians

Chapter 2

Psychological and Cognitive Assessment of Indigenous Australians

Preface

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This review chapter introduces the health and mental health status of Indigenous Australians while describing the complexity of issues underlying inadequate related health care for this population. An issue pertinent to this thesis is the scarcity of cognitive and psychological assessments that are relevant for Indigenous Australians. The limitations of applying mainstream assessment tools for use in this group are specifically explored. While very few assessments have been developed specifically for use with Indigenous Australians, the few that have been utilised are reviewed and evaluated. The studies reviewed here largely represent initial validations indicating that this is indeed a novel and emerging field of research and clinical practice. This review of the literature therefore identifies areas for future development of more appropriate psychological and cognitive assessments that may lead to improved service provision for Indigenous Australians.

Psychological and Cognitive Assessment of Indigenous Australians

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ABSTRACT

Objective: The aim of this review is to evaluate the psychological and cognitive assessments that have been considered suitable for Indigenous Australians. This will provide a basis from which future developments can occur, leading to improved mental health services for Indigenous Australians. **Method:** Literature searches of key health science databases were conducted using the following search terms in various combinations: Indigenous, Aboriginal, cognitive, assessment, mental health, social emotional wellbeing, psychological, Australian. Psychological, mental health or social and emotional wellbeing assessments as well as cognitive assessments that have been utilised and found suitable in Indigenous Australian populations were reviewed. **Results:** A limited number of assessments were found and discussed and these varied in their applications. **Conclusions:** Further research and development is necessary to establish a national approach to assessing or screening psychological and cognitive function among Indigenous Australians. This is an important and necessary step to improve mental health and related services for Indigenous Australians.

Keywords: cognitive, psychological, mental health, assessment, Indigenous

2.1 INTRODUCTION

Historical and sociocultural factors have contributed to comparably poorer health and mental health for Indigenous Australians compared to non-Indigenous Australians. This situation is further complicated by differing definitions, manifestations, and conceptualizations of health and mental health among Indigenous Australians that are poorly understood by the wider community. As a result, health and mental health care services for Indigenous people are often highly inappropriate and severely inadequate (Burdekin, 1993; Swan & Raphael, 1995). Although the inadequacy of mainstream service provision and assessment techniques for Indigenous Australians has been recognised for a number of years, little practical development has occurred (Davidson, 1995).

This review will introduce the health and mental health status of Indigenous Australians while outlining some of the issues leading to inadequate mental health care for this population. ‘Indigenous Australians’ as used in this review refers to both Aboriginal and Torres Strait Islanders. The term ‘non-Indigenous Australians’ refers to members of the Australian population who are not Aboriginal or Torres Strait Islander and who typically align with the dominant Anglo-Saxon or Westernised culture of Australia. As used in this review, the term ‘mental health’ will refer to both psychological and cognitive functioning. ‘Psychological’ and ‘social and emotional well-being’ (SEWB) is used interchangeably and includes both psychiatric or psychological disorder and mental well-being. ‘Cognitive’ incorporates the range of brain or mental processes needed to conduct the activities of daily life. The review will also summarise the limitations of applying mainstream

psychological and cognitive assessments to Indigenous Australians. Finally both the psychological and cognitive assessments that have been considered appropriate for use with Indigenous Australians will be reviewed and evaluated. This will lay a foundation for an appropriate evidence based framework from which future developments can lead to improved mental health services for Indigenous Australians.

2.2 HEALTH STATUS OF INDIGENOUS AUSTRALIANS

Indigenous Australians' experience of poor mental and physical health has been well documented (Australian Bureau of Statistics, 2004, 2006a, 2008; Burdekin, 1993; Swan & Raphael, 1995; Zubrick et al., 2005). According to recent reports, the life expectancy of Indigenous Australians is reduced by around 17 years compared to non-Indigenous Australians and death rates are almost threefold higher (Australian Bureau of Statistics, 2008). Indigenous babies are twice as likely to be low birthweight (< 2500g) and more likely to be hospitalised compared to non-Indigenous babies (Australian Bureau of Statistics, 2008). Low birthweight is associated with a greater risk of poor health, disability and death (Australian Bureau of Statistics, 2008). Indigenous Australians are also more likely to experience a chronic disease such as diabetes (threefold more likely), cardiovascular disease (1.3-fold more likely), respiratory disease (1.6-fold more likely to report asthma) or kidney disease (10-fold more likely) compared to non-Indigenous Australians (age-standardised) (Australian Bureau of Statistics, 2006a).

Physical ill health is strongly associated with mental ill health (Australian Institute of Health and Welfare, 2009; Swan & Raphael, 1995). Cawte (1988) has described an 'Aboriginal depression' known as 'ill-health depression' which is depression arising from high levels of ill health and disease. While comprehensive epidemiological data on mental illness in the Indigenous population are limited, recent reports suggest that 27% of Indigenous adults report high to very high levels of psychological distress; more than twice the rate for non-Indigenous Australians (Australian Bureau of Statistics, 2006a). Indigenous Australians are hospitalised for self harm at more than twice the rate of other Australians and for Indigenous males it is almost threefold the national rate (Australian Institute of Health and Welfare, 2009).

In a report on the burden of disease and injury for Indigenous Australians, mental health disorders were ranked second only to cardiovascular disease (Vos, et al., 2007). Anxiety and depression, alcohol dependence and harmful use, and schizophrenia contributed > 75% to this total mental health burden (Vos, et al., 2007). Despite little investigation into cognitive problems in this population, rates are likely to be relatively high with widespread exposure to known risk factors including substance abuse, violence, head trauma, malnutrition, chronic illness and foetal alcohol syndrome (Australian Bureau of Statistics, 2006a, 2008; Marsh, Inglis, Smith, & LoGiudice, 2007; Pollitt, 1997). The prevalence of dementia in Indigenous Australians aged > 45 years from the Kimberley region has been reported at 12.4%; more than fivefold higher than the 2.4% reported among the same age group in the general Australian population (Smith et al., 2008).

2.3 INDIGENOUS AUSTRALIANS AND MENTAL HEALTH

Sociocultural factors play an important role in the experience and expression of mental health and illness. Culturally, Indigenous Australians view life, including health, holistically where wellbeing is understood in terms of the harmonised inter-relationships between spiritual, environmental, ideological, political, social, economic, mental and physical domains (Swan & Raphael, 1995). Such holistic notions of health have led to the recognition and establishment of a national Indigenous SEWB health framework (Kowal, Gunthorpe, & Bailie, 2007; Zubrick, et al., 2005). For Indigenous Australians, a concept of self encompasses the individual, together with their family, the wider tribal group and the land, and involves a complex set of relational bonds and reciprocal obligations; loss or disintegration of which will lead to mental ill health (Reser, 1991; Swan & Raphael, 1995). Since colonisation in Australia, these traditional connections have been severely disrupted by cultural genocide, dislocation, forced removal of children, destruction of culture as well as a devastating denial of basic human rights (Burdekin, 1993). The consequence is an overwhelming sense of trauma, loss and grief for Indigenous Australians that is often not recognised or adequately addressed, and is perpetuated by their continued social, political and economic disadvantage (Burdekin, 1993).

Two dimensions of mental ill health have been described for Indigenous Australians. One is the ‘mental distress’ or ‘deep psychological malaise’ resulting from their collective experience as dispossessed and disadvantaged people (Burdekin, 1993; Reser, 1991). The other incorporates the range of serious psychiatric or mental disorders that are also prevalent within the Indigenous population but which may

manifest or be understood quite differently (Burdekin, 1993; Reser, 1991). For Indigenous Australians, mind, body and spirit are inextricably linked and illness can be perceived as a normal reaction to spiritual forces or a curse (Burdekin, 1993). Such concepts may be foreign to non-Indigenous people including health practitioners (Spencer, 1983).

The differential meaning and experiences of mental health problems for Indigenous Australians compared to non-Indigenous Australians mean that distinct methods for their assessment and management are required. Despite the disproportionate levels of mental health problems in Indigenous populations, there remains a scarcity of culturally appropriate, objective and scientifically validated mental health assessment tools for use with Indigenous Australians (Kowal, et al., 2007). Objective assessments enable valid measurement of psychological or cognitive changes and the detection of abnormalities with respect to healthy standards (Dingwall & Cairney, 2009). Without objective and scientific measures, clinical practice is dependent on the subjective skills and opinions of clinicians. The ability, however, of clinicians to accurately estimate mental functioning without the use of objective assessments can be poor (Fals-Stewart, 1997). Objective assessments can be used to detect abnormalities in settings in which psychological or cognitive impairments can affect an individual's ability to progress, learn, heal or rehabilitate such as in schools, employment, primary health care, prisons and drug rehabilitation programmes (Dingwall & Cairney, 2009). In these settings Indigenous Australians may be assessed by non-experts, or non-Indigenous people who may have poor understanding of the unique psychological problems of Indigenous Australians. Consequently, the nature and extent of mental health problems can remain

unrecognised, undiagnosed and untreated (Burdekin, 1993). Inability to appropriately measure psychological and cognitive function for Indigenous Australians is a fundamental hurdle that prevents any progress that may lead to the improvement of mental health services for this currently disadvantaged population.

2.4 LIMITATIONS OF TRADITIONAL ASSESSMENTS IN INDIGENOUS POPULATIONS

Cognitive and SEWB assessments can contribute to the misdiagnosis of impairment or mental illness if they are based on foreign concepts and/or symptomatology.

Definitions of what constitutes normal (or abnormal) expressions of behaviour can vary considerably between cultures and even within cultures (Ardila, 1996). In non-Indigenous cultures it may be perfectly normal for a man to speak the name of a deceased relative or to talk to his mother in law, but in Indigenous Australian cultures such behaviours may be considered mad because they violate strict cultural rules and norms (Dunlop, 1988; Pollitt, 1997; T. Westerman, 1998). Psychiatric disorders may also be expressed through different symptomatology. For example, anger may represent a culturally-specific symptom of depression for Indigenous Australians (Esler, Johnston, Thomas, & Davis, 2008; Thomas, et al., 2010; T. Westerman, 2002).

Context and experience dictates what is and what is not important or relevant for a particular culture and thus what abilities are valued and trained (Ardila, 1996; J. G. Harris, Echemendia, Ardila, & Rosselli, 2001). For non-Indigenous cultures, a small child might be considered intelligent if they can say a large number of words or

count to ten, however, an Indigenous child from a particular desert community might instead be expected to know directions, space and place or demonstrate independence to be considered intelligent (Department of Education and Children's Services, 1995; Kearins, 1988). Tests of verbal memory, such as list learning, may therefore be irrelevant to Indigenous people's lives and thus result in inferior performance when compared to non-Indigenous groups. However, on spatial memory tests or relevant verbal assessments that are based on skills nurtured by their specific culture, Indigenous people may demonstrate greater abilities than non-Indigenous people (Kearins, 1976, 1978, 1981, 1982, 1986). Despite these differences, psychological tests generally rely on questions and answers for which the standard response is obtained from the general population (Burdekin, 1993). Test interpretation for Indigenous Australians may therefore be extremely problematic because current Indigenous norms are rarely available (Australian Psychological Society, 1996).

Traditional tests of mental functioning can rely heavily on the use of the English language, require written responses and resemble formal educational processes. Poor English literacy, a lack of formal education, as well as differing concepts of numbers, time and space can mean that Indigenous Australians may have limited experience with the knowledge base from which such tests are derived (Drew, 2000; Janca & Bullen, 2003; Kearins, 1988; LoGiudice, et al., 2006; Pollitt, 1997; T. Westerman, 2004; Wettinger, 1997). Administration of pencil-and-paper tests can be inappropriate for a culture that has no traditional written language and in which rates of English illiteracy can be high. Additionally, the common one-on-one approach used by many psychological tests can be both uncommon and objectionable to

Indigenous Australians who may reject direct approaches between strangers and can consider it rude to ask numerous questions (Kearins, 1988; Wettinger, 1997).

Indigenous people might also find it inappropriate to talk to strangers about their innermost thoughts and feelings, which is a requirement of many mental health assessments (LoGiudice, et al., 2006). An appropriate assessment must therefore meet two often conflicting prerequisites: it must be both scientifically and biomedically valid, and it must have relevance culturally for the target group.

2.5 APPROACHES FOR ASSESSING MENTAL HEALTH AND COGNITION IN INDIGENOUS AUSTRALIANS

A literature search of key health science databases, (including, but not limited to: PsychINFO, PsychARTICLES, Medline, PubMed, Academic Search Premier (EBSCO), Science Direct, JSTOR, SpringerLink) was conducted using the following search terms in various combinations: Indigenous, Aboriginal, cognitive, assessment, mental health, social emotional wellbeing, psychological, Australian. Tests and techniques applied in assessing mental health for Indigenous Australians are summarised in Table 1 and discussed in the following sections.

Table 1. Approaches to Assessing Cognitive Function and Mental Health in Indigenous Australians

Assessment	Sample	Applications	Reference
<u>Psychological and SEWB assessments</u>			
▪ Sheldon's Interview techniques	Not empirically validated	Clinical assessment – for use in clinical settings	(Sheldon, 2001)
▪ Westerman Aboriginal Symptom Checklist – Youth (WASC-Y)	N = 183 urban and remote Indigenous youth (aged 13-17)	Measures self reported risk for depression, anxiety, suicide alcohol/drug use, impulsivity and resilience – for use in research and clinical settings	(T. Westerman, 2002, 2003)
▪ Strong Souls	N = 361 urban and remote Indigenous youth (aged 16-19)	Self report measure of depression, anxiety, suicide risk and resilience – for use in research and clinical settings	(Thomas, et al., 2010)
▪ Strengths and Difficulties Questionnaire (SDQ)	N = 3993 urban and remote Indigenous children (aged 4-17)	Measure of psychological adjustment using external raters – used in Population health surveys	(De Maio et al., 2005; Zubrick, et al., 2005)
▪ Kessler Psychological Distress Scale -10 (K-10)	N = 5,757 urban and remote Indigenous adults (>18 years)	Self reported SEWB – used in population health surveys	(Australian Bureau of Statistics, 2006a; NSW Department of Health, 2001; South Australia Department of Health Population Research and Outcome Studies Unit, 2006)
▪ Negative Life Events Scale (NLES)	N = 635 remote Indigenous adults	Self reported experience of stress – used in population health surveys	(Australian Bureau of Statistics, 2004, 2006a; Kowal, et al., 2007)
▪ Patient Health Questionnaire (PHQ-9)	N = 34 urban and remote Indigenous adults	Self report depression screen – for use in research and clinical settings	(Esler, Johnston, & Thomas, 2007; Esler, et al., 2008)

Assessment	Sample	Applications	Reference
<u>Cognitive assessments</u>			
▪ Kearins' Visual Spatial memory test	N ≥ 88 European & Indigenous children (aged 7.5 -16) per study	Research	(Kearins, 1976, 1978, 1981, 1982, 1986)
▪ The Queensland Test (The Q Test)	N >1500 European, Papuan and low, medium, and high contact Indigenous children and adults	General cognitive capacity, intelligence or trainability of subjects	(Kearney, 1966; McElwain & Kearney, 1970)
▪ Kimberley Indigenous Cognitive Assessment tool (KICA)	N = 70 older rural/ remote Indigenous adults in the Kimberley region N = 52 older rural/ remote Indigenous Adults (aged >45 years) in the NT.	Assessment of dementia in geriatric populations	(LoGiudice, et al., 2006; Marsh, et al., 2007; Smith et al., 2007)
▪ Cambridge Neuropsychological Automated Test Battery (CANTAB)	N = 21 to 112 Indigenous adolescents/adults per study	Range of applications	(Cairney, Clough, et al., 2003; Cairney, et al., 2004a, 2004c, 2005; Cairney, Maruff, et al., 2003; Maruff, et al., 1998; Maruff et al., 1996)
▪ CogState	N = 40 to 404 urban and remote Indigenous children and adults per study	Range of applications including repeated assessment	(Cairney, et al., 2007; Dingwall, Lewis, Maruff, & Cairney, 2009; Lewis, Dingwall, Sawyers, Berkhout, & Cairney, 2010)

2.5.1 Psychological and Social and Emotional Wellbeing (SEWB) Assessments

2.5.1.1 Clinical Psychiatric Assessment

While the clinical interview is currently considered the most appropriate way of assessing psychological problems among Indigenous Australians, it can be time consuming and cultural and language factors may still hinder appropriate assessment (Kowal, et al., 2007). Guidelines have been developed for the psychiatric assessment of Indigenous patients in remote settings (Sheldon, 2001). These include a detailed description of how to act as a psychiatrist in remote communities, along with non-validated questions for assessing mental health of Indigenous Australians (Sheldon, 2001). Because the process of assessment can be as important as the content, these guidelines provide valuable guidance to assist mental health practitioners to adapt standard clinical interviews to assess Indigenous patients, including cultural protocols and communication strategies (Sheldon, 2001). Although this approach is useful clinically, it does not represent a distinct tool that can be assessed for its validity and reliability and used to research or screen for psychological dysfunction in this population. This approach therefore requires further empirical evaluation to meet the requirements for evidence based practice.

2.5.1.2 Youth Psychological/SEWB Assessments

A promising development has been the construction of an SEWB inventory that reflects Indigenous expressions of mental health problems (T. Westerman, 2002, 2003). The Westerman Aboriginal Symptom Checklist for Youth (WASC-Y)

incorporates 53 self report items measuring six constructs (depression, suicide, alcohol/drug use, impulsivity, anxiety, and cultural resilience) and includes a set of clinician guidelines for its application. The clinician guidelines include methods for culturally valid engagement of Indigenous youth, interpretation of youth symptoms within the culture, a model of cultural validation that assesses the role of culture in mental health symptoms and a model for the resolution of such culturally related mental health problems (T. Westerman, 2003).

The reliability and validity of the WASC-Y were assessed in a sample of 183 Indigenous people aged 13–17 years from either the Perth metropolitan region or the northwest region of Western Australia including Port Hedland, Wickham, Karratha and Roebourne. Initial validation of the WASC-Y involved conducting separate exploratory factor analyses on each of the subscales individually rather than on all items collectively (T. Westerman, 2002). It is therefore unclear whether the items purporting to measure each of the constructs do actually cluster together.

Nevertheless each of the scales demonstrated good internal consistency (Cronbach α = 0.78, 0.88, 0.78, 0.67, 0.84, and 0.75 for the Depression, Suicide, Alcohol/drug use, Impulsivity, Anxiety, and Cultural Resilience subscales respectively). Further validation involved comparing the WASC-Y to clinical interview, resulting in kappas from 0.75 to 0.84, which represented good to excellent agreement between WASC-Y score and clinical interview for each of the scales (T. Westerman, 2002). Potential unintentional bias may have been introduced however, with the clinical interviews conducted by the main researcher, who was not blind to outcomes generated by the WASC-Y. Further validation in a larger sample and in other regions of Australia is therefore warranted before its appropriateness for broader applications can be

established (T. Westerman, 2002, 2003). Nevertheless, with its clinician guidelines, the WASC-Y provides a comprehensive assessment process for use with Indigenous Australians. The content is familiar and applicable to Indigenous expressions of psychological problems and its adaptation for use with other Indigenous populations (e.g. Inuit people) has also been considered (Tagalik & Joyce, 2006).

Strong Souls is a screening tool that was developed in the Northern Territory to assess SEWB in Indigenous youth enrolled since birth in an extensive life course study of chronic health outcomes (Aboriginal Birth Cohort; ABC study) (Sayers et al., 2003; Thomas, et al., 2010). Using plain English, Strong Souls consists of 25 items measuring four aspects of SEWB: anxiety, resilience, depression and suicide risk. While Strong Souls measures similar constructs to the WASC-Y, it is shorter and has demonstrated better discriminative ability (with its four item response scale) in combination with good face validity and strong reliability when pilot tested alongside the WASC-Y and the abridged version of the Kessler Psychological Distress Scale (K6+) (Thomas, et al., 2010).

An initial validation study assessed the psychometric properties of Strong Souls in a sample of 361 Indigenous young people, aged 16–19 years, from > 70 urban, rural and remote communities across the Northern Territory. The sample therefore represented significant cultural and linguistic diversity. Principal components and exploratory factor analyses were conducted using all items, and a four factor solution was identified. This solution was consistent with the constructs of interest: anxiety (eigenvalue = 4.96; % variance = 17.5), resilience (eigenvalue = 2.67; % variance = 7.8), depression (eigenvalue = 1.96; % variance = 5.34) and suicide risk (eigenvalue

= 1.49; % variance = 3.87). The tool demonstrated good internal consistency, with Cronbach alphas of 0.80, 0.71, 0.71 and 0.73 for the anxiety, resilience, depression and suicide risk subscales, respectively. Each of the subscales correlated with each other, demonstrating good convergent validity. Stable and consistent replication of identified factors was demonstrated when different extraction models were used in factor analyses. Construct validity was further demonstrated through the consistency of the derived factors with constructs identified as prevalent SEWB issues for Indigenous Australians (Thomas, et al., 2010).

The authors concluded that Strong Souls is valid, reliable, and appropriate for screening Indigenous young people in the Northern Territory, although replication of the findings in other regions and further clinical validation is warranted (Thomas, et al., 2010). While the WASC-Y and Strong Souls may turn out to be important tools for cross-cultural evaluations of SEWB, both have been validated only for Indigenous youth. Other limitations include their design for pencil-and-paper administration and their high reliance on language. These limitations are, however, difficult to avoid in assessing mental and emotional status and oral administration of both tools is possible.

National surveys have also recognised the relative lack of appropriate assessment tools for nationwide epidemiological data collection regarding the mental health of Indigenous Australians (Australian Bureau of Statistics, 2004, 2006a, 2008; Kowal, et al., 2007; Zubrick, et al., 2005). Some have therefore adapted mainstream tools for use with Indigenous populations. The Western Australian Aboriginal Child Health Survey (WAACHS) used an adapted version of the Strengths and Difficulties

Questionnaire (SDQ) to assess the SEWB of 3993 Aboriginal Australian children aged 4–17 years, in addition to asking some other more general questions about the child's SEWB (Zubrick, et al., 2005). The SDQ uses external raters (parent, carer or teacher) to investigate whether the child has displayed any of 25 distinct behaviours indicative of five areas of psychological adjustment: emotional symptoms, conduct problems, hyperactivity, peer problems and prosocial behaviour (De Maio, et al., 2005). Pilot testing showed that modifications in both wording and the response scale were needed for it to be better understood by the Indigenous participants (De Maio, et al., 2005). In clinical settings the SDQ can be used in conjunction with other techniques to identify and diagnose psychological problems because it specifies normal, borderline and abnormal ranges of scores. The WAACHS, however, did not involve comprehensive clinical assessments, so the SDQ was used to assess risk for clinically significant emotional or behavioural difficulties (De Maio, et al., 2005).

The adapted version of the SDQ was assessed for its validity and reliability. This process found that the reliability and consistency of the measure is of a high standard (Zubrick, Lawrence, De Maio, & Biddle, 2006). Four of the five subscales provided good reliabilities (reliability coefficients = 0.77–0.81) with the peer problems scale proving the least reliable (0.60). The overall scale reliability was exceptional (0.93) and the data showed adequate congruence with those reported by the creator of the scale. However, the internal reliability of the five subscales (and to a lesser degree the overall scale) declined slightly as level of relative isolation increased. This may reflect differences with interview procedures, because those living more remotely were more likely to require simultaneous translation to an Indigenous language during the interview. Alternatively, some concepts may have been less salient to

remote cultural and living circumstances (Zubrick, et al., 2006). The adapted SDQ scale represents a promising measure for the assessment of mental health and wellbeing in Indigenous children and its use in future national surveys is advocated to enable appropriate comparisons between Indigenous and non-Indigenous data (Australian Institute of Health and Welfare, 2006).

2.5.1.3 Adult Psychological/SEWB Assessments

Recognition of the lack of available data relating to adult mental health status for Indigenous Australians led to the addition of an SEWB module to the National Aboriginal and Torres Strait Islander Health Survey (NATSIHS; 2004-05)(Australian Bureau of Statistics, 2006a). This module included five (slightly modified) questions from the Kessler Psychological Distress Scale (K-5) measuring non-specific psychological distress; along with additional questions relating to seven other domains: positive aspects of SEWB, the impact of psychological distress, feelings of anger, cultural identification, experience of discrimination, experience of life stressors and removal from natural family (Australian Bureau of Statistics, 2006a).

The Australian Institute of Health and Welfare (AIHW) assessed the psychometric properties of the module to determine its suitability for understanding SEWB in Indigenous Australians. A workshop and report were provided to representatives from the National Advisory Group on Aboriginal and Torres Strait Islander Health Information and Data, the Office of Aboriginal and Torres Strait Islander Health, the Australian Bureau of Statistics and the National Aboriginal Community Controlled

Health Organisation (Australian Institute of Health and Welfare, 2009; Black, 2006). They concluded that the module performed well and all eight domains (psychological distress (K-5), impact of psychological distress, positive wellbeing, anger, life stressors, discrimination, cultural identification, and removal from family) should be retained in future national surveys with some modification to five of the domains. The eight domains were well accepted, the data fitted with information gained from other data sets and each corresponded with the other SEWB domains and other measures of health as expected (Australian Institute of Health and Welfare, 2009; Black, 2006). While the 'don't know/not stated' responses were at an acceptable level, most responses of 'don't know/not stated' were reportedly due to language and conceptual issues (Black, 2006). In addition, stakeholder consultation identified important SEWB factors such as resilience and self efficacy that were not captured by the module. It was therefore recommended that the feasibility of including them in future surveys should be explored. Although not yet completely comprehensive, the utility of this module for epidemiological data collection and cross-cultural comparisons shows good potential.

Questions relating to the experience of life stressors that were used in the NATSIHS, were also used previously in the National Aboriginal and Torres Strait Islander Social Survey 2002 (NATSISS). Recognising the potential value of the tool, and the apparent lack of published data (at the time), another study set out to evaluate what was termed the Negative Life Events Scale (NLES). The sample included 635 Indigenous householders and carers of young children from 11 remote communities across the Northern Territory (Kowal, et al., 2007). The study's larger aim was to assess the impact of improved housing on the health of young children. Participants

were required to indicate whether any of a list of negative life events had been a problem for them or their family or friends in the last 12 months (Australian Bureau of Statistics, 2006b). Modifications to the scale were made based on the AIHW workshop recommendations and in consideration of the overall aims of the project. The word 'problem' was changed to 'worry' to reflect the Aboriginal English in use in the Northern Territory, and the phrase 'you or anyone else living in this house' was used instead of 'you or your family or friends'. An item asking about vandalism or malicious damage was also added.

The results indicated that all except three items were appropriate for use in a wide range of Indigenous communities. These three items ('divorce or separation', 'not able to get a job' and 'lost job') were poorly endorsed, and showed poor discriminative ability and poor external reliability. This suggested that these items were not widely experienced by the sample and those who did endorse them were not among the most stressed respondents. Therefore, these items may not be measuring what they were intended to measure, or are not doing so in a reliable way (Kowal, et al., 2007). Although the NLES was found appropriate for use in Indigenous populations, the effectiveness of the scale in comprehensively capturing Indigenous experiences of stress remains to be determined. Recommendations from the AIHW included broadening the range of stressors that are captured by the scale (Australian Institute of Health and Welfare, 2009; Black, 2006).

With a more clinical focus, Esler *et al.* (2007; 2008) have begun to assess the acceptability and validity of a tool for diagnosing depression: the Patient Health Questionnaire 9 (PHQ-9), for use with Indigenous Australian adults. The

unmodified PHQ-9 was considered unacceptable for use with Indigenous Australians due to its wording and rating scale. After consultation with Indigenous community members and health workers along with other health and mental health centre staff, a number of changes in wording and the addition of a question on the experience of anger were recommended, resulting in a 10-item scale. The consultation process led to recommendations that the screen be administered by an Aboriginal health worker and that family could be included in the assessment process. The adapted version of the tool was considered acceptable for use in the Darwin-based community controlled Aboriginal health clinic where the study was conducted. Its appropriate use, however, was not generalisable for use in other situations without further evaluation.

A further validation study involved an Indigenous health worker administering the PHQ-9 to a sample of 34 Indigenous adults (mean age = 57.7 years) with Ischemic Heart Disease (IHD). They also underwent a semi-structured diagnostic clinical interview with a general practitioner to determine whether a diagnosis of minor or major depression was appropriate. Although the internal consistency of the tool was good (Cronbach $\alpha = 0.80$) and the tool showed good concordance (73.6%) with the results of the diagnostic psychiatric interview, the results of the study may not be generalisable to the wider Indigenous population. As with many of these mental health tools, further validation in a larger sample of the general Indigenous population is therefore required.

2.5.2 Cognitive Assessments

Identifying validated cognitive assessments appropriate for Indigenous Australians can prove equally as challenging. Cognitive assessment involves the measurement of specific behaviours as accepted surrogate markers of brain function (Cairney & Maruff, 2007a). Changes or abnormalities in brain function detected on cognitive assessments are typically interpreted with respect to healthy standards. For Indigenous populations however, appropriate normative data are rarely available (Australian Psychological Society, 1996). In research studies, cognitive assessment is used to improve knowledge about the factors that alter normal brain function and the nature of related changes. Such studies generally involve case-control study designs.

2.5.2.1 Research Task

Following years of poor performance by Indigenous people on traditional forms of cognitive testing, in 1976 Kearins (1976) developed a memory task designed to reflect skills and strategies thought to be important for survival in the harsh desert environment of Central Australia. Her research demonstrated that by providing tasks appropriate to Indigenous contexts, Indigenous children could perform the task at a level superior to their non-Indigenous counterparts. Other researchers however failed to replicate her results in different Indigenous groups (Drinkwater, 1976, 1978; Knapp & Seagrim, 1981). Nevertheless, the performance of at least one other Indigenous sample, although not significantly superior, did equal the performance of non-Indigenous participants (Drinkwater, 1976). Although somewhat encouraging

as an appropriate task for testing Indigenous memory ability, the task assesses merely one aspect of cognition and has never been transferred to a standardised assessment procedure with appropriate normative data. Its utility for clinical evaluations is therefore limited. Nevertheless, Kearins' research demonstrated the importance of designing and using ecologically valid tests for Indigenous Australians. This work was therefore pivotal in recognizing that poor performance by Indigenous Australians on tests that were designed for non-Indigenous populations may reflect the inadequacies of the assessment tools themselves for use in this population, rather than indicating organic brain dysfunctions. It also highlights the difficulties in comparing test scores between cultures on any assessment for which the design is based primarily on the cultural characteristics of one of the groups. Appropriate assessment of any cultural group must therefore involve the use of culturally fair assessment tools for which performance scores are interpreted with respect to normative data established from the same group.

2.5.2.2 Intelligence Test

The Queensland Test was developed in the 1960s to assess general intelligence in Indigenous Australians, using five subtests (Kearney, 1966; McElwain & Kearney, 1970). These subtests are adapted versions of the Knox Cube Imitation Test, the Beads Test, Alexander's Passalong Test, the Form Assembly Test and the Pattern Matching Test (Kearney, 1966). Administered using pantomime alone, the test requires the solution of clear and unambiguous overt tasks using concrete, tangible materials (Kearney, 1966). Although the tasks incorporated in the Queensland test have been modified for use with Indigenous Australians, they are "still essentially

Western in both origin and content” (Garton, 2003, p. 370). The extent of contact with mainstream non-Indigenous culture was found to impact on performance and this led to the establishment of three sets of norms for low, medium or high degrees of contact with mainstream non-Indigenous culture. Although originally designed as an intelligence test, the Queensland Test was later described as more useful for assessing the health or organic brain dysfunction of individuals within the culture (Ross, 1984). Norms for the Queensland test are currently outdated (Drew, 2000) and no recent studies using this tool have been reported in the literature.

2.5.2.3 Dementia Screen

A recent advance for assessing cognition in Indigenous Australians was the development of a dementia screen for older Indigenous Australians in the Kimberley region: The Kimberley Indigenous Cognitive Assessment (KICA) (LoGiudice, et al., 2006; Smith, et al., 2007). This screening tool assesses cognitive capacities associated with dementia including orientation, naming, registration, verbal comprehension, verbal fluency, free and cued recall, praxis and frontal executive function (Smith, et al., 2007). Although initially designed and validated for use with Indigenous people in the Kimberley region of Western Australia (n = 77), it has recently been validated among Indigenous populations in the Northern Territory (n = 52) (LoGiudice, et al., 2006; Marsh, et al., 2007; Smith, et al., 2007). These studies demonstrated that the KICA displays good internal consistency (Cronbach α = 0.8–0.9), good sensitivity ($\geq 82.3\%$) and good specificity ($\geq 87.5\%$) for a cut-off score of 31–32/39 (LoGiudice, et al., 2006; Marsh, et al., 2007). Limitations of the KICA include its question and answer format, with some questions requiring a pencil-and

paper response. Although cognitive screen data are supplemented by self and family reports regarding everyday behaviours and medical histories, making the KICA a comprehensive tool, these sections are also highly language based.

In addition, the test is designed to detect gross brain dysfunction at a single point in time and may have poor reliability for detecting the mild cognitive decline that may precede dementia. This is also a limitation of traditional pencil-and-paper neuropsychological tests used commonly in non-Indigenous populations, such as the Mini-Mental State Examination (MMSE). In the non-Indigenous population, more sensitive tests such as computerised cognitive screens are now used in at risk patients to monitor cognitive change over time and detect mild cognitive decline early (Collie et al., 2003; Darby, Maruff, Collie, & McStephen, 2002; Sahakian & Owen, 1992). The KICA therefore shows promise in the same realm as the MMSE, to assess the overall severity of dementia; but it may have limited utility for monitoring change over time. The functions-tested by the KICA specifically target those affected in patients with dementia, so tasks measuring attention, long-term memory, and visuo-spatial abilities that are likely to be affected by other causes of brain dysfunction have been excluded due to their inappropriateness during pilot testing (Smith, et al., 2007). These factors may be more suitably assessed using other styles of cognitive assessment.

2.5.2.4 Computerised Cognitive Assessments

The Cambridge Neuropsychological Test Automated Battery (CANTAB) is a computerised assessment tool utilizing non-verbal stimuli and requiring non-verbal

responses on a touch screen computer (Sahakian & Owen, 1992). CANTAB has proven effective for cross-cultural assessments and for individuals with English as a second language (Luciana & Nelson, 2002; Sahakian & Owen, 1992). The test has also been used successfully in a number of studies with Indigenous Australians (Cairney, Clough, et al., 2003; Cairney, et al., 2004a, 2004c, 2005; Cairney, Maruff, et al., 2003; Maruff, et al., 1998; Maruff, et al., 1996). In this population, these studies have demonstrated associations between specific aspects of cognitive performance and neurological disorders including Sydenham chorea (Cairney, Maruff, Currie, & Currie, 2009) and Machado Joseph disorder (Maruff, et al., 1996) as well as substance abuse including petrol sniffing (Cairney, et al., 2004a, 2005; Maruff, et al., 1998) and kava abuse (Cairney, Clough, et al., 2003; Cairney, Maruff, et al., 2003). These studies have used case-control designs. Therefore, the specific psychometric properties of the test for Indigenous people have not been documented. Advantages of computerised tests, however, can include standardised and quick administration, multiple alternate forms, automation of response recording, randomised presentation of stimuli, superior test–retest reliability, a lack of floor and ceiling effects, and the ability to assess a range of functions and record many responses in a short period (Collie, Maruff, McStephen, & Darby, 2003; Makdissi et al., 2001; Sahakian & Owen, 1992; R. Westerman, Darby, Maruff, & Collie, 2001). Nevertheless CANTAB has limited utility for more widespread use in remote regions because it requires specialised technical equipment that can be expensive, cumbersome, and difficult to operate (Cairney & Maruff, 2007a).

Cogstate (cogstate.com) is a more recently developed computerised, non-verbal assessment that can be downloaded from the Internet and administered on any

computer, making it accessible and portable for a range of applications. Intended for the repeated assessment of cognitive function in diverse groups, Cogstate removes the chance aspect of card playing and modifies the rules of such games to generate valid tests of psychomotor function, attention, learning, memory and executive function (Cairney & Maruff, 2007a). Like many cultural groups internationally, Indigenous Australians in urban and remote regions have demonstrated enjoyment, familiarity and proficiency in the practice of card playing (Cairney & Maruff, 2007a; Davidson, 1979). Recognizing the universality of playing cards, Cogstate was developed as a response to the need for appropriate cognitive assessments for Indigenous Australians. The test was initially applied more widely, and its scientific validity and clinical applications have been established in a number of non-Indigenous populations including children and adults, patients with Alzheimer's disease, attention-deficit-hyperactivity disorder, and sports related head injury as well as in non-English speaking populations (Collie et al., 2007; Collie, Maruff, Darby, & McStephen, 2003; Collie, Maruff, Makdissi, et al., 2003; Falletti, Maruff, Collie, & Darby, 2006; Mollica, Maruff, Collie, & Vance, 2005; A. M. Snyder, Maruff, Pietrzak, Cromer, & Snyder, 2007; P. J. Snyder, Bednar, Cromer, & Maruff, 2005; Straume-Naesheim, et al., 2005).

Cogstate has also been used successfully with Indigenous Australians in research studies showing substance abuse related cognitive impairments, and its psychometric properties in this population are in the process of being reported (Cairney, et al., 2007; Dingwall, et al., 2009; Dingwall, Lewis, Maruff, & Cairney, 2010; Lewis, et al., 2010). Using Cogstate, one study describes the performance of 237 healthy Indigenous adolescents living in remote regions and representing a diversity of

cultural and language groups (Lewis, et al., 2010). These results suggest that the tasks were performed appropriately, with response times and error rates increasing in association with task difficulty. For tasks that were presented over five rounds, participants' response duration and error rates decreased with each round, meeting task expectations and corresponding with performance patterns in non-Indigenous groups. The test-retest reliability of Cogstate has also been assessed in a sample of 40 Indigenous adolescents over repeated assessments (Dingwall, et al., 2009 see Chapter 3). The results of these analyses indicated no practice effects and good retest reliabilities ($r = 0.29-0.82$) for the simple card based tests of psychomotor function, visual attention and working memory. Accuracy (but not speed measures) on the more complex learning and memory tasks also exhibited satisfactory reliabilities ($r = 0.23-0.73$) and no practice effects. Speeded measures exhibited some practice effects that may be ameliorated with the use of a dual baseline or practice test prior to the first assessment. These characteristics together with its sensitivity in detecting mild cognitive impairment make Cogstate a valuable tool for detecting cognitive decline or recovery of function with repeated assessments (Darby, et al., 2002; Dingwall, et al., 2009). Other analyses have demonstrated the test's sensitivity to substance abuse related impairments and have also indicated minimal impact of demographic factors such as gender and education on performance (Cairney, et al., 2007; Dingwall, Lewis, et al., 2010 [see Chapter 4]; Lewis, et al., 2010). Age effects have been observed, however, in line with cognitive changes in other populations (Dingwall, Lewis, et al., 2010; Lewis, et al., 2010). Thus the clinical utility of this (and other) tools is limited until appropriate normative data are established that accommodate factors (such as age) that are known to impact upon performance.

2.6 CONCLUSION

The assessments reviewed here are few and largely represent initial validations, indicating that this is indeed a novel and emerging field of research and clinical practice. Given the considerably high rates of poor health and particularly mental health experienced among Indigenous Australians, however, these studies are very important and further development in this field is a necessity to improve mental health outcomes for Indigenous Australians. Many of these assessments require further evaluation so it is clear that considerable development is required before a national protocol for assessing or screening for cognitive or mental health problems in Indigenous Australians is established. Until appropriate assessment tools and investigation methods are developed and utilised, the prevention, recognition and treatment of mental health problems for Indigenous Australians will remain severely inadequate.

Chapter 3

Reliability of Repeated Cognitive Testing in Healthy Indigenous Australian Adolescents

Preface

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[see Appendix A].

A comprehensive review of the literature (Chapter 2) has revealed very few empirically validated tools for detecting cognitive impairment among Indigenous Australians. While some assessments have been adapted or developed specifically to be culturally neutral, the psychometric properties of those tools within an Indigenous Australian population have not been adequately described. Further development of many of the identified assessment tools is therefore required to assess their validity and reliability among Indigenous Australians. The cognitive assessment, CogState, and a psychological assessment based on Strong Souls, both of which are described in detail in Chapter 2, were selected for use in this thesis for reasons discussed in Chapter 1. The remaining chapters in Part A establish the validity and reliability for using CogState and Strong Souls with Indigenous people. Performance improvements on repeated assessments with the same test can occur due to practice effects, therefore it is necessary to identify and control for any practice effects in order to effectively monitor any changes in cognition longitudinally. Thus, the specific aim of Chapter 3 is to describe the reliability and extent of any practice effects associated with the CogState cognitive assessment in a group of young Indigenous people from the Northern Territory.

**Reliability of Repeated Cognitive Testing in Healthy Indigenous Australian
Adolescents**

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ABSTRACT

Serial assessment is required in situations where decline or recovery of function is anticipated. Serial assessment of cognition in Indigenous populations, however, can be problematic due to a lack of culturally appropriate assessments with psychometric properties suitable for repeated administration. This study assessed a non-verbal, culturally neutral, computerised cognitive test battery for its test-retest reliability and any practice effects in a sample of 40 healthy Indigenous adolescents (mean age = 15.25 years). No practice effects and adequate retest reliabilities were recorded for both accuracy and speed on tests of psychomotor function, visual attention and working memory (i.e. card tasks). A lack of practice effects and adequate reliabilities were also observed for accuracy (but not speed) on the more complex learning and memory tasks (i.e. non-card tasks). Interestingly, this outcome contrasts with those of similar studies in which the performance of non-Indigenous people on the same tasks showed speed to be a more reliable measure than accuracy, and this may reflect different perceptions of time between these groups. Among Indigenous adolescents, this study demonstrates acceptable reliability and stability of the selected cognitive assessment process, providing validity for its use as a research and screening tool in this population.

Keywords: adolescent, cognition, cognitive assessment, Indigenous, reliability

3.1 INTRODUCTION

High rates of substance abuse, domestic violence, chronic illness, psychological stress, head trauma, and malnutrition may lead to high rates of cognitive dysfunction among Indigenous Australians (Pollitt, 1997). Such impairments, however, go largely unnoticed and untreated due to an inability to assess cognitive function appropriately for Indigenous Australians. This situation further burdens this already disadvantaged population. Additional challenges arise in conducting the repeated assessments that are necessary to understand the progressive cognitive decline or subsequent cognitive recovery associated, for example, with substance abuse or other disease progression. Repeated assessments can be considerably time and resource consuming, result in additional sources of stress or anxiety for the patient, and also lead to practice effects (Teng & Manly, 2005).

Issues related to culture that normally limit the application of cognitive tests developed in Western society to other cultures also operate for Indigenous Australians (see Ardila, 2005; Greenfield, 1997 for reviews). Mainstream tests can rely heavily on the use of the English language, utilise question-answer formats and resemble formal educational processes. Poor English literacy and a lack of formal schooling as well as differing concepts of numbers, time and space, differing communication styles, and lack of written language in Indigenous cultures may therefore contribute to unreliable performance on such tests (Ardila, 2005; Janca & Bullen, 2003; Kearins, 1988; LoGiudice, et al., 2006; Pollitt, 1997; T. Westerman, 2004; Wettinger, 1997).

Past attempts to assess the cognitive capabilities of Indigenous Australians have utilised non-verbal assessments such as the Porteus Maze or the Queensland Test (McElwain & Kearney, 1970; Porteus, 1917, 1963). While the former relied on minimal verbal instruction, the latter was administered through pantomime alone and was considered useful for minimising the effects of language or cultural differences (Kearney, 1966; McElwain & Kearney, 1970). Nevertheless, for both tests, a relationship was observed between test performance and degree of contact with European or Western culture (Kearney, 1973; McElwain & Kearney, 1970). This highlights the fact that personal characteristics, such as familiarity with Western practices and formal education, may also affect non-verbal test performance for Indigenous Australians. Interpretation of test performance may therefore be particularly problematic if it is based on normative data collected from inappropriate (typically non-Indigenous) samples (Zurcher, 1998).

Following years of poorer performance by Indigenous Australians on traditional forms of cognitive testing, Kearins (1976, 1981, 1982, 1986) demonstrated that by providing tasks appropriate to Indigenous contexts (and potentially their preferred cognitive processing style), Indigenous children could perform a spatial memory task at a level superior to their non-Indigenous counterparts. She concluded that the Indigenous children in her research utilised a visual coding strategy, while the non-Indigenous children utilised a verbal coding strategy that was evidently inefficient. Davidson (1979), however, proposed that the multidimensional model of simultaneous versus successive cognitive processing, based on Luria's (1966, 1973) neuropsychological model and discussed by Das, Kirby, and Jarman (1975), may be more effective for understanding Indigenous Australians' cognition than the spatial

versus verbal distinction. Based on his own observations of Indigenous Australians' card playing in the Northern Territory as well as others' observations of Indigenous skills and behaviours, Davidson concluded that when a task permits Indigenous Australians may be more likely to store and retrieve information in a simultaneous or synchronous manner (e.g., learning the value of card combinations), rather than a serial or successive manner (e.g., logical addition). In assessing the cognitive capabilities of Indigenous Australians, it is therefore important to consider both the familiarity of stimuli as well as the typical cognitive processes that may be used to interpret such stimuli.

The problems associated with assessing individuals against (typically inappropriate) normative samples, with potentially differing characteristics and processing styles to the individual being tested, highlight the advantage of assessing individuals with respect to themselves (through repeated assessment). Nevertheless, conventional cognitive tests have typically been designed to detect the presence or absence of gross brain dysfunction at a single time point and can have poor reliability and sensitivity for detecting changes over time (Straume-Naesheim, et al., 2005). The lack of alternate forms, restricted range of scores, floor and ceiling effects and practice effects associated with some conventional tests can contribute to their unsuitability for repeated assessment (Collie, Darby, Falleti, Silbert, & Maruff, 2002; Collie, Maruff, Makdissi, et al., 2003; Falleti, et al., 2006; Straume-Naesheim, et al., 2005). Poor psychometric properties can also mean that large changes in cognitive function are required before small changes in test score are observed and therefore mild but "true" changes in cognition can remain undetected (Collie, et al., 2002).

CogState, is a non-verbal, computerised test of cognitive function that uses playing cards and other game-like stimuli, which are intuitive and intrinsically motivating (R. Westerman, et al., 2001). The card-based tasks are presented serially and measure aspects of psychomotor function, visual attention and working memory. The other tasks use spatially arranged stimuli to measure spatial memory, executive function, long-term memory, learning and spatial awareness and these may permit the use of simultaneous processing strategies. As a computerised test, CogState has standardised and quick administration, multiple alternate forms, automated response recording, randomised presentation of stimuli, and the ability to assess a range of functions and record many responses in a short period (Collie, et al., 2002; Collie, Maruff, McStephen, et al., 2003; Makdissi, et al., 2001; R. Westerman, et al., 2001).

These characteristics can improve the accuracy and sensitivity of measurement and reduce the impact of practice effects. Good reliabilities (0.38–0.94) have been reported, particularly for reaction time on psychomotor and attention measures at very brief (<1day) retest intervals for both children and adults (Collie, Maruff, Makdissi, et al., 2003; Falletti, et al., 2006; Mollica, et al., 2005; Straume-Naesheim, et al., 2005). Given the use of a dual baseline, practice effects are not evident at short retest intervals (P. J. Snyder et al., 2005). The validity of CogState subsets is demonstrated through good correlations (0.49–0.83) with other neuropsychological measures (e.g., Grooved Pegboard Test, Trail Making Test) of the same constructs (Collie, Maruff, Makdissi, et al., 2003; Maruff et al., 2009). By providing simple instructions, prompts and feedback, along with a demonstration of the task prior to responses being recorded, the utility of the test for assessing cognition cross-culturally is improved (Lopez, Lamar, & Scully-Demartini, 1997). Although the test

has been used in non-English-speaking and Indigenous Australian samples, its psychometric properties are yet to be described for Indigenous Australians. The aim of the current paper was therefore to assess the test-retest reliability and practice effects associated with CogState in a sample of Indigenous Australian adolescents as a step toward demonstrating the utility of the test for assessing cognition longitudinally in this population.

3.2 METHOD

3.2.1 Participants

Study participants were recruited to the adolescent healthy control group for a longitudinal study monitoring cognitive function following petrol sniffing and other drug abuse in Indigenous Australians. Participants were recruited from a boarding school for Indigenous students in a large regional centre in Central Australia and were from a wide range of communities, and therefore language groups, throughout the region. Participants were screened through a self-report questionnaire to exclude those with frequent use of alcohol or other drugs. Lists of participants were also reviewed with teaching staff, and those with known drug histories were identified. Seven participants (five male, two female) were therefore excluded from the analyses because they or their teachers reported that they were frequent (response of ‘fair bit’ or ‘everyday’) users of either petrol (i.e., ‘sniffing’), cannabis, or alcohol. Of the participants who were tested at baseline, 40 completed a second assessment, 30 completed a third assessment and 17 completed a fourth assessment. Therefore 14 male (mean age = 15.71 years; range = 13–19 years) and 26 female participants

(mean age = 14.92 years; range = 13–17) were included in the analyses. The mean age, years of education, and Accessibility/Remoteness Index of Australia (ARIA) score (as a measure of remoteness) for the sample at Time 1 were 15.41 years, 7.47 years and 10.12, respectively, and 15.20 years, 7.15 years and 10.17, respectively at Time 4.

3.2.2 Apparatus

The CogState battery consists of a number of subtests that can be tailored to suit a specific research situation (Cairney, et al., 2007; Collie, Maruff, Makdissi, et al., 2003; Falleti et al., 2003). As a result of prior research and consultation with Indigenous community members, tasks that were considered suitable for assessing Indigenous Australians were selected for use in the study. The cognitive test battery therefore consisted of seven subtests (described below) and took approximately 20 minutes to administer. The tests were fully supervised and brief on screen instructions were provided. Responses were recorded using the keyboard and the computer mouse. The stimuli in each subtest are presented repeatedly and the data averaged over those presentations.

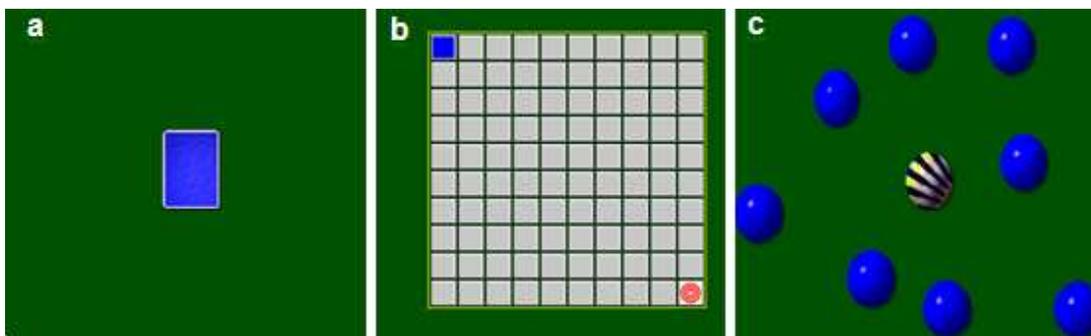


Figure 1. On-screen representation of (a) card based tasks, (b) Groton Maze Learning Test and (c) Continuous Paired Associate Learning task.

3.2.2.1 CogState Subtests

3.2.2.1.1 Card Based Tasks

On-screen presentation for these tasks is given in Figure 1(a).

Detection Task: This task uses playing card stimuli presented onscreen to measure simple reaction time. A playing card is presented facedown on the screen and the participant is required to press a key on the keyboard once the card has turned face-up. This task measures visual attention and psychomotor function.

Identification Task: This task uses the same presentation as the Detection task with a playing card presented facedown. In this task however, once the card turns face up the participant needs to determine the colour of the suit (either red or black) and press corresponding keys on the keyboard to indicate this. This task primarily measures visual attention.

Visual Learning Task: A series of cards are presented on the screen, one card at a time. The participant is required to attend to each of the cards and maintain each card in their working memory. The participant is required to indicate whether the card has been seen before or whether it is a new card by using defined keys on the keyboard. This task measures aspects of working memory and attention.

3.2.2.1.2 *Non Card Based Tasks*

On-screen presentation for these tasks is given in Figure 1(b) and (c)

Groton Maze Chase Test (GMCT): A grid 10 tiles by 10 tiles is presented on the screen with a target tile in the top left (Figure 1b). To commence this task the participant must click the target tile with the mouse and chase it around the grid as it moves one tile at a time. The task continues for 30 seconds and records the total number of correct movements. This task assesses manual dexterity and visual perception and is used to step up to the next task and familiarise participants with the format for the next task.

Groton Maze Learning Test (GMLT): Using the same 10 by 10 tile grid as presented in the GMCT (Figure 1b), the participant is required to use the mouse to uncover a circuitous path, moving one tile at a time (across 28 correct tiles), from one corner of the grid to the diagonally opposite corner. On the first presentation the path can be found only by using trial and error. Correct responses are indicated with a tick, and incorrect responses are indicated with a cross. If a cross is revealed, the participant must click on the last correct square to continue. Once the pathway has been uncovered and completed by the participant, the task is then repeated for four more rounds along the same path. This task measures aspects of spatial memory, working memory and executive function.

Groton Maze Learning Test – Delayed Recall (GMLT-R): Approximately ten minutes after completing the five presentations of the Groton Maze Learning Test

(GMLT), and with other tasks being completed in the interim, the grid is presented one more time with the same hidden pathway as presented on the initial trials. The participant is required to remember the pathway and complete it as quickly and accurately as they can, using the mouse. This task measures longer term memory.

Continuous Paired Associate Learning (CPAL): This paired associate learning task presents a series of eight blue balls on the screen (Figure 1c). In the acquisition phase, six patterns are presented serially in individual balls, leaving two 'empty' distracter balls, so that the participant can learn where each is located. Once this is completed one of the patterns is presented in a central location. The location of that pattern's matching pair has to be recalled, and this location clicked with the mouse. The task will not progress until the location of the pattern is correctly recalled, and will continue until the locations of the six patterns have been remembered. After acquisition this task is repeated for five rounds (locating all six patterns) with the patterns in the same location for each round. This task measures learning and spatial awareness.

3.2.3 Procedure

Institutional ethics approval, which complies with NHMRC Guidelines for Ethical Conduct in Aboriginal and Torres Strait Islander Health Research, was gained prior to commencing the study. Background consultation during the development of the assessment process ensured that the procedures were culturally appropriate, while simultaneously providing meaningful and rigorous information. Throughout the study period, participants were educated about the effects of petrol sniffing and given

feedback regarding their class performance over time and compared to the performance of a person who had sniffed petrol. Participants were approached through their educational facility and invited to participate on a voluntary basis. Signed informed consent was gained for each participant and from their legal guardian. Assessments were completed in the school computer lab with groups of up to 15 students tested together. The assessment was administered four times at approximately fortnightly intervals. Due to the transient nature of the population, however, not all participants were present for each of the assessments (Dingwall & Cairney, 2009). Therefore the interval between assessments for each participant ranged from 14 to 43 days with a mode of 15 days (Times 1-2) and 14 days (Times 2-3 and Times 3-4).

At the beginning of each new subtest, the supervisor explained the instructions and requirements of the task and guided participants through a practice session in which they were given 1-5 trials to demonstrate their understanding of the requirements of the task. Following this the participants were told that the practice was over and they would now do the “real test”, in which their responses were recorded by the computer. Completion of each task led straight into the practice session for the next task.

3.2.4 Data Analysis

All data analyses were conducted using SPSS version 15.0 (SPSS, Chicago, IL, USA). Initial inspection of the data indicated some incomplete data, which were excluded for that task only. A number of extreme outliers (> 3 SD from the mean),

were also identified and removed (these ranged from 0 to 5 outliers per time point, per measure). Speed (reaction time) and duration measures were recorded in milliseconds. Accuracy for the card tasks was defined by number of correct responses divided by the total number of trials attempted. For the GMLT tasks, the total number of errors consisted of the total number of legal errors, the total number of perseverative errors and the total number of rule break errors. The number of moves per second was defined as the number of correct moves through the maze divided by the total duration to complete the task. For the GMLT, the moves per second were averaged over the five learning rounds to yield an average moves per second for this task. As prescribed by the test developers, the reaction time and accuracy data were transformed using logarithmic (base 10) and arcsine transformations, respectively, to achieve a normal distribution prior to analyses (Collie, Maruff, Makdissi, et al., 2003; Falleti, et al., 2006; Mollica, et al., 2005; Straume-Naesheim, et al., 2005). For repeated measures analyses, a sample size of 13 gives sufficient power (0.80) to detect a large effect with estimated average reliabilities of .50 at an alpha level of 0.05 (Stevens, 1996).

To investigate reliability, Pearson's correlation coefficients (Pearson's r) were calculated. A series of one-way repeated measures analyses of variance (ANOVA; general linear model) were also conducted, for participants who had completed four assessments ($n = 17$), to examine any changes in performance over time. The within-subjects factor was time tested with four levels (repeated measures; Time 1, Time 2, Time 3, and Time 4), and each of the performance measures were the dependent variables. No demographic covariates were included as previous analyses indicated no major effects of age or gender on performance within this sample (Lewis, et al.,

2010). In cases in which violations of the assumption of sphericity were indicated by a significant result for Mauchly's test of sphericity in SPSS, the multivariate approach was used. When the ANOVA indicated a significant effect of session, post-hoc paired samples *t*-tests were conducted to compare group means between adjacent assessments.

To determine if the individuals who were present for the four assessments were different to those who were not, independent *t*-tests were conducted between the groups with age, education and level of remoteness as the dependent variables (DVs). Level of remoteness was defined by the Accessibility/Remoteness Index of Australia (ARIA) for participant's home community on a scale from 1 (least remote) to 12 (very remote) (Commonwealth Department of Health and Aged Care, 1999). Performance at baseline was also compared between these groups using independent *t*-tests. All significance levels for the tests were maintained at $\alpha < 0.05$. It is understood that the number of statistical comparisons in the current study inflated the risk of Type I error but, given the exploratory nature of the current study, we feel that this was justified.

3.3 RESULTS

The Pearson's *r* correlation coefficients ranged from .09 to .84 and are presented in Table 1 for each subtest and adjacent sessions. For the majority of performance measures, reliability coefficients were $> .50$ suggesting that these measures demonstrated acceptable levels of reliability. Tasks (and measures) showing the greatest reliability ($r > .70$) over all sessions were Detection (speed), Identification

(accuracy), Visual Learning (accuracy), GMLT (duration and moves per second), GMLT-R (duration, moves per second, errors and rule break errors) and CPAL (total errors).

Table 2 presents the group means and standard deviations for participants who completed each test over all four sessions as well as results of the repeated measures ANOVAs with effect size estimates (partial η^2). These analyses indicated stable performance on measures of both speed and accuracy for all of the card-based tasks. The GMCT also exhibited stable performance, as did all accuracy measures for the GMLT-R and CPAL tests and the perseverative and rule break errors for the GMLT task. Repeated measures ANOVAs showed that performance improved significantly for the GMLT on duration (Wilks' $\lambda = 0.27$, $F_{(3, 12)} = 10.69$, $p < 0.01$), moves per second ($F_{(3, 42)} = 19.54$, $p < 0.01$), total errors (Wilks' $\lambda = 0.49$, $F_{(3, 42)} = 5.21$, $p < 0.05$), and legal errors ($F_{(3, 42)} = 2.90$, $p < 0.05$); for the GMLT-R on duration (Wilks' $\lambda = 0.45$, $F_{(3, 12)} = 4.91$, $p < 0.05$), and moves per second (Wilks' $\lambda = 0.51$, $F_{(3, 12)} = 3.88$, $p < 0.05$); and for CPAL on duration ($F_{(3, 48)} = 6.49$, $p < 0.05$) only (Table 2).

Paired samples post hoc t-tests showed significant improvements between Time 1 and Time 2 for GMLT duration ($t_{(14)} = 5.19$, $p < 0.01$), and moves per second ($t_{(14)} = -3.20$, $p < 0.01$); GMLT-R duration ($t_{(14)} = 3.73$, $p < 0.01$), and moves per second ($t_{(14)} = -3.37$, $p < 0.01$); and CPAL duration ($t_{(16)} = 3.06$, $p < 0.01$). Significant improvements also occurred between Time 2 and Time 3 for GMLT duration ($t_{(14)} = 3.44$, $p < 0.01$), and moves per second ($t_{(14)} = -3.57$, $p < 0.01$), indicating that participants moved faster on the GMLT on subsequent test sessions up to the third assessment, at which point performance stabilised. For total errors and legal errors

on the GMLT, significant differences existed only between Times 2 and 3 ($t_{(14)} = 3.49, p < 0.01$ and $t_{(14)} = 3.05, p < 0.01$ respectively). To examine this inconsistent finding further, subsequent ANOVAs using group sizes of 30 for three testing sessions were conducted on the GMLT data. As a result, the ANOVAs for total errors and legal errors on the GMLT became non-significant ($F_{(2, 28)} = 2.50, p = 0.10$ and $F_{(2, 56)} = 0.83, p = 0.44$ respectively), indicating no difference in performance between tests. There were no changes in significance for all other ANOVAs on the GMLT measures.

No significant differences were found between those who completed the four assessments and those who did not for age ($t_{(38)} = -0.77, p = 0.45$), education ($t_{(38)} = 0.71, p = 0.49$), or level of remoteness ($t_{(37)} = 0.18, p = 0.86$). Performance at Time 1 was also not significantly different for those who were present for all four assessments compared to those who were not.

Table 1. Pearson's Correlation Coefficients between Adjacent Tests

Cognitive test	Times 1-2	Times 2-3	Times 3-4
	N = 40	N = 30	N = 17
Detection Task			
Speed (log10)	.66**	.71**	.67**
Accuracy (arcsine)	.29	.45*	.50
Identification Task			
Speed (log10)	.58**	.40*	.38
Accuracy (arcsine)	.55**	.58**	.80**
Visual Learning Task			
Speed (log10)	.54**	.66**	.57*
Accuracy (arcsine)	.51**	.71**	.82**
Groton Maze Chase Test			
Speed – Moves per s	.42**	.56**	.41
Groton Maze Learning Test			
Speed – Total duration	.46**	.65**	.84**
Average moves per s	.57**	.65**	.80**
Accuracy – Total errors	.50*	.62**	.67**
Legal errors	.42**	.55**	.61*
Perseverative errors	.31	.44*	.24
Rule break errors	.51**	.66**	.67**
Groton Maze Learning Test (recall)			
Speed – Total duration	.53**	.81**	.54*
Moves per s	.50**	.78**	.67**
Accuracy – Total errors	.23	.76**	.43
Legal errors	.31	.53**	.59**
Perseverative errors	-.12	.50**	.68**
Rule break errors	.09	.70**	.09
Continuous Paired Associate Learning Task			
Speed – Total duration	.24	.17	.44
Accuracy – Total errors	.62**	.41*	.73*

Note. Log 10 = logarithmic 10 transformation applied. Arcsine = arcsine transformation applied.
*p < .05. **p < .01.

Table 2. Means (Standard Deviations) and ANOVA Results for Participants Tested over all 4 Sessions on Each Measure (N = 17)

Cognitive test	Time 1	Time 2	Time 3	Time 4	F-statistic	p value	Partial η^2
Detection Task							
Speed (log10)	2.54 (.15)	2.55 (.14)	2.57 (.15)	2.54 (.12)	$F_{(3,39)} = 0.64$	$p = .60$	.05
Accuracy (arcsine)	1.25 (.30)	1.19 (.18)	1.31 (.27)	1.23 (.24)	$F_{(3,36)} = 0.78$	$p = .51$	.06
Identification Task							
Speed (log10)	2.76 (.09)	2.79 (.07)	2.79 (.09)	2.78 (.10)	$F_{(3,39)} = 0.97$	$p = .42$	.07
Accuracy (arcsine)	1.18 (.47)	1.13 (.28)	1.14 (.42)	1.00 (.49)	$F_{(3,39)} = 1.19$	$p = .33$	.08
Visual Learning Task							
Speed (log10)	2.98(.25)	2.90 (.18)	2.91 (.17)	2.91 (.13)	$F_{(3,39)} = 1.65$	$p = .19$	.11
Accuracy (arcsine)	0.58 (.25)	0.67 (.28)	0.59 (.20)	0.62 (.26)	$F_{(3,39)} = 0.67$	$p = .57$	.05
Groton Maze Chase Test							
Speed – Moves per s	1.65 (.32)	1.56 (.50)	1.64 (.44)	1.79 (.40)	$F_{(3,36)} = 1.40$	$p = .26$	.10
Groton Maze Learning Test							
Speed – Total duration	245458 (71746)>	184370 (43013)>	148137 (32145)	150204 (32220)	$F_{(3,12)} = 10.69$	$p < .01$	.73
Average moves per s	0.76 (.17)<	0.90 (.19)<	1.07 (.19)	1.05 (.23)	$F_{(3,42)} = 19.54$	$p < .01$	.58
Accuracy – Total errors	87.27 (49.56)	73.73 (24.87)>	56.07 (21.14)	58.53 (19.01)	$F_{(3,12)} = 4.20$	$p < .05$	.51
Legal errors	45.33 (11.61)	46.73 (10.29)>	38.87 (11.31)	41.73 (8.42)	$F_{(3,42)} = 2.90$	$p < .05$	.17
Perseverative errors	1.57 (2.07)	1.67 (1.62)	0.87 (.83)	1.47 (1.77)	$F_{(3,39)} = 0.828$	$p = .49$	.06
Rule break errors	39.73 (39.03)	25.33 (16.39)	16.33 (10.53)	15.33 (13.02)	$F_{(3,12)} = 2.27$	$p = .13$	.36

Groton Maze Learning Test (recall)						
Speed – Total duration	40691 (19769)>	27017 (7804)	25781 (6813)	23416 (5338)	$F_{(3,12)} = 4.20$	$p < .05$
Moves per s	0.84 (.38)<	1.13 (.34)	1.17 (.34)	1.25 (.26)	$F_{(3,12)} = 3.89$	$p < .05$
Accuracy – Total errors	10.00 (9.19)	7.47 (5.19)	7.33 (7.37)	6.33 (4.85)	$F_{(3,12)} = .69$	$p = .58$
Legal errors	5.87 (4.67)	5.60 (3.50)	4.33 (3.50)	4.40 (3.40)	$F_{(3,42)} = 1.34$	$p = .28$
Perseverative errors	0	0	0	0	-	-
Rule break errors	3.93 (4.40)	1.73 (2.66)	1.86 (2.11)	1.36 (1.45)	$F_{(3,10)} = 2.20$	$p = .15$
Continuous Paired Associate Learning Task						
Speed – Total duration	170047 (44123)>	142512 (20128)	146228 (27986)	138312 (25070)	$F_{(3,48)} = 6.62$	$p < .01$
Accuracy – Total errors	29.76 (27.81)	26.35 (27.55)	25.94 (27.22)	17.59 (18.44)	$F_{(3,48)} = 1.59$	$p = .20$

Note. – = ANOVA was not performed. Log 10 = logarithmic 10 transformation applied. Arcsine = arcsine transformation applied.

> Mean is significantly greater than mean adjacent on the right as indicated by significant t-test at $p < .05$. < Mean is significantly less than mean adjacent on the right as indicated by significant t-test at $p < .05$.

3.4 DISCUSSION

The cognitive assessment used here had adequate reliability for healthy Indigenous adolescents, proving it to be a useful instrument for research and screening in this population. Satisfactory test-retest reliabilities ($> .70$) were recorded on specific measures for the card tasks (i.e., Detection speed, Identification accuracy and Visual Learning accuracy) and on non-card tasks (GMLT speed, GMLT-R speed and accuracy and CPAL accuracy), which generally improved from the second to the third and fourth assessments. Practice effects were observed only for response speed measures on the non-card tasks, and for accuracy only on the GMLT task between Times 2 and 3. If a more conservative alpha level (0.01) was used, however, this latter effect would not have reached significance. Additionally, further examination of this result, with subsequent ANOVAs using group sizes of 30 for three testing sessions, indicated no practice effects for accuracy on the GMLT task. These analyses therefore support the stability of these cognitive measures for researching and screening for change in psychomotor function, visual attention, working memory, spatial memory, executive function, long-term memory, learning and spatial awareness in Indigenous adolescents.

The reliabilities reported here are comparable in magnitude to other conventional and computerised tests of cognitive function. Reliabilities reported for conventional tests in adults have been between .40 and .84 for the Wechsler Memory Scale–Revised subtests, .24–.76 for the California Verbal Learning Test and -.02–.54 for the Wisconsin Card Sorting Test (and subtests) at intervals from two weeks to 12 months (Basso, Bornstein, & Lang, 1999; Paolo, Troster, & Ryan, 1997; Theisen, Rapport,

Axelrod, & Brines, 1998). For computerised tests of cognitive function, reliabilities in the range of .09–.89 have been reported for various subtests (Iverson, Lovell, & Collins, 2003; Lowe & Rabbitt, 1998; L. M. Williams, Simms, Clark, & Paul, 2005). The range of .09–.84 that was found for the CogState subtests is comparable with this.

Other researchers, using the Detection and Identification tasks from the CogState battery, have also found reliability coefficients of between .46 and .94 and .06–.45 for Detection speed and accuracy, respectively; and .38–.81 and .30–.60 for Identification speed and accuracy, respectively, with some also demonstrating poorer reliabilities at the initial (Times 1–2) test-retest interval (Collie, Maruff, Darby, et al., 2003; Falleti, et al., 2006; Mollica, et al., 2005; Straume-Naesheim, et al., 2005). Such studies, have generally found speed measures to be more reliable than accuracy measures, but this pattern was not clearly evident in the current study (Collie, Maruff, Makdissi, et al., 2003; Falleti, et al., 2006; Straume-Naesheim, et al., 2005). The absence of a ceiling effect for the Identification and Visual Learning tasks that is often found on accuracy measures in other studies (Collie, Maruff, Makdissi, et al., 2003; Falleti, et al., 2006; Straume-Naesheim, et al., 2005) may have contributed to the lack of superiority of speed over accuracy and might be explained by the relatively young age of the sample. For instance, despite observing ceiling effects for accuracy on the Detection task, Mollica et al. (2005) also failed to report ceiling effects on the Identification task in their sample of children. It is therefore possible that the Identification task is sufficiently difficult for children and adolescents but not challenging enough for adult samples.

Alternatively, the lack of superiority of speed over accuracy may reflect the differing perceptions of time between Indigenous and non-Indigenous populations or differing cognitive processing styles (Davidson, 1979; Janca & Bullen, 2003; T. Westerman, 1998). According to Janca and Bullen “Time contains no innate or inherent importance as such to an Aboriginal person; it is not adhered to and rarely directs an Aboriginal person” (Janca & Bullen, 2003, p. S41). These authors found that unlike Western concepts of time that follow a linear progression through past, present and future, Aboriginal concepts of time are circular or multidimensional and could be described: ‘as a pond you can swim through – up, down, around’ (p. S41).

Observations of Indigenous people completing the test indicate a lack of urgency to complete the test quickly, despite explicit instructions to do so and this may explain reduced reliabilities on speed for the Identification task. Indigenous Australians’ view of time is somewhat analogous to their proposed preference for a synchronous or simultaneous rather than serial or linear processing style. It may be then that the serially presented card tasks did not suit the simultaneous processing style that is potentially likely to have been used by the Indigenous participants, thereby resulting in more variable processing times. Further research exploring reliability and existence of any ceiling effects in Indigenous adult populations may help to clarify this issue.

Consistent with other repeated measures studies of cognitive function, the current study demonstrated that when they occurred, poorer reliabilities and larger practice effects were most evident between the first and second test interval and diminished thereafter (Collie, Maruff, Darby, et al., 2003; Falletti, et al., 2006; Ivnik et al., 1999; Straume-Naesheim, et al., 2005). Existing practice effects occurred predominately

on the speed measures for the executive function, memory and learning tasks (GMLT, GMLT-R and CPAL), which were more complex. This is consistent with other studies reporting that practice effects and reliability can vary with cognitive function tested and task difficulty (Basso, et al., 1999; Beglinger et al., 2005; Benedict & Zgaljardic, 1998; Falletti, et al., 2006; Lowe & Rabbitt, 1998; Straume-Naesheim, et al., 2005). Despite the use of alternate forms, learning effects occurred potentially due to increased familiarity with the testing procedure. This can be common, particularly for novel tasks that are unlikely to be performed in everyday life (Beglinger, et al., 2005) and potentially for Indigenous cultures unfamiliar with testing procedures.

The observed practice effect for moves per second on the GMLT is consistent with at least two other studies using the GMLT in repeated assessment of non-Indigenous participants (Collie, et al., 2007; Roman et al., 2005). No other GMLT measures were examined by these studies, but the current results were consistent with their findings for GMLT-R measures. That is, on the GMLT-R, a practice effect was found for moves per second (Roman, et al., 2005) and no practice effect was evident for total errors (Collie, et al., 2007). Nevertheless, further studies using the GMLT task in repeated assessments have reported no practice effects for any of the measures (Maruff et al., 2006; P. J. Snyder, Bednar, et al., 2005; P. J. Snyder, Werth, et al., 2005). Most of these latter studies, however, used a practice or familiarisation baseline assessment (i.e., dual baseline), which was then excluded from the analyses. This implies that practice effects may be a more common concern than is explicitly reported. Nonetheless, all of the studies mentioned observed no practice effects between any of the successive trials. The current results differ slightly to this

because a practice effect was observed for the speed measures of the GMLT that continued to the third assessment. This suggests that in this sample of Indigenous adolescents, task familiarisation on the GMLT may take somewhat longer than in non-Indigenous samples, and this may relate to the differing concepts of time as discussed earlier. Performance patterns on the GMLT-R however, remained fairly consistent with the previous, although somewhat limited, research in non-Indigenous samples just discussed.

The conclusions that are able to be drawn from this study are tempered by the moderate sample size and high attrition rates. Only 17 of the initial 40 participants were present for all four testing sessions. Although a sample size of 13 provides sufficient power to detect a large effect (0.57) in repeated measures studies where the average correlation is estimated to be .5 with an alpha level of .05, the high attrition rate may be more problematic (Stevens, 1996). This high attrition rate can partly be attributed to the highly transient nature of this population and the considerable challenges involved in maintaining regular school attendance (Dingwall & Cairney, 2009). School attendance figures suggest that only 20% of enrolled students attend all four school terms, with many (39%) attending only for one school term (Dingwall & Cairney, 2009). In Indigenous Australian populations, religious, ceremonial and familial obligations can take precedence over education (Wettinger, 1997). Consequently, students are often intermittently removed from schooling sometimes for long periods at a time for family or ceremonial obligations, irrespective of the semester structure (Dingwall & Cairney, 2009).

Nevertheless, non-attendance may also reflect individual differences in terms of scholastic achievement, parental support (or lack thereof) in relation to schooling or even drug abuse, and this type of attrition may introduce bias into the sample.

Although there is no adequate remedy, comparisons between those who were present for all four test sessions and those who were not present, indicated no differences in age, education, level of remoteness, or baseline test performances for the two groups. This suggests that attrition was relatively random and reflects the transient nature of the population. Poor follow-up rates have similarly been reported in other studies of Indigenous Australians and appear to be a limitation of conducting longitudinal research in this population generally (Clough, 2006).

The card tasks from the CogState battery appeared to be the most stable measures overall because they demonstrated adequate reliability and were the least likely to suffer practice effects. The simplicity of the tasks, large number of trials with the same stimuli and format, and inclusion of practice trials on these tasks would have contributed to their superior stability compared to the non-card tasks. Although the card tasks are highly reliable, participants may be prone to boredom due to the tasks' repetitive nature. But although the CPAL, GMLT, and GMLT-R exhibited some practice effects, during testing, it was apparent that these tasks were very engaging; their pictorial presentations are quite intuitive and game-like and therefore seemed to appeal more to participants. This is very important in this low-English literacy population, and in children, who can be particularly prone to boredom (Luciana & Nelson, 2002). The use of a dual baseline is therefore recommended and would potentially improve the reliability of these measures for assessing change in cognition for this population.

This is one of the first studies of its kind to assess test-retest reliability and the extent of any practice effects associated with the repeated assessment of cognitive function in a sample of Indigenous Australian adolescents. The results suggest that many of the previous findings regarding reliability and practice effects in non-Indigenous adult (Collie, et al., 2007; Collie, Maruff, Makdissi, et al., 2003; Falleti, et al., 2006; Straume-Naesheim, et al., 2005) and child (Falleti, et al., 2006; Mollica, et al., 2005) populations also hold true for this sample of Indigenous adolescents. The main difference exists on speeded measures and may reflect the differing perceptions of time between Indigenous and non-Indigenous populations (Janca & Bullen, 2003). Although the use of a dual baseline is recommended, the data support the stability of this cognitive tool for monitoring psychomotor function, visual attention, working memory, spatial memory, executive function, long-term memory, learning and spatial awareness in Indigenous adolescents. Future research should examine the sensitivity and specificity of this test for detecting clinically significant change and examine performance correlates in representatives of the population with known psychopathology so that cut-offs for impairment can be established. Further examination of the impact of specific demographic or contextual factors on performance should also be conducted, along with examination of the reliability of the test in an adult Indigenous sample.

Chapter 4

Assessing Cognition Following Petrol Sniffing for Indigenous Australians.

Preface

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Chapter 3 examined the utility of the cognitive assessment protocol for the serial assessment of healthy Indigenous people. Acceptable reliability and stability was demonstrated, supporting its use as a research and screening tool for monitoring cognitive changes over time in this population. Chapter 3 also highlighted the need to first establish the impact on cognitive performance of demographic factors such as age, education or gender that are generally known to impact cognitive scores as well as other cultural factors that may be relevant specifically to this population. The cognitive assessment protocol can also be validated through its application to groups of the population with known psychopathologies and associated cognitive sequelae. Chapter 4 therefore aims to investigate which if any demographic or contextual factors impact upon cognitive performance for Indigenous Australians, so that these may be considered or controlled for when interpreting test results. It also aims to assess the utility of the cognitive assessment process for use in substance abuse rehabilitation programs, and investigate its ability to detect petrol sniffing related cognitive impairments among a group of Indigenous petrol sniffers from the NT.

Assessing cognition following petrol sniffing for Indigenous Australians.

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ABSTRACT

Background: Chronic petrol inhalation can be associated with significant cognitive impairment. While rehabilitation programs can rely on such skills to educate clients and achieve treatment outcomes, cognitive function is rarely assessed on admission. This is particularly true for Indigenous populations where standard assessments are not appropriate. This paper describes a process for assessing cognition in Indigenous Australians. Two studies investigate firstly the demographic factors impacting on cognition for healthy Indigenous Australians and secondly the utility of the assessment process for detecting petrol sniffing related cognitive impairments.

Methods: Study One assessed a naturalistic sample of healthy Indigenous Australians from the Northern Territory (N = 206; mean age = 28.03) on computerised tests of psychomotor speed, visual attention, memory, learning, spatial awareness and executive functions. Multiple regression analyses determined the unique contributions of six factors (age, education, gender, familiarity with computers, regular long term cannabis use and locality) to the variance in performance for this group. Study Two examined group differences in cognitive performance on the same tests between healthy Indigenous Australians (N = 96) and Indigenous petrol sniffers (N = 50; both age restricted to < 26 years) while controlling those factors found to impact on performance from Study One. **Results:** Age, computer familiarity, and education significantly contributed to the variance in performance measures. While controlling these factors, petrol abuse was associated with poorer performance on complex tasks of psychomotor, visual attention, memory, learning, spatial awareness and executive function. **Conclusions:** This assessment process is useful for detecting substance abuse related impairments in

Indigenous Australians and when using this assessment process, age and computer familiarity in particular should be controlled for.

Keywords: Cognition, Indigenous, substance abuse, petrol sniffing.

4.1 INTRODUCTION

Volatile solvent abuse (VSA) is a worldwide problem, however petrol sniffing (also termed gasoline inhalation or huffing) is a form of VSA that occurs more commonly in disadvantaged or isolated societies, and the practice has become endemic in some remote Indigenous communities (Brady, 1992; Cairney, et al., 2002; Tregenza, 2002). While petrol is not the only substance used, it can be the most accessible. In the Anangu Pitjantjatjara lands of South Australia, acquired brain injury from petrol sniffing has become the single biggest cause of disability amongst its people (Tregenza, 2002). This may reflect the unique cultural, geographical, and social context surrounding remote Indigenous Australians, including a history of cultural oppression and dispossession, considerable geographical isolation, poor health and healthcare, as well as reduced employment and recreational opportunities. Impairments of psychomotor, memory, attention, learning and executive functions can be associated with petrol sniffing (or other solvent abuse) and these impairments can present prior to the more severe neurological symptoms such as ataxia, nystagmus and dementia (Cairney, et al., 2002; Cairney, et al., 2004a, 2004c). Hence in individuals who abuse petrol, the measurement of cognitive function may be a useful tool for early detection of the adverse CNS effects of petrol abuse and for monitoring responses to rehabilitation strategies.

Impairment in cognitive function may reduce an individual's insight into their own behaviours and therefore their desire or ability to seek or respond to treatment (Fals-Stewart, et al., 1994; Teichner, et al., 2002). Furthermore, individuals with more severe cognitive impairments are more likely to drop out of rehabilitation or

substance abuse treatment programs (Teichner, et al., 2002). This may be because treatment programs often rely on cognitive skills such as memory, attention, and complex cognition in order to educate and achieve treatment outcomes (M. E. Bates, et al., 2002; Fals-Stewart, et al., 1994). Hence in addition to psychiatric, psychological, medical and social domains, cognitive function may be an important element to consider in the effectiveness of substance abuse treatment programs (Brannigan, Schackman, Falco, & Millman, 2004). Clear identification of cognitive impairments would enable health practitioners to recommend and support access to treatment, and allow treatment providers to adjust the complexity or timing of treatment programs to accommodate any identified impairments, presenting more complex material as cognitive recovery proceeds (Fals-Stewart, et al., 1994). For treatment providers, cognitive assessment is a useful tool to monitor the effects of abstinence and educate clients about the importance of treatment or the severity of their substance abuse. Rigorous evaluation of treatment outcomes is a key element for effective treatment programs (Brannigan, et al., 2004) that may be strengthened substantially by inclusion of the robust psychometric indicators provided by cognitive assessment.

Conventional cognitive assessment tools can be inappropriate for Indigenous populations however, as they are typically developed in a Western European and American context and rely heavily on the use of English spoken and written language and on concepts that may be unfamiliar to Indigenous people (Dingwall & Cairney, 2010b). Test interpretation can be difficult as standardisation samples are usually comprised of non-Indigenous individuals (Dingwall & Cairney, 2010b).

Performance impairments identified among different cultural or ethnic groups using

conventional assessment tools may therefore arise from cultural or contextual determinants such as familiarity with Western European or American concepts, practices, language, or education, rather than being an accurate measure of cognitive function (Cairney & Maruff, 2007a). Appropriate assessment of any cultural group must therefore involve the use of culturally fair assessment tools where performance scores are interpreted with respect to the performances of individuals from the same group.

The CogState test battery is a set of non-verbal, computerised, cognitive tasks developed to be culturally neutral (Cairney & Maruff, 2007a). Designed in response to the need for appropriate cognitive assessments for Indigenous Australians, the test has since been applied more widely, with its scientific validity and clinical utility first demonstrated in various non-Indigenous as well as non-English speaking populations (Cairney & Maruff, 2007a; Collie, Maruff, Makdissi, et al., 2003; Straume-Naesheim, et al., 2005). The validity and reliability of these assessment processes have also been established within healthy Indigenous groups (Dingwall, et al., 2009; Lewis, et al., 2010) and they have been used to define specific cognitive changes associated with heavy episodic alcohol abuse in Indigenous Australians (Cairney, et al., 2007). It is therefore likely that this same assessment process might be appropriate for the assessment of cognitive function for people in programs designed for the treatment of substance abuse.

The paper's aim was to investigate the utility of the cognitive assessment process for use in substance abuse rehabilitation programs. Study One considered the demographic (e.g. age) or contextual factors (e.g. locality) that may impact on

cognitive performance in healthy Indigenous adults from regional and remote communities representative of those affected by petrol sniffing. Study Two investigated the nature and magnitude of cognitive impairment in Indigenous individuals who had abused petrol.

4.2 METHODS

The procedure and apparatus were consistent across both Study One and Study Two and are described once here.

4.2.1 Procedure

Participants were recruited voluntarily from Indigenous secondary or tertiary education centres, drug rehabilitation centres, or an adult correctional facility in the Northern Territory. Indigenous specific secondary and tertiary education institutions in Darwin and Alice Springs (i.e. 4), were chosen to enable assessment of large groups of Indigenous people representing a variety of communities throughout the region. All known residential rehabilitation centres (i.e. 3) in Darwin and Alice Springs treating petrol sniffers at the time of the study were also selected. All organisations invited agreed to participate. Participants therefore represented over 25 different language groups, 60 distinct communities, and geographical regions including the arid desert of central Australia and the tropics of Northern Australia.

The joint Human Research Ethics Committee for the Department of Health and Community Services and Menzies School of Health Research granted ethical

approval. All individuals attending treatment at the rehabilitation organisations during the two-year period (2007–2009), who were present on the fortnightly study days, were invited to participate. All individuals attending health certificate courses at the tertiary education institutions, the entire student population of the secondary college, and all Indigenous medium security prisoners from the correctional facility who were present on the study days were invited to participate. Each participant (and a guardian if under 18 years old) gave written informed consent.

Questionnaires eliciting demographic information (including age, education, community, medical history, etc) and substance use histories (including frequency, amount, first and last use of alcohol, cannabis, solvents, cigarettes, kava or other drugs) were completed with the participants by trained researchers. Where available, this data was crosschecked with more detailed self report data, clinic notes, and proxy assessments using a consensual methodology described previously in this population (Clough et al., 2002; Clough, Cairney, et al., 2004).

Up to seven trained researchers conducted the assessments at the education, rehabilitation or correctional facilities with groups of up to 15 participants tested together at one time. The average ratio of supervisors to participants was 1:2. At the beginning of each task, the researchers explained the instructions and guided participants through a practice session in which they had one to five trials to demonstrate their understanding of the task. Following this, researchers explained that the practice was over and they would now do the ‘real test’. Completion of each task led straight into the practice session for the next task.

4.2.2 Apparatus

The CogState computerised cognitive test battery used here consisted of seven cognitive tasks selected, through previous research and consultation with Indigenous community members, to be suitable for assessing Indigenous Australians. The time for administration was approximately 20 minutes and stimuli in each subtest are presented repeatedly with data averaged over those presentations. Each has been described in detail elsewhere and is summarised below (Collie, et al., 2007; Dingwall, et al., 2009; Falleti, et al., 2006; Lewis, et al., 2010).

4.2.2.1 Card Based Tasks

These tasks are in the form of card games with a playing card initially presented face down in the centre of the screen (see Figure 1a).

Detection Task: The participant attends to the card and presses either the ‘K’ (if right hand dominant) or ‘D’ (if left hand dominant) key as fast as they can when the card turns face up. This is a simple reaction time task measuring visual attention and psychomotor function.

Identification Task: The participant attends to the card and, when the card turns face up, follows the rule ‘Is the face-up card red?’. The ‘K’ and ‘D’ keys correspond to ‘yes’ and ‘no’ respectively (reversed if left hand dominant). This is a choice reaction time task measuring visual attention.

Visual Learning Task: Measuring working memory and attention, this task requires the participant to attend to the card and follow the rule ‘Have you seen this card before in this task?’ with ‘K’ and ‘D’ corresponding to ‘yes’ and ‘no’ respectively (reversed if left hand dominant).

4.2.2.2 Non Card Based Tasks

The other CogState tasks were presented using more complex visual displays.

Groton Maze Chase Test (GMCT; See Figure 1b for onscreen task layout): For this psychomotor task, a grid 10 tiles by 10 tiles is presented with a target tile in the top left. The participant has to click the target tile with the mouse and ‘chase’ it around the grid as it moves one tile at a time. The task continues for 30 seconds and records the total number of correct movements per second.

Groton Maze Learning Test (GMLT; See Figure 1b for onscreen task layout): Using the same grid as the GMCT, the participant uses the mouse to uncover a circuitous path, moving one tile at a time (across 28 ‘correct’ tiles), from one corner of the grid to the diagonally opposite corner. On the first presentation, the path can only be found using trial and error. Correct responses are indicated with a tick, and incorrect responses with a cross. If a cross is revealed, the participant must click on the last correct tile to continue. Once the pathway has been uncovered and completed, the task is repeated for four more rounds along the same path. This task measures executive function.

Groton Maze Learning Test – Delayed Recall (GMLT-R): Approximately 10 minutes after completing the five presentations of the GMLT, and with other tasks being completed in the interim, the grid is presented once more. The participant is required to remember the same hidden pathway as presented on the initial trials and complete it as quickly and accurately as they can. This task measures visual learning and memory.

Continuous Paired Associate Learning (CPAL) (See Figure 1c for onscreen task layout): This task measures learning and spatial awareness using a series of eight blue balls. During acquisition, the participant learns the location of six patterns, presented serially in individual balls leaving two ‘empty’ distracter balls. Then, one of the patterns is presented in a central location and the location of that pattern’s matching pair has to be recalled and clicked with the mouse. The task will not progress until the location of the pattern is correctly recalled, and will continue until the locations of all six patterns have been remembered. After acquisition, this task is repeated for five rounds (locating all six patterns) with the patterns in the same location for each round.

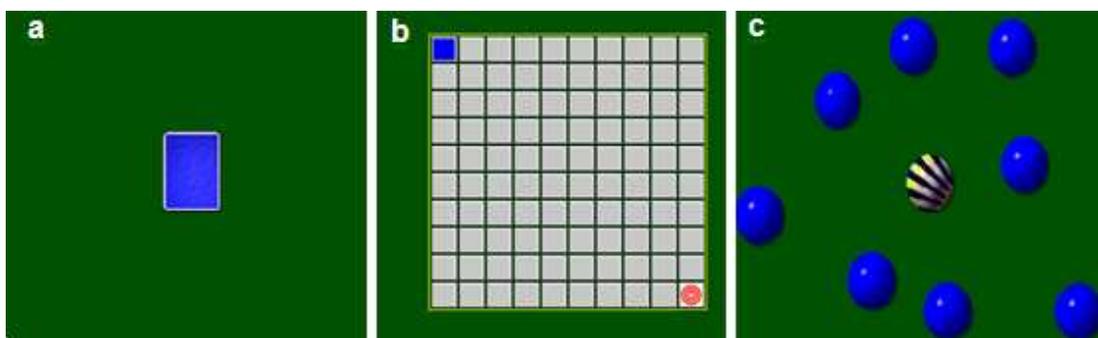


Figure 1. On-screen representation of (a) card based tasks, (b) Groton Maze Learning Test and (c) Continuous Paired Associate Learning task.

4.3 STUDY ONE

4.3.1 Participants

Individuals were selected for Study One if: (1) their usual alcohol consumption was less than six drinks per occasion, or their consumption was between six and ten alcoholic beverages per occasion *and* last use was greater than 180 days ago; (2) they had never abused volatile solvents regularly (i.e. > 1 time); and (3) they had not abused any other drugs (excluding cannabis) regularly (i.e. > 1 time). Because concurrent cannabis use was common in our sample of petrol sniffers and due to its increasingly widespread use in Indigenous communities, this will be factored into the analyses described below (Clough, et al., 2006; Lee, Clough, & Conigrave, 2007). Exclusion criteria included self reported psychiatric conditions or use of psychotropic medications. These individuals represented a naturalistic sample of Indigenous Australians ($N = 206$; 95 males and 111 females) aged between 11 and 68 years ($M = 28.03$, $SD = 13.45$) from urban, rural or remote areas.

4.3.2 Data Analysis

A series of standard linear multiple regression analyses were conducted on data from this group to identify any relationship between performance measures and six demographic factors: age, education, level of remoteness (locality), regular long-term cannabis use, gender, and familiarity with computers (computer familiarity). Age, education, and locality were continuous variables and cannabis use (yes/no), gender (female/male), and computer familiarity (used a computer before/not used a

computer before) were dichotomous variables. Daily or near daily use of cannabis for greater than 5 years has been associated with subtle cognitive impairment in non-Indigenous users (Hall, Solowij, & Lemon, 1994). Therefore, regular long-term cannabis use was defined as use of cannabis more than five times per week for greater than 5 years. Locality was defined by the Accessibility/Remoteness Index of Australia (ARIA+) for the participant's home community. This is the standard Australian Bureau of Statistics endorsed measure of remoteness and is expressed as a number on a scale from 0 (least remote) to 15 (very remote) (GISCA, 2006).

Speed (reaction time and duration) measures were recorded in milliseconds. These measures were transformed using logarithmic (base 10) transformations and accuracy data (number of correct responses divided by number of presentations) for the card tasks were transformed using arcsine transformations as prescribed by the test developers and to achieve normal distributions (Collie, Maruff, Makdissi, et al., 2003; Falletti, et al., 2006; Mollica, et al., 2005; Straume-Naesheim, et al., 2005).

Total number of errors for GMLT-R and CPAL exhibited very minor skew.

Transformation of these variables resulted in no change to the substantive interpretation of the analyses, so results using untransformed data are presented to enable more meaningful interpretation. All other variables, including moves per second (mps; number of correct moves divided by total duration), had normal distributions. Data analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 16.0 (SPSS Inc; Chicago, IL, USA). Initial inspection of the data indicated 37 univariate outliers (greater than 2 SD from the mean) across the 15 measures which were removed. Four multivariate outliers were removed from the regression analysis for the GMCT and one was removed from the

mps measure of the GMLT. As the number of statistical comparisons was high due to the exploratory nature of the study, significance levels for the tests were set at $\alpha < 0.01$ to reduce the risk of Type I error.

4.3.3 Results

The multiple regression analyses indicated that the 6 predictors together accounted for a significant proportion of the variance in: Detection speed ($F_{(6, 185)} = 4.27$; $p < .01$); Visual Learning accuracy ($F_{(6, 184)} = 5.05$; $p < 0.01$); GMCT mps ($F_{(6, 182)} = 20.75$; $p < 0.01$); GMLT mps, and log duration ($F_{(6, 180)} = 15.14$, $p < 0.01$; $F_{(6, 182)} = 14.79$; $p < 0.01$ respectively); GMLT-R mps, and log duration, ($F_{(6, 172)} = 7.38$, $p < 0.01$; $F_{(6, 177)} = 9.12$, $p < 0.01$ respectively) and CPAL log duration and errors ($F_{(6, 179)} = 21.95$, $p < 0.01$; $F_{(6, 176)} = 6.26$, $p < 0.01$ respectively). There were no violations of the assumptions apart from some very slight heteroscedasticity on GMCT mps, GMLT mps, and GMLT-R mps.

Mean scores, values for R , R^2 and semi-partial correlations (sr^2) for significant predictors are presented in Table 1. Age and computer familiarity accounted for the greatest amount of unique variability for the more complex, non-card based measures with better performance (faster or more accurate) for those who were younger and those who had used a computer before. Age and education impacted significantly on just one of the simpler card based tasks (i.e., Detection). Those of younger age and those with more years of education had better reaction times than older or less educated participants. As age was the most significant predictor of performance (up to 22% of the unique variance explained), particularly on the more complex speed

measures, these effects were investigated in more detail by expressing figuratively performance by six age categories (i.e., under 15s, 15–18, 19–29, 30–39, 40–49 and 50+). Results indicated a gradual worsening in performance with increasing age, beginning primarily around the 30s but in some cases beginning in the late teens with a plateau in young adulthood (20s–40s).

Table 1. R, R Square and Significant Semi-Partial Squared Correlations for Multiple Regression Analyses (Study One)

Task (cognitive function assessed)	n	Mean Score	R	R ²	Age sr ²	Education sr ²	Locality sr ²	Computer sr ²	Gender sr ²
Card Tasks									
<i>Detection</i> (Psychomotor)	192	2.56	.35*	.12	.06*	.04*			
<i>Identification</i> (Visual attention)	185	2.78	.24	.06					
<i>Visual learning</i> (Working memory)	191	0.66	.38*	.14					
Non-Card Tasks									
<i>Groton Maze Chase Test</i> (Psychomotor) moves per second	189	1.30	.64*	.41	.22*			.07*	
Groton Maze Learning Test (GMLT; Learning and executive function)									
- Moves Per Second	187	0.58	.58*	.34	.20*			.04*	
- Log Duration	189	5.46	.57*	.33	.21*			.03*	
- Total Errors	177	80.78	.27	.07					
GMLT-delayed recall (Visual learning and memory)									
- Moves Per Second	179	0.74	.45*	.21	.10*			.05*	
- Log Duration	184	4.60	.49*	.24	.13*			.04*	
- Total Errors	177	10.15	.24	.06					
Continuous Paired Associate Learning (Associate learning and spatial awareness)									
- Log Duration	186	5.32	.65*	.42	.22*			.06*	
- Total Errors	184	40.78	.42*	.18	.07*			.03^	

Note. *p < .01. ^p = .01

4.4 STUDY TWO

4.4.1 Participants

Participants 25 years or younger who were classified as either healthy controls (from Study One; $n = 96$) or current petrol sniffers ($n = 50$) were included in this study.

Petrol sniffers were defined as those who inhaled petrol regularly or episodically and had done so within the past 60 days (but not < 12 hours prior to testing). These individuals had been excluded from analysis in Study One due to their history of petrol sniffing. Five participants had inhaled substances other than petrol (i.e., paint, glue or aerosols); however removal of these participants resulted in no change to the significance or magnitude of results so their data were included. Frequency of petrol sniffing ranged from once per week to everyday with the majority sniffing daily.

Demographic characteristics of the two groups are presented in Table 2.

Table 2. Demographic Characteristics of Controls and Petrol Sniffers (Study Two)

	Controls (n = 96)	Petrol Sniffers (n = 50)
Mean age in years (SD; Range)	16.26 (4.07; 11-25)	17.35 (3.65; 11-25)
Mean education in years (SD; Range)	7.44 (2.55; 4-13)	7.92 (2.41; 0-12)
Mean ARIA+ (SD; Range)	12.30 (3.07; 3-15)	11.50 (3.25; 3-15)
No. regular long term cannabis users (%)	6 (6.2%)	6 (12.2%)
No. used a Computer before (%)	81 (84.4%)	37 (74%)
No. males (%)	41 (42.7%)	38 (76%)*
Mean years of VSA (SD; Range)	-	4.44 (3.82; 0-13)*

Note. Where scores for petrol sniffers were significantly different to controls * $p < .01$.

4.4.2 Data Analysis

Independent groups *t*-tests and chi-square analyses were conducted to investigate whether the groups were equal on those factors found in Study One to impact on cognitive performance (i.e., age, education, computer familiarity). Independent groups *t*-tests with each of the cognitive measures as dependent variables were then used to identify any differences in cognitive performance between the two groups (controls and petrol sniffers).

Speed and accuracy measures were transformed as per Study One to achieve normal distributions. Total errors for GMLT was slightly skewed, however transforming the data resulted in no change to the substantive interpretation, so results from untransformed data are presented. All other variables had normal distributions. Initial inspection of the data resulted in removal of 39 univariate outliers (greater than 2 SD from the mean) across the 15 measures. Significance levels were again set at $\alpha < 0.01$ to reduce the risk of Type I error.

4.4.3 Results

Mean age ($t_{(141)} = -1.97$; $p = 0.051$), years of education ($t_{(141)} = -1.25$; $p = 0.21$), and proportions of individuals who had or had not used a computer before ($\chi^2 = 2.19$; $p = 0.14$; continuity correction) were not significantly different between the controls and petrol sniffers (see Table 2). Petrol sniffers had significantly worse performance compared to controls for Identification speed ($t_{(135)} = -3.67$; $p < 0.001$), GMCT mps ($t_{(138)} = 8.64$; $p < 0.001$), GMLT mps ($t_{(135)} = 4.84$; $p < 0.001$), GMLT log duration

($t_{(130)} = -4.68$; $p < 0.001$), GMLT total errors ($t_{(52)} = -2.82$; $p < 0.01$; equal variances not assumed), GMLT-R mps ($t_{(131)} = 4.18$; $p < .001$), GMLT-R log duration ($t_{(131)} = -4.49$; $p < 0.001$), CPAL log duration ($t_{(137)} = -6.35$; $p < 0.001$), and CPAL total errors ($t_{(125)} = -5.79$; $p < 0.001$; see Table 3). Levene's test of homogeneity of variance was significant for Visual Learning accuracy, and GMLT total errors so SPSS results with equal variances not assumed are presented for these variables. Effect size estimates (Cohen's d) are presented in Table 3 suggesting medium to large effect sizes (0.66 to 1.52) for significant measures, according to Cohen's classifications (Cohen, 1988).

Table 3. Group Means (Standard Deviations) and Effect Sizes for Each of the Cognitive Measures (Study Two)

Task (cognitive function assessed)	n	Controls Mean (SD)	Petrol Sniffers Mean (SD)	Effect Sizes (Cohen's d)
<u>Card Tasks</u>				
<i>Detection</i> (Psychomotor)	143	2.54 (0.13)	2.57 (0.13)	0.19
<i>Identification</i> (Visual attention)	140	2.78 (0.08)	2.84 (0.10)*	0.66
<i>Visual learning</i> (Working memory)	144	0.59 (0.22)	0.59 (0.14)	0
<u>Non-Card Tasks</u>				
<i>Groton Maze Chase Test</i> (Psychomotor)				
Moves Per Second	140	1.54 (0.32)	1.01 (0.40)*	1.52
<i>Groton Maze Learning Test</i> (GMLT; Learning and executive function)				
- Moves Per Second	137	0.67 (0.19)	0.52 (0.15)*	0.89
- Log Duration	132	5.39 (0.12)	5.49 (0.10)*	0.89
- Total Errors	131	77.28 (27.45)	103.37 (57.52)*	0.66
<i>GMLT-delayed recall</i> (Visual learning & memory)				
- Moves Per Second	133	0.83 (0.27)	0.63 (0.24)*	0.76
- Log Duration	133	4.54 (0.15)	4.67 (0.17)*	0.83
- Total Errors	130	10.11 (6.64)	11.90 (5.99)	0.28
<i>Continuous Paired Associate Learning</i> (Associate learning and spatial awareness)				
- Log Duration	139	5.25 (0.12)	5.39 (0.13)*	1.15
- Total Errors	127	26.93 (20.94)	52.44 (27.84)*	1.09

Note *significantly different to controls at $p < .01$

4.5 DISCUSSION

Age, computer familiarity, and education were shown in Study One to impact on the cognitive performance of a group of healthy Indigenous Australians. While the amount of unique variance accounted for by computer familiarity and education was low (between 3 and 7%), age accounted for up to 22% of the unique variance in performance on some measures. Education impacted only on the simplest card based task (i.e., Detection) and age and computer familiarity impacted predominately on the more complex tests of learning, memory, psychomotor and executive functions. Study two demonstrated that after controlling for these demographic factors, petrol sniffers showed significantly poorer performance on tasks of visual attention, psychomotor skills, executive function, visual learning and memory and spatial awareness with up to 1.5 standard deviations separating the means of the two groups. This poorer performance was evidenced primarily by significantly reduced speed but also reduced accuracy on the more complex tasks with the greatest deficits (large effect sizes) observed for the psychomotor, learning and executive function, and spatial awareness domains.

The significant impact of age and familiarity with computers on performance is consistent with findings from another study using this test in older, non-Indigenous people (Fredrickson et al., 2010). The significant effect for age may be expected considering the large range of ages represented in Study One. Graphing performance by decade in general revealed gradual cognitive declines across the years, beginning primarily around the 30s but in some cases from the late teens with a plateau in early adulthood. Age related cognitive changes, such as these, are expected across the

lifespan. Finding age to have the greatest impact on performance is consistent with previous studies in adults (aged 18–90) demonstrating that age is the strongest and most consistent predictor of memory performance (West, Crook, & Barron, 1992).

The relatively small but significant effect of computer familiarity highlights the importance of familiarity and underscores approaches taken where the test can be repeated until the individual's understanding of the task has been demonstrated. A recent study using CogState in older non-Indigenous people also found an association between low computer familiarity and slower initial performance that did not persist with subsequent testing (Fredrickson, et al., 2010). This indicates that it is possible to overcome a lack of familiarity by allowing people to do multiple tests. These results also suggest that the lower performance for some Indigenous people was not related to their ethnicity per se rather it is merely a function of computer experience and reflects similar findings in non-Indigenous groups. Taken together the results of Study One indicate that the test battery can be used appropriately with Indigenous people.

In Study Two, petrol abuse was associated with significantly reduced performance (between 0.7 and 1.5 SD) compared to healthy controls for the more complex tests of psychomotor function, memory, learning, executive function, and spatial awareness. Fewer differences were found however between petrol sniffers and controls on the simpler tests of psychomotor function and working memory. While this suggests that complex cognition and attention may be significantly compromised (with medium to large effect sizes) in those attending rehabilitation for petrol abuse, it also suggests that simpler cognitive processes may remain relatively intact. These

findings reflect those of similar studies in Indigenous populations where recreational petrol abuse was associated with severe memory and attentional impairments but performance on simpler tests (e.g. simple and choice reaction time) remained unimpaired (Cairney, et al., 2004a; Maruff, et al., 1998). Removal of individuals who had abused only other solvents (e.g., paint, glue) from the analysis resulted in no change to the results. Volatile solvents such as petrol, paint, and glue comprise varying combinations of aliphatic and aromatic hydrocarbons including xylene, toluene, *n*-hexane and benzene which are highly lipid soluble (Dingwall & Cairney, 2010c). Previous research demonstrates similarities between the pharmacological and neurotoxic effects of these substances that reflect similarities in their composition (Cairney, et al., 2004a; Cairney, Maruff, Burns, Currie, & Currie, 2004b; Dingwall & Cairney, 2010c; Hormes, Filley, & Rosenberg, 1986; Maruff, et al., 1998). The results from this study may therefore also apply to other solvent abusers and not just to petrol sniffers.

Cognitive performance deficits such as those reported here and in other studies may be the first sign of more severe or irreversible neurological damage (Cairney, et al., 2004a; Maruff, et al., 1998). Previous research suggests that rehabilitation clients with cognitive deficits tend to make less clinical progress, spend less time in treatment and participate less throughout the treatment process (Teichner, et al., 2002). The specific relationship between baseline cognitive performance and treatment outcome for this population should therefore be investigated. Previous research also suggests however, that some degree of cognitive recovery can occur with abstinence from further petrol abuse (Cairney, et al., 2004b, 2005). The treatment process might therefore be enhanced if rehabilitation centres actively

monitored cognition and individual programs were modified to accommodate any cognitive impairments by delaying introduction of complex material until improvements in cognitive function are observed. Ongoing monitoring of cognition throughout the treatment process might therefore be beneficial, not only to inform the treatment process, but also to educate and illustrate to clients the effects of their substance use behaviours. More research is needed however to investigate the value of actively monitoring cognition and adapting programs to accommodate identified impairments in relation to treatment outcome. Future research should also investigate the utility of this process to assess substance abuse related cognitive changes over time.

The assessment of participants in small groups may be considered a limitation of this study as interference, distraction, and learning through observation may have introduced unexplained variance into the data. One to one supervision of participants might have enhanced the data collection process by minimising motivational or compliance issues. However, group assessments are a common method of data collection using this tool (Collie, Maruff, Makdissi, et al., 2003; Dingwall, et al., 2009; Lewis, et al., 2010; Straume-Naesheim, et al., 2005) and a ratio of supervisors to participants of 1:2 was generally achieved. With this ratio, the appropriate supervision of participants was manageable and the impact of non-compliance minimal. In treatment settings, this issue is likely to be further eliminated if assessments are conducted on initial intake interview or within one to one counselling sessions.

While Study One indicated that the impact of age and familiarity with computers should be considered when assessing the cognitive performance of Indigenous Australians with computerised assessments, other factors such as locality and gender, do not appear impact substantially on performance in this sample. Study Two identified reduced cognitive performance in petrol sniffers that worsened as the complexity of the task increased. The utility of the computerised cognitive assessment battery for detecting substance abuse related impairments for Indigenous petrol sniffers in primary care settings was demonstrated. These results provide a basis from which future research can occur investigating the specific relationships between cognitive performance patterns, defined level and type of substance abuse, and treatment outcomes.

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Chapter 5

Detecting Psychological Symptoms Related to Substance Use among Indigenous Australians

Preface

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Effects on cognition are but one consequence of substance abuse. Associations between substance use and mental health are also well established. However, substance use and psychological problems are quite often managed separately with poor understanding regarding their underlying interrelationships and treatment. Research suggests that individuals with comorbid substance use and psychological disorders may have poorer treatment outcomes than those with either disorder alone. It is therefore necessary to identify and address psychological symptoms among substance users attending treatment. As discussed in Chapter 1, the Strong Souls assessment was identified as the most appropriate tool for use in this research. However, as the focus of this thesis was on cognition, an appropriate, abbreviated version of Strong Souls was adopted for use in this research. This chapter therefore assesses the appropriateness of an eight-item screening tool derived from Strong Souls, for detecting psychological symptoms among Indigenous Australian substance users. Like the previous chapter, this chapter also examines any impact of demographic or other contextual factors on each of the test items so that these may be considered when interpreting the test results. To understand the impact of psychological symptoms on substance abuse generally in this population, associations were examined for all substances commonly used among the target group, rather than just petrol and alcohol, which are the primary focus of this thesis. The outcomes of these analyses will then inform the relevant aspects of study design for the subsequent empirical chapters.

**Detecting psychological symptoms related to substance use among Indigenous
Australians**

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ABSTRACT

Introduction and Aims: Substance misuse and psychological comorbidities can be common and may impact negatively on treatment outcomes. However, without appropriate tools, detecting psychological symptoms for Indigenous people can be difficult. This study assessed the appropriateness of an 8-item screening tool (based on Strong Souls) for measuring any relationships between substance use and psychiatric symptoms for Indigenous Australians. **Design and Methods:** Indigenous Australians attending secondary or tertiary education institutions or substance use rehabilitation facilities in the Northern Territory (n = 407; mean age = 27.82) were assessed for depressive, anxiety and psychotic symptoms. The group represented 45 language groups from 95 urban and remote communities. English comprehension was measured on a scale from 0 (no understanding) to 10 (excellent understanding; M = 7.99, SD = 2.31). Ordinal regression analyses examined any associations between demographic and substance use factors and psychological symptoms. **Results:** Compared to non-users, current cannabis users were significantly more likely (ORs = 2.2 - 4.4) to experience depressive or anxiety symptoms. Frequent cannabis users experienced more symptoms than occasional users. Prior-solvent users were more likely to feel lonely (OR = 2.18) compared to non-solvent users. Frequent alcohol users were less likely (OR = 0.44) to feel sad than non-users. These results are interpreted with respect to previous research and methodological limitations. **Discussion and Conclusions:** Symptoms of depression or anxiety may be common for individuals seeking treatment for substance misuse and with minor improvement these 8-items, may provide a useful screen for psychological symptoms in Indigenous Australians. **Keywords:** Indigenous, substance use, depression

5.1 INTRODUCTION

Substance use disorders often coexist with other psychological disorders and their course and prognosis may be more chronic than for either disorder alone (Kessler, et al., 1996). A recent Australian study found that just under half of adult females and a third of males with alcohol use disorders also met criteria for a comorbid anxiety, affective or other drug use disorder (Teesson, Hall, Lynskey, & Degenhardt, 2000). For those with another drug use disorder, two thirds of both males and females met criteria for another anxiety, affective or alcohol use disorder (Teesson, et al., 2000). However, the likelihood of an individual seeking treatment increases with the presence of more than one disorder (Regier et al., 1990; Scott, Gilvarry, & Farrell, 1998). This provides a unique opportunity for substance misuse treatment providers to actively screen for and detect comorbid psychological symptoms.

While higher rates of affective or anxiety (Clough, et al., 2005; Degenhardt, Hall, & Lynskey, 2001a; Lee, Clough, Jaragba, Conigrave, & Patton, 2008; Regier, et al., 1990; Teesson, et al., 2000), personality (Kessler, et al., 1996; Rey, Sawyer, Raphael, Patton, & Lynskey, 2002), and psychotic symptoms (Arseneault et al., 2002; Clough, et al., 2006) have been documented for both adolescent and adult substance users, some studies also report attenuation of these associations after controlling for demographic, personality and other drug use factors (Degenhardt, et al., 2001a; Degenhardt, Hall, & Lynskey, 2001b; Green & Ritter, 2000). Few studies have examined the differential psychological effects of psychoactive substances for Indigenous Australians. While one study found an association between cannabis use and psychotic symptoms for Indigenous Australians aged 13–36, another found no

such relationship (Clough, et al., 2005; Clough, et al., 2006). Associations between cannabis use, anxiety and depressive symptoms for Indigenous Australians were also modified (in some cases to non-significance) when individuals with a history of petrol sniffing (a form of volatile solvent use) or alcohol use were removed (Clough, et al., 2005). Little research has examined the psychological effects of regular volatile solvent use for Indigenous Australians. However, a history of petrol sniffing has been associated with later cannabis use in this population (Lee, Conigrave, Clough, et al., 2009). In addition, limited evidence from other populations indicates that regular solvent use can be a significant risk factor for suicide (Freedenthal, Vaughn, Jensen, & Howard, 2007; Kirmayer, Boothroyd, & Hodgins, 1998) and depressive (Jacobs & Ghodse, 1987) or psychotic (Daniels & Latcham, 1984) symptoms.

Mental health disorders account for the second largest proportion (i.e., 15%) of total disease burden for Indigenous Australians (Vos, et al., 2007). Anxiety and depression, alcohol dependence and harmful use, and schizophrenia are the largest contributors to this mental health burden (Vos, et al., 2007). Additionally, substance use disorders account for the majority of the gap between Indigenous and non-Indigenous mental health (Vos, et al., 2007). Given this evidence it is important to screen for psychological symptoms in Indigenous people using psychoactive substances (Dingwall & Cairney, 2010b). However, differing definitions, manifestations, and conceptualisations of health and mental health among Indigenous Australians mean that traditional assessment tools can be inappropriate for Indigenous people (Dingwall & Cairney, 2010b). For example, unique findings with Indigenous Australians suggest a link between the externalisation of anger with

depression as well as a different pattern of suicide risk based on impulsivity rather than prolonged depressive symptoms (Esler, et al., 2008; Thomas, et al., 2010; T. Westerman, 2002). For Indigenous Australians, psychological assessments should therefore reflect Indigenous conceptualisations and expressions of mental health.

This article describes an eight-item screening tool, based on the recently developed Strong Souls inventory, for measuring psychological symptoms for Indigenous Australians (Thomas, et al., 2010). The aim was to examine the utility of the tool for detecting associations between psychological symptoms and substance use for this population.

5.2 METHODS

5.2.1 Participants

The larger focus of this study was to monitor neuropsychological performance with solvent users. All known residential rehabilitation centres (i.e. 3) in Darwin and Alice Springs who were treating volatile solvent use specifically, as well as other substance use at the time of the study, were invited to participate. Indigenous specific secondary and tertiary education institutions in Darwin and Alice Springs (i.e. 4), were also invited, to enable assessment of large groups of ‘healthy’ (i.e. with infrequent or no substance use) Indigenous people, representing a variety of communities throughout the region. All seven organisations invited agreed to participate. Participants represented over 45 different language groups and 95 urban, rural and remote communities. English comprehension was measured by asking

participants how well they understood English. Responses were measured on a pictorial scale from 0 (no understanding) to 10 (excellent understanding). If participants were unable to understand the question, the researcher gave a score of 0. Individuals with very poor English understanding (response < 3; n = 9) were excluded from the study. Participants therefore consisted of 224 (55%) males and 183 (45%) females aged 11–68 years (M = 27.82; SD = 12.03) with an average rating of English understanding of 7.99 (SD = 2.31).

5.2.2 Procedure

The joint Human Research Ethics Committee of Menzies School of Health Research and the NT Health Department granted ethical approval prior to recruitment and data collection. All individuals attending treatment at the rehabilitation organisations during the two-year period (2007–09), or attending health certificate courses at the tertiary education institutions, and the entire student population of the secondary college, who were present on the fortnightly study days, were invited to participate. Each participant (and their guardian if under 18 years old) was advised of the study's aims, advised that participation was voluntary and gave written informed consent prior to participation. Up to seven trained researchers conducted the assessments at the education or rehabilitation facilities with groups of up to 15 participants assessed together at one time. The average ratio of supervisors to participants was 1:2. Demographic information was first collected using pencil and paper questionnaires completed with the participants by the trained researchers. Then, as part of a computer interface (see Figure 1(a) for onscreen presentation), participants were asked if they ever 'drink grog', 'sniff petrol or other stuff' (i.e. solvents) 'smoke

gunja' (i.e. cannabis) or 'smoke cigarettes'. Questions and responses were read aloud to participants who selected with the mouse either 'never', 'used to not anymore', 'yes little bit', 'yes fair bit', 'yes everyday' or 'no response' (so no verbal response was required). Where available, demographic and substance use data were crosschecked with more detailed self-report data, clinic notes, and proxy assessments using a consensual methodology described previously in this population (Clough, Cairney, et al., 2004). This information was substituted where data were missing or if inconsistencies were noted. Following this the eight-item screening tool was completed.



Figure 1. Onscreen presentation of (a) one of the substance use questions and (b) one of the psychological items

5.2.3 Strong Souls and the Eight-Item Screening Tool

Strong Souls is a recently developed questionnaire designed to measure psychological symptoms for Indigenous Australians (Thomas, et al., 2010). It shows good internal reliability ($\alpha = 0.70$), good discriminant ability, and good convergent and construct validity (Thomas, et al., 2010). To develop Strong Souls, comprehensive reviews of Indigenous and general mental health literature and

assessment tools were conducted as well as widespread consultation with a network of Indigenous people and Indigenous mental health experts producing an initial pool of potential questions. The current authors then selected eight items from this initial pool of questions, as they were considered appropriate items by the Strong Souls consultation network, demonstrated good psychometric properties during Strong Souls pilot testing, and were considered most relevant to the study’s larger aim of investigating neuropsychological changes associated with solvent use. The items were presented prior to a computerised cognitive test (CogState), as part of the same computer interface (see Figure 1(b) for question presentation). Table 1 lists the items with their variable names as used in this paper. The researchers asked participants, ‘In the past week have you felt any of these things?’ and then read each item aloud. The participant was required to select either ‘not much’, ‘sometimes’, ‘fair bit’, or ‘lots’ with the computer mouse. Participants could select ‘no response’ if they did not want to answer each question. The lack of a ‘never’ category was identified as an issue early in the research so participants were instructed to choose ‘not much’ if their answer was ‘never’.

Table 1. Psychological Items Used and Variable Name

Variable	Items
SLEEP	Wake up in the middle of the night and can’t get back to sleep?
THINK	Thinking all over the place. Can’t remember stuff
ANGRY	Get angry or wild real quick?
WORRIED	Have you felt so worried it was hard to breathe? Maybe feel shaky too?
SAD	Have you felt so sad that nothing could cheer you up?
VOICES	Heard voices in the head? Not cultural stuff.
LONELY	Feel lonely all the time even around other people?
TROUBLE	Feel like you are too much trouble? People don’t like you?

5.2.4 Data Analysis

Items were examined for endorsement rates and non-responses to identify potentially problematic items. Internal reliability was assessed using Cronbach's alpha (SPSS Version 16.0, SPSS Inc., Chicago, IL, USA). Ordinal regression analyses (using the logit link function) examined any associations between demographic, substance use and psychological factors. For substance use, cell numbers were small for 'yes fair bit' and 'yes everyday' so these were collapsed into one category – 'frequent use'. Reported use of alcohol, cannabis, solvents, and cigarettes were included as factors along with gender, locality (urban/remote) and test location education/rehabilitation). Age was included as a covariate.

Because previous studies found that a history of petrol sniffing affected the relationships between cannabis use and psychological symptoms (Clough, et al., 2005), χ^2 analyses compared proportions of frequent cannabis users *with* a history of solvent use to frequent cannabis users *without* a history of solvent use on each of the significant psychological variables.

5.3 RESULTS

For each of the psychological items, all four response categories were endorsed, with no category receiving greater than 67% endorsement. Fewer individuals endorsed the higher frequency categories (i.e. fair bit and lots). Data were missing most frequently for the VOICES item with no data for 15.6% of participants. A greater proportion of non-users of solvents (19.03%) had missing data on this item compared

with prior (0.06%) or current solvent users (0.07%). Reliability of the eight items together was good with $\alpha = .74$.

Substance use variables and psychological variables were cross-tabulated to identify any cells with zero frequencies. As a result, the ‘yes’ response categories for solvent and cigarette use were collapsed into one category – ‘currently using’. The never and used to categories for cigarette use were also collapsed to make a dichotomous variable – ‘smokes cigarettes’ (yes/no). The models for ANGRY, WORRIED, SAD, LONELY, TROUBLE, and SLEEP were significant ($\chi^2_{(13, N = 334-365)} = 26.13-34.66$, $p < 0.05$) and each met the parallel lines assumption. Goodness of fit (Pearson’s χ^2) indicated the observed data were consistent with the estimated values in the fitted model for each significant model ($\chi^2_{(986-1079, N = 334-365)} = 993.13-1089.70$, $p > 0.10$). The pseudo R-square values are presented in Table 2. The overall model failed to reach significance for THINK and VOICES ($\chi^2_{(13, N = 320-364)} = 9.36-16.07$, $p > 0.25$).

Table 2. Pseudo R Squared Values for Significant Models

Variable	Cox and Snell	Nagelkerke	McFadden
ANGRY	.091	.100	.041
WORRIED	.075	.087	.039
SAD	.078	.088	.037
LONELY	.073	.082	.034
TROUBLE	.092	.106	.048
SLEEP	.070	.077	.031

Odds ratios and 95% confidence intervals for the significant predictors in each of the significant models are presented in Table 3. Frequent cannabis users were significantly more likely to endorse ANGRY, WORRIED, SAD, LONELY and TROUBLE than non-cannabis users. Occasional cannabis users were also more likely to endorse ANGRY, WORRIED and LONELY than non-cannabis users. Interestingly, prior solvent users were more likely to endorse LONELY, frequent alcohol users were less likely to endorse SAD and cigarette users were more likely to endorse SLEEP than non-users. Individuals living remotely were more likely to endorse LONELY than those living in urban centres and individuals tested at the education centres were more likely to endorse SLEEP and marginally more likely to endorse WORRIED than those in rehabilitation.

Table 4 presents demographic information for each drug class and proportions of concomitant drug use. Almost half of current cannabis users reported a history of solvent use and over half of frequent cannabis users also reported frequent alcohol use. Over three-quarters of current drug users (solvents, cannabis, and alcohol) also reported using cigarettes.

Chi-squared analyses, comparing frequent cannabis users *with* a history of solvent use to those *without* a history of solvent use, revealed that only WORRIED was significantly associated with a history of solvent use in frequent cannabis users. Thirty-seven percent of frequent cannabis users with a history of solvent use endorsed 'fair bit' or 'lots' compared with just 9% of frequent cannabis users without a history of solvent use.

Table 3. Significant Predictors with Odds Ratios (ORs) and 95% Confidence Intervals (95% CIs) for Significant Models

Factor level/covariate	ANGRY		WORRIED		SAD		LONELY		TROUBLE		SLEEP				
	Ors	Est. 95%CI	ORs	Est. 95%CI	ORs	Est. 95%CI	ORs	Est. 95%CI	ORs	Est. 95%CI	ORs	Est. 95%CI			
Solvents (prior)							2.18	0.75	0.16-						
									1.40						
Cannabis (frequent)	3.76	1.31	0.65-	3.68	1.21	0.58-	3.96	1.30	0.67-	2.78	0.85	0.33-	4.43	1.31	0.75-
			2.00			2.03			2.08			1.72			2.23
Cannabis (occasional)	2.38	0.80	0.21-	2.18	0.71	0.08-				2.37	0.82	0.18-			
			1.52			1.48						1.55			
Alcohol (frequent)							0.44	-0.86	-1.60-						
									0.03						
Cigarettes (yes)													2.05	-0.76	0.17-
															1.26
Remote (vs. urban)										1.96	-0.58	0.13-			
												1.23			
Education (vs. rehab)				1.76	0.56	0.002-							2.13	0.82	0.22-
						1.13									1.29

Note. Substance use categories are compared to no use. Est. = Estimate

Table 4. Demographic Information for Each Class of Drug Use and Proportions of Concomitant Drug Use

	Solvent Users		Cigarette Smokers		Cannabis Users		Alcohol Users	
	(n = 59)	(n = 269)	(n = 66)	(n = 69)	(n = 93)	(n = 118)		
Mean age (SD)	19.87 (8.28)	30.01 (11.14)	26.87 (11.47)	26.85 (8.98)	28.27 (11.00)	33.40 (9.40)		
% Male	70%	62%	68%	70%	56%	71%		
% Remote	86%	70%	80%	63%	74%	64%		
Also report frequent cannabis use	33%	25%	-	-	14%	38%		
Also report frequent alcohol use	14%	39%	32%	65%	-	-		
Also report current or prior solvent use	-	32%	49%	42%	40%	23%		
Also report current cigarette use	75%	-	86%	96%	82%	88%		

5.4 DISCUSSION

After accounting for demographic factors and other substance use, this study found significant associations between current cannabis use and a number of depressive and anxiety symptoms for Indigenous Australians. Associations were strongest for frequent cannabis use, with occasional use associated with only some of these symptoms. Associations between alcohol and solvent misuse with psychological symptoms were few with prior-solvent users more likely to feel lonely compared with non-solvent users and frequent alcohol users less likely to feel sad than non-users. Individuals tested at the education centres and cigarette users were both more likely to experience sleep problems, while individuals living remotely were more likely to feel lonely. Together these results suggest that symptoms of depression or anxiety may be common for individuals seeking treatment for substance misuse. These problems have the potential to impact on treatment outcome if left unrecognised and untreated (Degenhardt, et al., 2001b), and therefore should be screened for on admission.

A dose response relationship has been observed in previous studies, with cannabis dependence (or frequent use) more likely to be associated with depressive symptoms than cannabis misuse (or infrequent use) (Chen, Wagner, & Anthony, 2002; Clough, et al., 2005; Kessler, et al., 1996; Lee, et al., 2008). This trend is supported by the current study with frequent cannabis users experiencing more symptoms than occasional users. Previous research in non-Indigenous groups has suggested that any relationship between cannabis use and affective or anxiety disorders may be mediated by educational attainment, marital status, employment and other drug use

(Degenhardt, et al., 2001b; Green & Ritter, 2000); factors that are problematic for many Indigenous Australians. The current study revealed high proportions of heavy cannabis users who also used other substances. This finding is consistent with previous studies where a history of petrol sniffing predicted later cannabis use (Lee, Conigrave, Clough, et al., 2009). Another study, with Indigenous Australians, reported an association between cannabis use and depressive or anxiety symptoms that attenuated (to non-significance) when those with a history of petrol sniffing or alcohol use were removed (Clough, et al., 2005). In the current study, the measure 'WORRIED' was the only variable for which proportions of frequent cannabis users endorsing higher frequency categories differed depending on whether or not they had a history of solvent use. Although concurrent solvent and alcohol use were also accounted for by their inclusion in the regression model, the number of years of use and age of initiation of these substances were not considered. Previous research suggests age of onset of cannabis use may be important in the relationship between cannabis use and mental health (Arseneault, et al., 2002; Green & Ritter, 2000; Lubman, Hides, Yucel, & Toumbourou, 2007; Yucel et al., 2006). Non-random missing data however prevented inclusion of these variables in the current analysis. This limitation might explain the unexpected lack of other significant associations between alcohol and solvent misuse and adverse psychiatric symptoms.

The associations found between prior use of solvents with feeling LONELY and frequent alcohol use with feeling less SAD, although unanticipated, are justifiable. Petrol sniffing in Indigenous populations is often a group activity, and may stem from a lack of parental care (Brady, 1992; McCoy, 2008). Therefore, those who sniff petrol may be more likely to associate with a sniffing group thereby creating a

sense of belonging (Brady, 1992; McCoy, 2008). Subsequently solvent users may feel less lonely as a result of this perceived support and allegiance with the sniffing group (McCoy, 2008). For individuals in treatment for solvent use (prior users) it follows that feelings of loneliness may occur due to separation from the sniffing group. The observation of less sadness among frequent alcohol users may reflect the reality that many people drink alcohol because it makes them feel good.

Interestingly, an Australian study found that rates of affective and anxiety disorders were lower among alcohol users compared to non-users, while dependent users had the highest rates (Degenhardt, et al., 2001a). The current study did not assess alcohol dependence so it is unclear whether a different picture would emerge if this group of frequent users were further categorised as *either* frequent *or* dependent users.

Associations between cannabis misuse and psychotic symptoms are widely accepted for the general population (Arseneault, et al., 2002; Moore et al., 2007; Zammit, Allebeck, Andreasson, Lundberg, & Lewis, 2002), however, results for Indigenous Australian groups are mixed (Clough, et al., 2005; Clough, et al., 2006). Hearing voices was not associated with cannabis use in the current study. One study with Indigenous Australians found an association between cannabis use and auditory hallucinations reported in clinic records (Clough, et al., 2006). However for a similar population, no such relationship was observed between cannabis use and psychosis (including auditory and visual hallucinations) using self-report methods (Clough, et al., 2005). This suggests that capturing culturally applicable experiences of hallucinations or psychotic symptoms with self-report items is difficult. While it is possible that this item was affected by a social desirability response set, it is equally likely that the item may not adequately reflect Indigenous experiences of psychotic

symptoms. It is also possible that other psychotic symptoms (e.g. visual hallucinations) not captured by the current questionnaire, may be more likely to show an association with cannabis use.

The assessment process successfully identified psychological symptoms for Indigenous Australians attending rehabilitation for substance misuse, although the process may be improved further. For example, it is likely that the tool did not suitably capture some psychological constructs. It is therefore recommended that items measuring suicide risk as well as a broader range of psychotic symptoms should be included in future versions. It is also recommended that the response categories be refined to include a 'never' option where appropriate (e.g. VOICES). These results indicate that the experience of depressive or anxiety symptoms may be common for individuals attending treatment for substance use or those simply using cannabis. It is therefore important to screen for, detect and manage such problems to improve psychological wellbeing for this disadvantaged population.

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Part B: Longitudinal Assessment of Petrol and Alcohol Users in Treatment

Preface

Part A of this thesis responded to an identified lack of appropriate assessments for measuring the cognitive and psychological impacts of substance abuse for Indigenous Australians. The literature review in Chapter 2 detailed the difficulties associated with assessing cognitive and psychological function for this group and highlighted the need for appropriate assessment processes to be developed. The studies presented in Chapters 3, 4 and 5 advanced this situation by describing the psychometric properties of the selected cognitive and psychological assessments and evaluating their effectiveness for detecting substance abuse related impairments for Indigenous Australians. These studies showed the selected assessments to be reliable and suitable for this purpose and that a dual baseline assessment will help to control for computer familiarity and practice effects. It is also important to use a control group with similar demographic characteristics to reduce the impact of contextual confounding influences. The studies presented in Part B will therefore apply these culturally appropriate assessment procedures to monitor the cognitive and psychological impacts of petrol and alcohol abuse for Indigenous Australians.

While there is some evidence of recovery of brain function following abstinence from petrol sniffing (see Chapter 7) the specific time course for cognitive recovery immediately following cessation of abuse remains unclear, as does the impact of cognitive and psychological changes on the rehabilitation process. This information is necessary to inform the development of appropriate and responsive treatment programs.

Although the impact of chronic alcohol abuse on cognition and the nature of recovery with abstinence is fairly well understood for non-Indigenous groups, little research has investigated the cognitive consequences of chronic alcohol use among Indigenous Australians. The impact of episodic alcohol use patterns, as is common among some Indigenous groups, has not been empirically investigated. Part B therefore aims to address these issues by measuring cognition longitudinally for Indigenous Australians attending treatment for petrol or alcohol abuse.

Chapter 6

Social, Psychological, and Physical Impacts of Petrol (Gasoline) Sniffing and other Volatile Solvent Use for Indigenous Communities

Preface

Manuscript submitted for publication and extract accepted for publication in Journal of Paediatrics and Child Health [see Appendix A].

Chapter 6 introduces petrol and other volatile solvents as specific substances of abuse. Their use is prevalent in some isolated Indigenous communities internationally and may be associated with a number of factors including geographical isolation, reduced employment and recreation opportunities, poverty, poor academic achievement, poor social adjustment and importantly family, community, and cultural disruption. This review chapter focuses specifically on the use of volatile solvents among Indigenous Australians, while comparing and contrasting the characteristics of use with other Indigenous groups internationally. Pharmacological and toxicological effects of volatile solvents are described together with the serious cognitive, neurological, physical and mental health effects. Finally, relevant interventions typically used to address volatile solvent abuse will be discussed. While the epidemiology and context surrounding volatile solvent use may be relatively population specific, the direct chemical actions and biomedical effects of solvents are more generalisable. Although empirical evidence regarding the physical and psychological consequences of solvent use has improved over the last few decades, there is still a lack of understanding regarding the specific biochemical actions of solvents, the precise timeline for cognitive recovery and the nature of the relationships between solvent use and specific psychological symptoms, particularly among Indigenous populations. These issues are outlined here in Chapter 6.

**Social, psychological, and physical impacts of petrol (gasoline) sniffing and
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ABSTRACT

This review aims to describe the social, psychological and physical impacts of petrol (i.e. gasoline) sniffing and other volatile solvent use (VSU) for Australian Aboriginal communities. Using the following search terms: Indigenous, Aboriginal, petrol, gasoline, sniffing, inhalants and volatile solvents, 19 Australian peer reviewed research studies on VSU in Aboriginal communities, published between 1970 and 2010, were identified. Due to the limited availability of peer reviewed journal articles regarding VSU in Aboriginal Australians, other 'grey' literature was also included and, where appropriate, comparisons with findings from other Indigenous and non-indigenous groups were made.

Keywords: petrol, gasoline, volatile solvents, inhalants, Indigenous, Aboriginal

6.1 INTRODUCTION

Volatile solvent use (VSU) creates disproportionate public health burden internationally, despite occurring primarily among small populations with distinct geographical and sociocultural characteristics (J. F. Williams, Storck, & Committee on Substance Abuse and Committee on Native American Child Health, 2007). Petrol (i.e. gasoline) inhalation or ‘petrol sniffing’ is a form of VSU that occurs almost exclusively in marginalised, isolated or Indigenous groups such as the American and Mexican Indians, Aboriginal Canadians, New Zealand Maoris, and Aboriginal Australians (Cairney, et al., 2002). While petrol is the most common solvent used in many Indigenous communities, other solvents, such as paint, and glue are also inhaled for their intoxicating effects (Coleman, Charles, & Collins, 2001; Midford, MacLean, Catto, & Debuyst, 2010; Thurman & Green, 1997)

The aim of this review was to describe the social, psychological and physical impacts of petrol sniffing and other VSU for Aboriginal Australian communities and consider appropriate interventions. The term ‘VSU’ is used throughout to reflect the range of volatile solvents that can be inhaled. Where evidence relates to one substance in particular, more specific terms (e.g. glue sniffing, toluene abuse) are utilised.

Literature searches of key health science databases (including PsychINFO, PsychARTICLES, Medline, PubMed, Academic Search Premier (EBSCO), Science Direct, JSTOR, SpringerLink) were conducted using the following search terms in various combinations: Indigenous, Aboriginal, petrol, gasoline, sniffing, inhalants and volatile solvents. This identified only 19 Australian peer reviewed research studies, published between 1970 and 2010, on VSU in Australian Aboriginal

communities. Eleven were outcomes research or ecological studies, 6 were case controls studies, one was a cohort study and another was a case series report. An additional article systematically reviewed the literature on petrol sniffing interventions in Indigenous communities. As a result of the small number of articles identified, literature published in books, and accessible online government or organisational reports (i.e. grey literature) were also incorporated throughout this review. Although the psychological, social, and environmental factors associated with VSU in Indigenous communities may remain relatively population specific, cultural context is less likely to impact the direct physical actions and biomedical effects of solvent inhalation. Therefore, results from wider international empirical studies with non-Indigenous urban users (e.g. biomedical, neuroimaging and animal studies) were also included to provide important insight into the toxicological and biomedical consequences of the practice.

Many Indigenous groups internationally, share similar cultural, geographical, and social characteristics with Aboriginal Australians, including a history of cultural oppression and dispossession, considerable geographical isolation, and significant economic, social and cultural disadvantage (Beauvais, 1992d; Dingwall & Cairney, 2010b). While there are many differences in VSU among these groups, similarities also exist. This review therefore provides a broad overview of petrol sniffing and other VSU among Aboriginal Australians while highlighting the similarities and differences in VSU among other Indigenous groups internationally.

6.2 EPIDEMIOLOGY

For Aboriginal Australians, VSU occurs primarily among youth aged between 5-35 years, and solvent use generally begins earlier (i.e. between 6-14 years) than for other substances of misuse (Burns, d'Abbs, & Currie, 1995; Cairney, et al., 2004a; Dingwall, Maruff, Clough, & Cairney, In Press; Garrow, 1997; Goodheart & Dunne, 1994; Maruff, et al., 1998; Mosey, 1997; Nurcombe, Bianchi, Money, & Cawte, 1970; Winch, Chenhall, Kelly, Berkhout, & Cairney, 2010). While use occurs among both Indigenous and non-Indigenous people, Indigenous youth are more likely to use solvents for longer and in greater quantities (Midford, et al., 2010). While Australian, Canadian, and Pacific Island studies report the practice to be more common among Indigenous males than females (ratio of 3:1) (Barnes, 1989; Coleman, et al., 2001; Daniels & Latcham, 1984; Dingwall, Lewis, et al., 2010; Dingwall, et al., In Press; Garrow, 1997; Kaufman, 1973; Mosey, 1997; Nurcombe, et al., 1970; Seshia, Rajani, Boeckx, & Chow, 1978) recent research suggests that there is less of a gender difference, for both lifetime or 30 day prevalence among American Indian groups, and in some cases greater use among females is reported (S. C. Bates, Plemons, Jumper-Thurman, & Beauvais, 1997; Beauvais & Oetting, 1988; Beauvais, Wayman, Jumper-Thurman, Plested, & Helm, 2002; Oetting, Edwards, & Beauvais, 1988; Thurman & Green, 1997).

In affected Indigenous communities internationally, VSU is often cyclical in nature so prevalence rates are difficult to determine (Beauvais, 1997; Garrow, 1997; Smart, 1988). Short-term increases may occur at times of increased community conflict or with seasonal variations (Garrow, 1997; Nurcombe, et al., 1970; Smart, 1988).

Occasional or experimental use patterns appear most common amongst young adolescents internationally, which likely account for the cyclical nature of the practice (Barnes, 1989; Coulehan et al., 1983; Nurcombe, et al., 1970; Roper & Shaw, 1996). However chronic or long-term use among older adolescents or adults also occurs, causing ongoing community disruption (Coulehan, et al., 1983; Garrow, 1997; Nurcombe, et al., 1970; Roper & Shaw, 1996). During the 1990s in Australia, these patterns were thought to be shifting, with more users sniffing for longer periods resulting in a drop in occasional users and an increase in morbidity and mortality as a result of chronic use (Brady & Torzillo, 1994; Roper & Shaw, 1996). With the elimination of leaded petrol, and the introduction of fuel replacement strategies, including aviation gasoline (AVGAS) in the 1990s and the low aromatic 'Opal' fuel this decade, in combination with other policy strategies, it is likely that patterns of use in remote Australian Aboriginal communities are again changing.

Internationally, surveys of specific isolated Indigenous communities have generally found considerably higher proportions of solvent users (26-100%) compared to surveys of urban dwelling Indigenous adolescents (6-38%) (Beauvais, 1992c; Boeckx, Posti, & Coodin, 1977; Coulehan, et al., 1983; Forero, Bauman, Chen, & Flaherty, 1999; Freeman, 1986; Gray, Morfitt, Ryan, & Williams, 1997; Howard, Walker, Walker, Cottler, & Compton, 1999; Kaufman, 1973; Perkins et al., 1994; Senior, Chenhall, & Daniels, 2006; York, 1990; Zebrowski & Gregory, 1996). In isolated Indigenous communities, the availability of other drugs can be limited. Nevertheless, a group of American Indian adolescents living on reservations perceived both alcohol and solvents as easily accessible, and drug availability had no major effect on subsequent drug use patterns (Beauvais, 1992a). For Aboriginal

Australians however, petrol accessibility clearly plays a role in VSU (Brady, 1992; Brady & Torzillo, 1994; Dingwall, et al., In Press; Winch, et al., 2010). A recent evaluation of the impact of the low aromatic Opal fuel in Australia found a decrease of around 70% in the number of people sniffing in the remote communities assessed (d'Abbs & Shaw, 2008). However in some communities VSU increased (i.e. petrol and aerosols) and a significant relationship was found between the distance from each community to the nearest unleaded petrol outlet and the size of the decrease in prevalence (d'Abbs & MacLean, 2002).

VSU is commonly a group activity (Brady, 1992; Burns, et al., 1995; Carroll, Houghton, & Odgers, 1998; Coulehan, et al., 1983; Dingwall, et al., In Press; Kaufman, 1973; McCoy, 2008; Oetting, et al., 1988). For many Indigenous communities internationally, peer or family influence can be strong, and individual sniffers may be recruited and 'taught to sniff' by peers, siblings or older users (Barnes, 1989; Beauvais, 1992b; Brady, 1992; Burns, et al., 1995; Coleman, et al., 2001; Dingwall, et al., In Press; Nurcombe, et al., 1970; Oetting, et al., 1988; Winch, et al., 2010; York, 1990). An Alaskan study found peer influence to be the most common reason for VSU given by light users, but heavy users were more likely to use in response to affect (e.g. anger, sadness) (Zebrowski & Gregory, 1996). Similarly, a longitudinal Australian study found that petrol sniffers who relapsed after treatment were more likely to report using in response to negative affect than those who had abstained from further use (Dingwall, et al., In Press). Associations found between VSU and psychological distress and disrupted family structure among Indigenous groups may therefore contribute to the formation of a 'sniffing group' among solvent users that acts like a surrogate family giving them a sense of

belonging and leading to a strong sense of allegiance (Barnes, 1989; Beauvais, 1992b, 1992d; Brady, 1992; Carroll, et al., 1998; Coleman, et al., 2001; McCoy, 2008; Nurcombe, et al., 1970; Oetting, et al., 1988; Smart, 1988; Stojanovski, 1999; Thurman & Green, 1997; Winch, et al., 2010; York, 1990).

Given the environmental (e.g. poverty, isolation, lack of opportunity) and cultural (e.g. rapid change and acculturative stress) similarities between a number of Indigenous groups, aetiological similarities are not surprising (Barnes, 1989; Brady, 1991; Senior, et al., 2006; Smart, 1988; Trotter, Rolf, & Baldwin, 1997).

Ethnographic studies from the USA, Australia and Canada have described boredom or curiosity, pleasure or fun, escape from despair or worry, rebellion, lack of opportunity on communities and high acculturative stress as common reasons for VSU among Indigenous groups (Barnes, 1989; Brady, 1991; McCoy, 2008; Nurcombe, et al., 1970; Senior, et al., 2006; Stojanovski, 1999; Trotter, et al., 1997). Poor academic achievement or school adjustment also characterises many Indigenous solvent users worldwide (Barnes, 1989; Beauvais, 1992b; Burns, et al., 1995; Coulehan, et al., 1983; Eastwell, 1979; Nurcombe, et al., 1970; Stojanovski, 1999; York, 1990). A retrospective study from the USA found that American Indian high-school dropouts were almost three times more likely to have ever used solvents than those who remained in school (S. C. Bates, et al., 1997). Reduced educational outcomes may underlie lower levels of employment that are also reported among Australian solvent users while unemployment may also trigger VSU (Burns, et al., 1995; Senior, et al., 2006).

In Australian Aboriginal communities with a persistent petrol sniffing problem, the ‘sniffing culture’ can become so entrenched (National Inhalant Abuse Taskforce, 2005; Stojanovski, 1999) that it becomes a viable lifestyle choice by young people with its associated antisocial behaviours (Central Australian Youth Link Up Service, 2005). Petrol sniffing can be seen as an opportunity to define ones identity, reclaim a sense of power and belong to a social group, thereby replacing roles previously provided through traditional practices (Brady, 1991, 1992; McCoy, 2008; Senior, et al., 2006). Reports of deviant acts involving criminal damage, violence, vandalism, and theft of food or petrol are common among many groups of solvent users (Boeckx, et al., 1977; Burns, et al., 1995; Coulehan, et al., 1983; Eastwell, 1979; Mosey, 1997; Senior, et al., 2006; York, 1990). Despite in-group acceptance, both American and Australians sniffers appear somewhat ostracised (or ostracise themselves) from the larger community and may be viewed by others as ‘mad’ or at the lower end of the social hierarchy (Nurcombe, et al., 1970; Senior, et al., 2006; Trotter, et al., 1997). Although apparently aware of the risks and consequences of sniffing, some youth continue to use solvents, choosing to focus on perceived short-term benefits rather than long term consequences, and thereby facilitating dependence (Beauvais, 1992b; Carroll, et al., 1998; Senior, et al., 2006; Trotter, et al., 1997). Even with treatment, a recent study suggests that a significant proportion (i.e.78%) of Indigenous users will relapse after discharge (Coleman, et al., 2001).

6.3 PHARMACOLOGY

6.3.1 Toxicology

Volatile solvents comprise varying combinations of aliphatic, aromatic and chlorinated hydrocarbons, ketones and in the case of leaded petrol, tetraethyl lead (Brouette & Anton, 2001; Brust, 1993). Aromatic hydrocarbons (particularly toluene) are largely responsible for the psychoactive and neurotoxic effects of solvents as they are highly lipid soluble, and are rapidly absorbed into the bloodstream and lipid rich central nervous system (CNS) (Brouette & Anton, 2001; Dinwiddie, 1994; Lubman, Yucel, & Lawrence, 2008).

Leaded petrol is commonly associated with a stronger psychotic effect and was often preferred by Australian users over unleaded petrol (Burns, et al., 1995). The tetraethyl lead may have been the main cause of long term neurotoxicity in chronic leaded petrol sniffers (Boeckx, et al., 1977; Coulehan, et al., 1983; Fortenberry, 1985; Harper, 1994) as their blood lead levels correlated well with the degree of cognitive and neurological impairment (Cairney, et al., 2005; Maruff, et al., 1998; Seshia, et al., 1978). Neurological evidence suggests that a lead encephalopathy, characterised by neurological signs including clouding of consciousness, tremor, myoclonus or chorea, limb and gait ataxia, hyperreflexia, nystagmus and seizures, could result from sniffing leaded petrol and cause catastrophic and long-term damage to cerebellar motor pathways (Boeckx, et al., 1977; Cairney, et al., 2004a, 2004c; Coulehan, et al., 1983; Seshia, et al., 1978).

6.3.2 Acute Effects

Many lipid soluble volatile hydrocarbons appear capable of producing similar intoxicating effects beginning with an initial period of intoxication resembling alcohol intoxication, and involving euphoria, or excitability, possibly with hallucinations, confusion, and disinhibition (Eastwell, 1979; Goodheart & Dunne, 1994; Nurcombe, et al., 1970; Press & Done, 1967a, 1967b; Steffee & Davis, 1996). Depression of the CNS also occurs, sometimes with nausea, vomiting, headache, ataxia, drowsiness, slurred speech, and/or anorexia, with unconsciousness, seizures or coma developing with larger doses (Brouette & Anton, 2001; Goodheart & Dunne, 1994; Lubman, et al., 2008; Nurcombe, et al., 1970). The specific cluster of subjective effects varies between individuals and can depend on the frequency and degree of exposure, type of solvent used, as well as cultural, environmental and personality factors such as setting, expectations or mood (Mahal & Nair, 1978; Press & Done, 1967b; Sourindrhin, 1985). For example, a study from Glasgow reported hallucinations among just 12% of their glue sniffers (Sourindrhin & Baird, 1984), while 86-100% of petrol sniffers from studies in India reported experiencing hallucinations (Mahal & Nair, 1978; Shah, Vankar, & Upadhyaya, 1999).

Differences in the setting or type of solvent inhaled may account for these differences, however hallucinations might also occur only in those individuals who are susceptible (Easson, 1962; Press & Done, 1967b). The ability to endure some of the frightening hallucinations arising from petrol sniffing may represent strength to some Aboriginal Australian sniffers, where visions of snakes and dead spirits are common (Brady, 1992; Nurcombe, et al., 1970). Visions of passed ancestors can be

a normal part of the grieving process for Aboriginal Australians and sorcery has been used to explain hallucinations and even murder where petrol sniffing was involved (Cairney & Maruff, 2007b; Nurcombe, et al., 1970).

6.3.3 Tolerance, Withdrawal and Dependence

The frequent (e.g. every day) and heavy (e.g. ≥ 6 hours intoxication) use of solvents is likely to reflect psychological dependence on the substance for some users (Flanagan & Ives, 1994; Mahal & Nair, 1978; Oetting, et al., 1988; Press & Done, 1967b; Shah, et al., 1999; Skuse & Burrell, 1982; Steffee & Davis, 1996). However, the existence of physiological dependence has been difficult to ascertain (Zebrowski & Gregory, 1996). A diagnosis of physiological dependence on a substance is made when tolerance and withdrawal symptoms are evident (American Psychiatric Association, 2000). Tolerance, defined as the need to increase the dose to maintain the same effect, may occur among chronic solvent users but, due to difficulties with monitoring dosage, its prevalence and clinical significance are unknown (American Psychiatric Association, 2000; Brouette & Anton, 2001; Easson, 1962; Press & Done, 1967b; Steffee & Davis, 1996). In animal studies, tolerance has been demonstrated with repeated exposure to toluene but this may reflect behavioural selectivity or mediation by behavioural or environmental factors (Himnan, 1984; Kjellstrand, Mansson, Holmquist, & Jonsson, 2009; Rees, Wood, & Laties, 1989).

Withdrawal symptoms are not included in the DSM-IV or ICD-10 as diagnostic criteria for VSU disorders as the evidence for their existence is somewhat mixed (Howard, Cottler, Compton, & Ben-Abdallah, 2001). Symptoms that are reported

are usually minor and include headache, irritability or sleep disturbance (Brouette & Anton, 2001; Flanagan & Ives, 1994). However other symptoms, resembling those of alcohol or other CNS depressant withdrawal such as tremors, psychomotor retardation, craving, headache, palpitations, sweating, fleeting illusions, nausea, vomiting, stomach cramps, diarrhoea, lower chest pain, and facial tics have been reported in severe cases (C. E. Anderson & Loomis, 2003; A. C. Evans & Raistrick, 1987; Keriotis & Upadhyaya, 2000; Ron, 1986; Shah, et al., 1999). A withdrawal syndrome, lasting 2-5 days was observed in 100% (N = 9) of a group of petrol sniffing peers in India, and in 62% (N = 31) of toluene inhaling and 50% (N = 12) of butane inhaling participants from the UK (A. C. Evans & Raistrick, 1987; Keriotis & Upadhyaya, 2000; Shah, et al., 1999). However, polysubstance use can be common among solvent users (Skuse & Burrell, 1982; Wu, Pilowsky, & Schlenger, 2004), so it is difficult to disentangle the specificity of the withdrawal syndromes (Dinwiddie, 1994).

Largely due to the inconsistent reports regarding the existence of withdrawal effects, much of the early literature suggests that physiological dependence on solvents does not occur (Press & Done, 1967b; Skuse & Burrell, 1982; Sourindhrin & Baird, 1984). However, an emerging body of work reports that toluene inhalation alters dopaminergic neurotransmission in pathways that play a role in the rewarding or reinforcing effects of other drugs of misuse (Balster, 1998; Fuxe et al., 1982; Riegel & French 1999). Although presently there is very little direct evidence available, these few studies implicate an addictive potential for solvents (Balster, 1998). For example, the misused chemical 1,1,1-Trichloroethane (found in dry-cleaning fluid) has been reported to produce physiological dependence of the CNS depressant type

in mice (E. B. Evans & Balster, 1993). In animals and humans, there is limited evidence of cross habituation, where the substitution of solvents for benzodiazepines or opioids produces similar behavioural effects or ameliorates withdrawal effects during abstinence (Davies, Thorley, & O'Connor, 1990; Geller, Hartmann, Mendez, & Gauss, 1983; Pollard, 1990). The pharmacological and behavioural similarities between solvents and other CNS depressants (e.g. alcohol, opioids, and benzodiazepines) therefore imply a similar potential for physiological dependence. Although it appears likely that VSU may be physiologically addictive, there remain too few empirical studies conducted to be conclusive.

6.4 BIOMEDICAL EFFECTS

6.4.1 Cognitive and Neurological Effects

The health effects of solvents can be profound, with neurological damage the most prevalent and debilitating (Access Economics, 2006; Burns, et al., 1995; Kucuk et al., 2000). For example, in the 1990s acquired brain injury from petrol sniffing was reported to be the single biggest cause of disability in the Anangu Pitjantjatjara lands of South Australia (Tregenza, 2002). Petrol (in Indigenous populations) and toluene (in non-Indigenous populations) have been the most studied solvents for their neurotoxic effects. Toluene is a constituent of petrol so considerable overlap in their effects is expected.

Table 1. Cognitive Impairments Associated with Volatile Solvent Use

Solvent and Cognitive Ability Impaired	References
<u>Petrol</u>	
▪ Attention/Visual attention	(Cairney, et al., 2004a, 2004b, 2005; Dingwall, Lewis, et al., 2010; Maruff, et al., 1998; McGrath, 1986; Valpey, Sumi, Copass, & Goble, 1978)
▪ Visual recognition memory	(Cairney, et al., 2004a, 2004b, 2005; Maruff, et al., 1998; White, 2005)
▪ Paired associate learning	(Cairney, et al., 2004a, 2004b, 2005; Dingwall, Lewis, et al., 2010; Maruff, et al., 1998)
▪ Learning and Memory	(Dingwall, Lewis, et al., 2010; Valpey, et al., 1978)
▪ IQ (below average)	(White, 2005)
▪ Visuo-spatial ability	(McGrath, 1986; White, 2005)
▪ Forward Planning	(White, 2005)
▪ Reasoning Ability	(Dingwall, Lewis, et al., 2010)
▪ Executive Function	(White, 2005)
▪ Psychomotor Function	(Dingwall, Lewis, et al., 2010)
<u>Toluene (including paint and glue)</u>	
▪ Complex cognition	(Hormes, et al., 1986)
▪ Concentration	(Deleu & Hanssens, 2000)
▪ Calculation	(Kamran & Bakshi, 1998)
▪ Vigilance	(Kamran & Bakshi, 1998)
▪ Memory	(Boor & Hurtig, 1977; Hormes, et al., 1986; Kamran & Bakshi, 1998; Knox & Nelson, 1966)
▪ Attention	(Hormes, et al., 1986; Kamran & Bakshi, 1998)
▪ Visuo-spatial ability	(Hormes, et al., 1986)
▪ IQ (below average)	(Kamran & Bakshi, 1998)
<u>Non specific/mixed (occupational) exposure (hydrocarbons)</u>	
▪ Verbal learning/memory	
▪ Visual recognition memory	(Hanninen, Antti-Poika, Juntunen, & Koskenvuo, 1991; Morrow, Stein, Bagovich, & Condray, 2001)
▪ Paired associate learning	
▪ Visuo-spatial ability	
▪ Psychomotor speed	

Table 1 presents the cognitive impairments associated with VSU. In short, impairments in psychomotor, memory, attention, learning and executive functions have been associated with chronic VSU (Cairney, et al., 2004a, 2005; Dingwall, Lewis, et al., 2010; Hormes, et al., 1986; Maruff, et al., 1998). The first sign of impairment in chronic users appears to be a progressive decline of these cognitive functions, suggesting disruption to frontostriatal brain regions, with the severity of impairment directly related to the number of years of use (Cairney, et al., 2004a, 2005; Maruff, et al., 1998).

Recovery of brain function occurs slowly following cessation of further use (Cairney, et al., 2004a, 2004b, 2004c, 2005; Caldemeyer, Pascuzzi, Moran, & Smith, 1993; Hormes, et al., 1986; Maruff, et al., 1998; Rosenberg et al., 1988; Rosenberg, Spitz, Filley, Davis, & Schaumburg, 1988). For example, a group of chronic petrol sniffers in Australia were assessed at baseline when a community intervention completely eradicated petrol sniffing, then again two years later and again, 15 years after sniffing cessation (Cairney et al., 2009; Cairney, et al., 2004b, 2005). These data show substantial recovery after two years of abstinence and almost complete recovery after 15 years of abstinence in most ex-sniffers. However, as a consequence of longer-term and heavier use, residual neurological abnormalities were observed even after 15 years of abstinence in individuals with more serious impairments prior to abstinence and among those with a history of sniffing related lead encephalopathy (Cairney, Berkhout, et al., 2009; Cairney, et al., 2005).

Long-term, chronic use may therefore lead to more serious neurological abnormalities that affect movement and speech, and indicate disruption to cerebellar

neural circuitry (Cairney, et al., 2004a, 2004c, 2005). Neurologic signs associated with inhaled substances are presented in Table 2, and include impairments of sensory abilities, motor control, and ocularmotor abnormalities. More catastrophic and abrupt neurological impairments, consistent with cerebellar and brain stem abnormalities, have also been observed in individuals with a history of lead encephalopathy (Cairney, et al., 2004c). Thus the degree of neurological recovery that is possible in solvent users depends on the severity of use and the initial degree of impairment (Cairney, et al., 2004b, 2005).

Table 2. Neurological Effects of Volatile Solvent Use

Solvent and Neurological Sign	References
<u>Petrol (leaded)</u>	
▪ Seizures	(Boeckx, et al., 1977; Goodheart & Dunne, 1994; Seshia, et al., 1978)
▪ Slurred speech (dysarthria)	(Boeckx, et al., 1977; Eastwell, 1979; Seshia, et al., 1978; Valpey, et al., 1978)
▪ Tremor (postural, intention, limb)	(Boeckx, et al., 1977; Cairney, et al., 2004a, 2004b, 2005; Maruff, et al., 1998; McGrath, 1986; Seshia, et al., 1978; Valpey, et al., 1978)
▪ Dysdiadochokinesis	(Cairney, et al., 2004a, 2005; Maruff, et al., 1998; McGrath, 1986; Seshia, et al., 1978; Valpey, et al., 1978)
▪ Ataxia (tandem, gait, stance, limb)	(Boeckx, et al., 1977; Cairney, et al., 2004a, 2004c, 2005; Eastwell, 1979; Goodheart & Dunne, 1994; Maruff, et al., 1998; Seshia, et al., 1978; Valpey, et al., 1978)
▪ Hyperreflexia	(Cairney, et al., 2004a, 2004c, 2005; Eastwell, 1979; Goodheart & Dunne, 1994; Maruff, et al., 1998; Seshia, et al., 1978; Valpey, et al., 1978)
▪ Palmomentary reflex	(Cairney, et al., 2004a)
▪ Oculomotor abnormalities/Nystagmus	(Cairney, et al., 2004c, 2005; Goodheart & Dunne, 1994; Maruff, et al., 1998)
<u>Toluene</u>	
▪ Slurred speech (dysarthria)	(Boor & Hurtig, 1977; Deleu & Hanssens, 2000; Kamran & Bakshi, 1998; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
▪ Tremor (postural, intention, limb)	(Deleu & Hanssens, 2000; Hormes, et al., 1986; Kamran & Bakshi, 1998; King, 1982; Knox & Nelson, 1966; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
▪ Dysdiadochokinesis	(Kelly, 2001)

-
- Ataxia (tandem, gait, stance, limb) (Boor & Hurtig, 1977; Caldemeyer, et al., 1993; Deleu & Hanssens, 2000; Hormes, et al., 1986; Kamran & Bakshi, 1998; Kelly, 2001; King, 1982; Knox & Nelson, 1966; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
 - Hyperreflexia (Boor & Hurtig, 1977; Hormes, et al., 1986; Kamran & Bakshi, 1998; Knox & Nelson, 1966; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
 - Oculomotor abnormalities/Nystagmus (Boor & Hurtig, 1977; Deleu & Hanssens, 2000; Hormes, et al., 1986; Kamran & Bakshi, 1998; King, 1982; Knox & Nelson, 1966; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
 - Cranial nerve abnormalities including:
 - Visual deterioration, blurring (Caldemeyer, et al., 1993; Deleu & Hanssens, 2000; Ehyai & Freemon, 1983; Hormes, et al., 1986; Kamran & Bakshi, 1998; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
 - Anosmia
 - Bilateral sensorineural hearing loss
 - Spasticity (Hormes, et al., 1986; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
 - Impaired ability to write or draw (Deleu & Hanssens, 2000; Knox & Nelson, 1966)

Butane

- Slurred speech (dysarthria) (D. Harris & Mirza, 2005)
 - Nystagmus
 - Ataxia
-

Neuro-imaging studies in adults have generally focussed on toluene and have reported primarily white-matter, periventricular and sub-cortical abnormalities (Lubman, et al., 2008). Neuroanatomical abnormalities associated with VSU are presented in Table 3. In addition to white matter abnormalities, brain atrophy may be observed in the hippocampus, cerebellum, cerebrum, corpus callosum and brainstem (see Table 3). While many of the studies presented are limited by poor sample sizes or are based on single case reports (Boor & Hurtig, 1977; Caldemeyer, et al., 1993; Deleu & Hanssens, 2000; Feldman, Ratner, & Ptak, 1999; Kamran & Bakshi, 1998; Lazar, Ho, Melen, & Daghestani, 1983; Rosenberg, Kleinschmidt-DeMasters, et al., 1988), other studies with larger sample sizes report similar characteristic abnormalities in 35-100% of their adult (VSU) subjects (Aydin et al., 2002; Fornazzari, Wilkinson, Kapur, & Carlen, 1983; Hormes, et al., 1986; Okada et al., 1999; Rosenberg, Grigsby, Dreisbach, Busenbark, & Grigsby, 2002; Thuomas, Moller, Odkvist, Flodin, & Dige, 1996; Yamanouchi et al., 1995). Evidence for adolescent populations is limited, however Lubman and colleagues (2008) suggest that the adolescent brain may be even more vulnerable to the impact of solvents.

Table 3. Neuroanatomical Changes Associated with Volatile Solvent Use

Solvent and Neuroanatomical Change	References
<u>Petrol (leaded)</u>	
▪ EEG abnormalities	(Boeckx, et al., 1977; McGrath, 1986; Seshia, et al., 1978)
▪ Cerebellar and Cortical atrophy	(Goodheart & Dunne, 1994; Valpey, et al., 1978)
▪ Ventricular dilation/enlargement	(Valpey, et al., 1978)
▪ Gliosis	(Valpey, et al., 1978)
▪ Bilateral infarction of basal ganglia	(Goodheart & Dunne, 1994)
▪ Pyramidal and Purkinje cell loss	(Valpey, et al., 1978)
<u>Toluene (including paint)</u>	
▪ EEG abnormalities	(Deleu & Hanssens, 2000; Hormes, et al., 1986; King, 1982)
▪ Cerebellar, cortical and brainstem atrophy	(Boor & Hurtig, 1977; Deleu & Hanssens, 2000; Ehyai & Freemon, 1983; Hormes, et al., 1986; Kamran & Bakshi, 1998; Knox & Nelson, 1966; Rosenberg, Kleinschmidt-DeMasters, et al., 1988; Unger, Alexander, Fritz, Rosenberg, & Dreisbach, 1994; Xiong, Matthes, Li, & Jinkins, 1993)
▪ Ventricular dilation/enlargement	(Kamran & Bakshi, 1998; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
▪ Gliosis	(Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
▪ Loss differentiation of grey-white matter on T2 weighted images	(Filley, Heaton, & Rosenberg, 1990; Kamran & Bakshi, 1998; Rosenberg, Kleinschmidt-DeMasters, et al., 1988; Unger, et al., 1994; Xiong, et al., 1993)
▪ Increased periventricular white matter signal on T2 weighted images	(Caldemeyer, et al., 1993; Filley, et al., 1990; Kamran & Bakshi, 1998; Rosenberg, Spitz, et al., 1988; Unger, et al., 1994)
▪ Myelin pallor	(Rosenberg, Spitz, et al., 1988)
▪ Thinning of corpus callosum	(Kamran & Bakshi, 1998; Rosenberg, Kleinschmidt-

-
- Diminished white matter volume (DeMasters, et al., 1988; Xiong, et al., 1993) (Filley, et al., 1990; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
 - Prolonged T1 and T2 relaxation times (Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
 - CNS demyelination (Kamijima et al., 1994; Kornfeld et al., 1994; Rosenberg, Kleinschmidt-DeMasters, et al., 1988)
 - Discolouration of cerebral and cerebellar white matter (Kornfeld, et al., 1994)
 - Abnormal BAERs (Hormes, et al., 1986)
 - Membrane disturbance in basal ganglia (Takebayashi et al., 2004)
 - Multifocal deep white matter lesions (Xiong, et al., 1993)
 - Bilateral optic atrophy (Ehyai & Freemon, 1983)
 - Optic disk pallor (Caldemeyer, et al., 1993; Deleu & Hanssens, 2000; Kamran & Bakshi, 1998)
 - Hypointensity on T2 in basal ganglia, thalamus, red nucleus and substantia nigra (Caldemeyer, et al., 1993; Deleu & Hanssens, 2000; Kamran & Bakshi, 1998; Unger, et al., 1994)
 - Widening of sulci (Boor & Hurtig, 1977; Kamran & Bakshi, 1998)

Glue (containing acetone, tricresyl phosphate, hexane, toluol, toluene, butyl alcohol)

- Increased spinal fluid pressure (Barman, Sigel, Beedle, & Larson, 1964)
-

6.4.2 Physical Health Effects

Through respiratory aspiration, solvents enter the lungs and are passed rapidly around the body via the circulatory system (C. E. Anderson & Loomis, 2003). Solvents therefore have the potential to impact negatively on the heart, liver, kidneys and lungs (Marjot & McLeod, 1989; Meadows & Verghese, 1996). Research from non-Indigenous groups suggests that some solvent users, including first time users, have suffered a 'sudden sniffing death' that is reported to involve medullary paralysis and respiratory failure or cardiac arrest (Bass, 1970; Johns, 1991; Steffee & Davis, 1996). Other less direct conditions may also lead to solvent related deaths including chronic airways disease, suicide, homicide, asphyxiation, burns, falls, and motor vehicle or other accidents (Access Economics, 2006; C. E. Anderson & Loomis, 2003; H. R. Anderson, MacNair, & Ramsey, 1985; Brady & Torzillo, 1994; Johns, 1991; National Inhalant Abuse Taskforce, 2005; Steffee & Davis, 1996; Wick, Gilbert, Felgate, & Byard, 2007). Table 4 describes the medical effects that can be associated with VSU. Much of this evidence is anecdotal, based on single or multiple case reports and very little evidence comes from Indigenous populations.

Besides the direct toxic impact, secondary health effects may result from a VSU lifestyle and these may be more population specific. For example, associations between VSU and poor nutrition, low body weight and reduced fitness have been observed in Australian and Canadian Aboriginal users (Eastwell, 1979; Garrow, 1997; York, 1990). Some Australian ethnographic studies also report that some individuals inhale petrol to lose weight, thereby giving them a sense of control over at least one aspect of their lives (Brady, 1991; Senior, et al., 2006). An increased risk

of infections, pneumonia and birth defects, low birth weight or miscarriage have been found for Australian users (Dodd, 2001). A foetal solvent syndrome, characterised by hypotonia, mental and physical developmental delay, microcephaly, and craniofacial and limb abnormalities, has been described that shares similarities with foetal alcohol syndrome (Arnold, Kirby, Langendoerfer, & Wilkins-Haug, 1994; Hunter, Thompson, & Evans, 1979; Jones & Balster, 1998; Pearson, Hoyme, Seaver, & Rimsza, 1994; Toutant & Lippmann, 1979). Among Aboriginal Australians, VSU has also been linked with increased libido although it is not clear if this is a direct neurophysiologic effect or a consequence of the behavioural disinhibition that is characteristic of VSU (Eastwell, 1979). Interestingly, increased rates of sexually transmitted infections (STIs) are reported among Australian solvent users (Access Economics, 2006; Burns, et al., 1995; d'Abbs & MacLean, 2002; Eastwell, 1979; Garrow, 1997; Gell, 1994; Miller, Law, Torzillo, & Kaldor, 2001), and in fact, petrol has reportedly been traded for sex in some remote Aboriginal Australian communities (*Inquest into the deaths of Kumanjay Presley, Kunmanara Coulthard and Kunmanara Brumby*, 2005).

Table 4. Other Physical Health Effects of Volatile Solvent Use

Physical Health Effects	Substance	References
Cardiac toxicity		
Cardiac arrhythmia, ventricular fibrillation,	Toluene, glue,	(H. R. Anderson, et al., 1985; Bass, 1970; Boon, 1987; Bruckner &
hypotension, tachycardia, bradycardia, myocarditis,	benzene,	Peterson, 1977; Cunningham, Dalzell, McGirr, & Khan, 1987; Kamm,
dilated cardiomyopathy, myocardial ischemia	deodorant	1975; Kaplan, Bakken, Quadracci, & Schubach, 1979; Kurtzman, Otsuka, & Wahl, 2001; Marjot & McLeod, 1989; Steffee & Davis, 1996; Vural & Ogel, 2006; Wille, 2004; Wiseman & Banim, 1987)
Renal toxicity		
Distal renal tubular acidosis, anion gap acidosis,	Toluene, glue,	(Baerg & Kimberg, 1970; Barman, et al., 1964; Baskerville, Tichenor, &
glomerulonephritis, Goodpasture's syndrome,	paint,	Rosen, 2001; Broussard, 2000; Daniell, Couser, & Rosenstock, 1988;
haematuria, urinary frequency, loin pain, oliguria,	Trichloro-	Gupta, Van Der Meulen, & Johnny, 1991; Kamijima, et al., 1994; Knight
nocturia, hypokalaemia	ethylene,	et al., 1991; Patel & Benjamin, 1986; Robert, Touchard, Meurice, Pourrat,
	diesel oil	& Yver, 1988; Stengel et al., 1995; Streicher, Gabow, Moss, Kono, &
		Kaehny, 1981; Tang et al., 2005; Taverner, Harrison, & Bell, 1988;
		Texido et al., 1981; Venkataraman, 1981; Voigts & Kaufman, 1983; Will
		& McLaren, 1981)
Pulmonary effects		
bronchospasm, emphysema Goodpasture's syndrome,	Paint, glue,	(C. E. Anderson & Loomis, 2003; Engstrand, England, & Huntington,
hemorrhagic alveolitis, pulmonary lesions, pulmonary	deodorant	1986; Kamm, 1975; Lecomte, Trophilme, Rudler, Josset, & Lageron,
oedema, pulmonary vascular congestion		1983; Marjot & McLeod, 1989; Meadows & Verghese, 1996; Schikler,
		Lane, Seitz, & Collins, 1984; Skuse & Burrell, 1982; Wille, 2004)

Hepatic toxicity

hepatitis

Toluene, glue, (Anagnostopoulos et al., 2004; Baerg & Kimberg, 1970; Gupta, et al., 1991; Kaplan, et al., 1979; Knight, et al., 1991; Park et al., 2003; Taverner, et al., 1988; Texido, et al., 1981)

Myelotoxic and carcinogenic effects

Leukaemia, lymphatic, hematopoietic, kidney, pharyngeal, laryngeal, lung and nasal cancers

Benzene, (Bruckner & Peterson, 1977; Glass, Gray, Jolley, Gibbons, & Sim, 2006; Jacobson, Ahlbom, Bellander, & Lundberg, 1993; Lyngge et al., 1997; Mehlman, 2006a, 2006b; Savitz & Andrews, 1997; Shaw et al., 2004) petrol (Bruckner & Peterson, 1977)

Haematological effects

Anaemia, leucopenia, thrombocytopenia

Benzene, petrol

6.4.3 Mental Health Effects

Between 2000 and 2002, an estimated 214 people were admitted to hospitals in the Northern Territory of Australia for mental and behavioural disorders related to VSU (Department of Health and Community Services Alcohol and Other Drugs Program, 2002). Symptoms such as depression, anxiety and dysphoria have been observed in current and recently abstinent solvent users and, in some cases, VSU can be a significant risk factor for suicide, self harm or psychotic episodes (Brouette & Anton, 2001; Clinger & Johnson, 1951; Daniels & Latcham, 1984; Dinwiddie, Reich, & Clonginger, 1990; Jacobs & Ghodse, 1987; Keriotis & Upadhyaya, 2000; Mosher, Rotolo, Phillips, Krupski, & Stark, 2004; Shaw, et al., 2004). Suicide reportedly played a role in approximately one quarter of the 35 deaths associated with petrol sniffing in central Australia during 1998-2003 (Access Economics, 2006). A survey of Inuit adolescent solvent users revealed that 43% had had thoughts of suicide in the past, and 34% had attempted suicide, with 20% having attempted suicide more than once (Kirmayer, Malus, & Boothroyd, 1996). Mainstream research suggests that antisocial personality and conduct disorders can also be common in solvent users (Dinwiddie, et al., 1990; Sakai, Hall, Mikulich-Gilbertson, & Crowley, 2004) and an association between petrol sniffing and schizophrenia has also been suggested (Clinger & Johnson, 1951; Daniels & Latcham, 1984). However, few empirical studies investigating these associations have been conducted, particularly for Indigenous groups. Hence, although associations between psychiatric symptoms and VSU have been reported, they are not well defined or well understood.

6.5 INTERVENTIONS

In Indigenous communities, VSU generally occurs in a context of poverty and reduced educational, recreational and employment opportunities (MacLean & d'Abbs, 2002; Smart, 1988). Primary interventions in these settings may therefore be as basic as providing for the fundamental needs of young people, including food, shelter, nurturing, and sustained education, employment, and recreation opportunities (Access Economics, 2006; Beauvais, 1992b; Bryce, Rowse, & Scrimgeour, 1992; MacLean & d'Abbs, 2002; Shaw, et al., 2004; Smart, 1988). However in these Australian contexts, communities can be ill equipped (socially and economically) to combat VSU, and years of imposed control by non-Indigenous people and dependency on the welfare state mean that a sense of powerlessness can prevail (Bryce, et al., 1992). Many VSU interventions have therefore focused on community development and addressing the sociocultural characteristics surrounding VSU. Others have addressed the psychological status of the user (e.g. counselling or skills development) or focussed on the substances themselves (e.g., reducing access) (see MacLean & d'Abbs, 2002; 2006 for reviews). The most successful interventions however, appear to be both multifaceted and community driven (Beauvais, 1992b; Beauvais & LaBoueff, 1985; Gruenewald, Johnson, Shamblen, Ogilvie, & Collins, 2009; MacLean & d'Abbs, 2002; Preuss & Brown, 2006; Select Committee on Substance Abuse in the Community, 2004; Shaw, et al., 2004; Urbis, 2008).

Beauvais and LaBoueff (1985) describe a method of substance misuse program development for use in American Indian communities that generates strong community involvement through the development of a substance misuse task force

that utilises local data collection to clearly define the problem, and produce community driven and relevant solutions. An Aboriginal community in Arnhem Land, northern Australia, successfully reduced petrol sniffing following a similar process, that involved community acknowledgment of the problem, the development of community driven solutions, and creation of a committee to implement those solutions (Senior & Chenhall, 2007). The 'Healthy Aboriginal Life Team' (HALT) addressed petrol sniffing in some central Australian communities through community development and individual and family counselling (Bryce, et al., 1992; Franks, 1989). The goal was to facilitate community action against VSU by restoring adults' 'nurturant authority' and creating capacity for problem solving (Bryce, et al., 1992; Franks, 1989). Beauvais and LaBoueff (1985) suggest that an important step in controlling deviant behaviour, including substance misuse, is establishing and communicating a clear message regarding the family or community's stance on those behaviours. Unless the acceptable options for an individual are clearly communicated, young people are likely to act in accordance with their peer groups standards which often allow or promote substance use (Beauvais & LaBoueff, 1985).

Gruenewald and colleagues (2009) describe a multidimensional community prevention intervention targeting harmful legal products, including solvents, in Alaskan frontier communities. The intervention involved adapting three complimentary evidence-based prevention interventions: (a) community mobilisation to increase readiness and engage communities in drug prevention activities and actions, (b) environmental strategies to reduce social, physical, and economic access to drugs and (c) a problem solving, life skills program. Increases in knowledge of associated harms, and decreases in perceived availability of harmful products

provided encouragement for the use of such mixed strategies in this setting (Gruenewald, et al., 2009). Skills enhancement programs have also shown promise in equipping American Indian adolescents to better manage pressures around drug use (Gilchrist, Schinke, Trimble, & Cvetkovich, 1987). While addressing factors associated with peer influence may be valuable for preventing low or experimental use, more specialised approaches to treatment are needed for heavy or chronic users.

Primary supply or access reduction interventions have often involved removing the user from the supply to a place of safety, often a remote outstation hundreds of kilometres away from access to petrol (Access Economics, 2006; MacLean & d'Abbs, 2002; Nurcombe, et al., 1970; Shaw, et al., 2004). 'Mount Theo' is a community initiated and run outstation program for petrol sniffers near Yuendumu in central Australia (Preuss & Brown, 2006; Warlpiri Youth Development Aboriginal Corporation, 2008). The program involves four main components including prevention, youth diversion, youth leadership and development, along with education and outreach to assist other communities (Preuss & Brown, 2006; Warlpiri Youth Development Aboriginal Corporation, 2008). Centred around an outstation model, Mt Theo delivers residential rehabilitation involving talking with young people about issues in their lives, talking about cultural law, engaging them in cultural activities (e.g. hunting), and simply providing for their basic needs (i.e. food, shelter, caring, education) (Preuss & Brown, 2006; Warlpiri Youth Development Aboriginal Corporation, 2008). Youth diversion prevention programs are run concurrently, along with mentoring of youth to develop leadership skills. The program also provides education and outreach to assist other communities in dealing with petrol

sniffing outbreaks and to establish youth development programs to prevent further outbreaks.

In a first of its kind approach, the Australian federal government recently introduced a multifaceted regional eight point plan to reduce petrol sniffing in remote Indigenous communities that included: (1) widespread roll-out of a new low aromatic fuel, 'Opal', across the region, (2) a uniform legal framework for dealing with petrol sniffing and mental health – Volatile Substance Abuse Prevention (VSAP) Act, (3) appropriate levels of policing, (4) diversionary activities for young people, (5) activities to strengthen and support communities, (6) new rehabilitation and treatment facilities, (7) a communication strategy, and (8) evaluation of the strategy (Urbis, 2008).

The replacement of the volatile unleaded ('sniffable') petrol with a low aromatic ('non-sniffable') fuel derivative (in conjunction with other measures) has been recognised as an effective strategy in Australia for some time (d'Abbs & Shaw, 2008; Senior, et al., 2006; Shaw, et al., 2004). For example, aviation gasoline ('avgas') replaced unleaded fuel in remote Indigenous communities in the 1990s and more recently, the low-aromatic fuel 'Opal' was similarly introduced. In both cases, significant reductions in petrol sniffing were observed, reducing the burden for communities who could then focus on manageable preventative and support programs (d'Abbs & Shaw, 2008; Shaw, et al., 2004). Similarly, strategies modifying other solvents to make them less appealing to sniffers have also been implemented with mixed success (MacLean & d'Abbs, 2006).

The new VSAP legislation, introduced in Australia gives ‘authorised persons’ (e.g. police, wardens) the power to search for, seize, and destroy volatile solvents (Northern Territory Volatile Substance Abuse Prevention Act, 2005). It does not criminalise VSU but allows provisions for individuals at risk of harm from VSU to be mandated through the courts into treatment. However treatment facilities that are appropriate, both culturally and for the treatment of VSU, can be scarce or difficult to access (i.e. clan specific). Involuntary sentencing of solvent users to the few available outstations or treatment facilities may provide respite, but it rarely elicits long term change unless other psychological and environment strategies are concurrently administered (Coleman, et al., 2001; MacLean & d'Abbs, 2002; Nurcombe, et al., 1970; Seshia, et al., 1978; Shaw, et al., 2004).

The benefits of some of these coordinated efforts are beginning to be recognised, with reductions in the numbers of petrol sniffers in some remote communities in Australia and reduced prevalence of VSU in American Indian reservations (Beauvais, Wayman, et al., 2002; Urbis, 2008). The limited literature and subsequent action therefore strongly maintains that sustained, consistent, multifaceted action is required, beyond crisis intervention, if the problem of VSU in Indigenous communities is to be resolved (MacLean & d'Abbs, 2002; Preuss & Brown, 2006; Urbis, 2008).

6.6 CONCLUSIONS

VSU is a recalcitrant burden for a number of Indigenous communities internationally. Many similarities exist between VSU in Australian Aboriginals and

other Indigenous groups but considerable heterogeneity is also evident. A context of individual, family, and community disadvantage, distress, and dysfunction both contribute to *and* result from the incidence of VSU in Australian Aboriginal communities. But these relationships are complex, and associations may vary depending on severity or patterns of use. Peer pressure may be more influential for experimental users, while chronic users may experience greater underlying sociocultural or psychological distress. The majority of studies from the USA have focussed on the epidemiology of VSU, while studies from Australia and Canada have also investigated the neuropsychological impacts of the practice. Empirical research on the mental or psychiatric effects of VSU are severely lacking for both Indigenous and non-Indigenous populations. Despite the potentially fatal and devastating consequences associated with VSU, communities are now only just beginning to coordinate appropriate interventions for dealing with what is proving a difficult public health burden.

Chapter 7

Recovery from Central Nervous System (CNS) Changes following Volatile Solvent Use (VSU)

Preface

Invited manuscript submitted for publication in a special issue of Substance Use and Misuse titled 'Volatile Substance Misuse: A Global Perspective' [see Appendix A].

The previous chapter reviewed the social, physical and psychological impacts of VSU in Indigenous populations. Chapter 7 will focus more specifically on the CNS impacts of VSU and the subsequent recovery that occurs with abstinence from further abuse. Chapter 4 and Chapter 6 both demonstrated that significant cognitive impairments are likely to result from the chronic abuse of petrol or other solvents. However recent evidence suggests that some of these impairments are recoverable with abstinence. The following chapter will review the available literature on cognitive, neurological and neuroanatomical recovery following VSU. While less than five case control studies were identified, these few studies suggest that progressive decline in cognitive and neurological function is related to the severity and duration of use. Furthermore, the degree of recovery that occurs with abstinence is dependent on the duration of use and degree of initial impairment and cognitive recovery following VSU can take years. If impairment has progressed to neuroanatomical damage, complete recovery may not be possible.

**Recovery from central nervous system (CNS) changes following volatile solvent
use (VSU)**

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ABSTRACT

This review examines cognitive, neurological and neuroanatomical recovery associated with abstinence from VSU. Using the following search terms: cognitive, neurological, neuropsychological, neurobehavioral, neuroanatomical, neuroimaging, CT, MRI, brain, recovery, rehabilitation, volatile, solvent, inhalant, gasoline, petrol, toluene, glue, paint, and sniffing, abuse, misuse, use; articles describing neurobehavioral function longitudinally or cross sectional reports comparing current and abstinent users, published between 1976 to the present, were identified and reviewed. A significant lack of empirical studies investigating CNS recovery following VSU was noted. The few case reports and group studies that were identified indicated that cognitive and neurological recovery may begin with just weeks of abstinence, but residual impairments are likely, and the degree of impairment and recovery is dependent on severity of abuse and degree of initial impairment. Neuroanatomical damage may not recover even with prolonged abstinence.

Keywords: solvents, inhalants, cognitive, neurological, recovery

7.1 INTRODUCTION

Volatile solvents comprise varying combinations of aliphatic, aromatic and chlorinated hydrocarbons, and in the case of leaded petrol, tetraethyl lead (Brouette & Anton, 2001; Brust, 1993). Table 1 lists commonly abused solvents and their constituents. Aromatic hydrocarbons are largely responsible for the psychoactive effects of solvents as they are highly lipid soluble, and are absorbed rapidly into the bloodstream and central nervous system (CNS) (Brouette & Anton, 2001; Dinwiddie, 1994; Goodheart & Dunne, 1994). Tetraethyl lead also contributes to the neurotoxic effects of leaded petrol which reportedly has a stronger psychotic effect compared to unleaded petrol (Cairney & Dingwall, In Press; Cairney, et al., 2002). The high lipid solubility of volatile hydrocarbons contributes to the rapid onset of intoxication following inhalation and appears to be why the lipid rich CNS is more vulnerable to the effects of volatile solvent use (VSU) than other parts of the body (Brouette & Anton, 2001; Fortenberry, 1985; Goodheart & Dunne, 1994; Watson, 1986).

One of the earliest signs of CNS disruption in solvent abusers is cognitive impairment particularly in the areas of memory, attention, visuospatial, executive and motor functions (Cairney, et al., 2004a; Dingwall, Lewis, et al., 2010; Maruff, et al., 1998). Solvent induced encephalopathies have also been reported with neurological effects including tremor, nystagmus, ataxia and other cerebellar signs (Cairney, et al., 2004a, 2004c; King, Day, Oliver, Lush, & Watson, 1981; Maruff, et al., 1998). Lead encephalopathy, characterised by clouding of consciousness, tremor, myoclonus or chorea, limb and gait ataxia, hyperreflexia, nystagmus, seizures and even death, may result from sniffing leaded petrol and requires emergency and intensive hospital

treatment (Boeckx, et al., 1977; Cairney, et al., 2004a; Coulehan, et al., 1983; Goodheart & Dunne, 1994; Seshia, et al., 1978). Treatment with chelating agents may reduce symptom severity and blood lead burden by mobilising inorganic lead for excretion, however residual neurological impairments may persist (Burns & Currie, 1995; Cairney, et al., 2004a). Despite these devastating impacts, there have been very few systematic studies of the long term CNS consequences of VSU and the prognosis for solvent abusers with CNS changes was previously considered poor (Brady & Torzillo, 1994; Kaufman, 1973; Knox & Nelson, 1966). Nevertheless, several case reports and recent empirical studies suggest that cognitive and neurological recovery is possible following abstinence from further VSU. This paper aims to review the literature on cognitive, neurological and neuroanatomical recovery from the CNS impacts of VSU.

Literature searches of key health science databases (including PsychINFO, PsychARTICLES, Medline, PubMed, Academic Search Premier (EBSCO), Science Direct, JSTOR, SpringerLink) were conducted using the following search terms in various combinations: cognitive, neurological, neuropsychological, neurobehavioral, neuroanatomical, neuroimaging, CT, MRI, brain, recovery, rehabilitation, volatile, solvent, inhalant, gasoline, petrol, toluene, glue, paint, sniffing, abuse, misuse, use. Articles describing neurobehavioral function longitudinally (i.e., more than one examination) or cross sectional reports comparing current to abstinent users, published between 1976 to the present, were reviewed and these are presented in Table 2. The majority of reports identified had examined recovery (or lack of) among users of toluene (10 case reports; 4 group studies) or petrol (4 case reports; 6

group studies), with three papers examining mixed solvents and two case reports describing changes associated with n-hexane inhalation.

Table 1. Abused Substances and their Constituents

Substances and Compound Classes	Common Constituents
<u>Petrol</u>	
Aromatic hydrocarbons	Toluene, benzene, xylene
Aliphatic hydrocarbons	<i>n</i> -hexane, paraffins
Other	Tetraethyl lead (leaded petrol)
Alicyclic compounds	Cycloalkanes or Naphthenes
<u>Adhesives/Glues/Cements</u>	
Aromatic hydrocarbons	Toluene, benzene, xylenes, naphthalene
Aliphatic hydrocarbons	<i>n</i> -hexane, aliphatic acetates
Ketones	Acetone, methyl butyl ketone (hexanone), ethyl acetate, methyl ethyl ketone (butanone)
Alicyclic compounds	Cyclohexane
<u>Paints/Varnish/Thinners</u>	
Aromatic hydrocarbons	Toluene, xylenes, benzene
Aliphatic hydrocarbons	Hexane, aliphatic acetates
Ketones	Acetone, butanone, esters, hexanone
Chlorinated hydrocarbons	Trichloroethylene, 1,1,1-Trichloroethane
<u>Aerosols</u>	
Aliphatic hydrocarbons	Butane, Propane
Fluorocarbons	Tetrafluoromethane
<u>Cleaning agents/Typewriter Correction Fluid</u>	
Chlorinated hydrocarbons	Trichloroethylene, 1,1,1-Trichloroethane, Tetrachloroethylene

Reference: (Brouette & Anton, 2001; Brust, 1993; Flanagan & Ives, 1994; Lubman, et al., 2008)

Table 2. Studies Identified Documenting Changes Associated with Abstinence or Continued Inhalation of Solvents

Reference	N (k)	Mean Age (years)	Assessments	Study design/setting	Use severity	Treatment	Main Findings
Petrol							
(McGrath, 1986)	1	15	Neurological, psychological, cognitive, blood lead levels, CT head scan, EEG, laboratory tests	Clinical case report	Sniff petrol on occasions	Chelation	Lead encephalopathy. Mental state improved on 5 th day of chelation therapy (i.e. day 10). Psychometric testing at 1 month: mild visuospatial impairment recovered within 2 months
(Valpey, et al., 1978)	1	17	Neurological, physical, cognitive, laboratory tests	Clinical case report	4 years petrol use	Chelation	Neurological, cognitive abnormalities. Movement disorder abated and cognitive function improved somewhat after 5 days chelation. Residual ataxia dysarthria and dysmetria at discharge.
(Boeckx, et al., 1977)	2	15	Neurological, EEG, ALAD, Blood lead level, behavioural	Clinical case report	'Chronic petrol sniffing' otherwise unstated	Chelation	4-6 weeks: still tremulous and ataxic; 8-weeks: gait recovered, minimal tremor; 2 months: normal
(Edminster & Bayer, 1985)	2	17 & 19	Neurological, physical, laboratory tests.	Clinical case reports	3-4 weeks petrol use	Chelation	Neurologic abnormalities including seizures. Clinical improvement but residual neurological abnormalities at discharge.
(Goodheart & Dunne, 1994)	25 (1)	17	Neurological, physical, CT, laboratory tests EEG	Clinical observations	Acute to chronic petrol use	Chelation	Neurologic, neuroanatomical & EEG abnormalities. Ataxia and dementia common at discharge after 1-5 months.

(Seshia, et al., 1978)	50 (1)	4-20 (range)	Neurological, blood lead levels, ALAD, nerve conduction velocity, EEG, laboratory tests	Clinical observations longitudinally up to 11 months	6 months to >5 years petrol use; 2/day to 3/week	Chelation	92% of abnormal neurological signs recovered within 8 weeks in all but one case (i.e. postural tremor evident at 11 months). Dose response relationship. Abnormal EEG recovered 8-12 weeks later in 10/15 patients.
(Cairney, et al., 2004b, 2005)	40 (2)	22	Neurological, cognitive, saccadic eye movements	Longitudinal case control study of encephalopathic users, non-encephalopathic users & healthy controls	≥6 months petrol use, (mean 7-13 years use);	Abstinence (2 years)	Neurobehavioral impairments improved and in some cases normalised within 2 years.
(Cairney, et al., 2004c)	96 (4)	20	Neurological, saccadic eye movements	Cross-sectional case control comparing encephalopathic users, non-encephalopathic users, ex-users and healthy controls	≥6 months petrol use, (mean 6-10 years use); mean 3-6 cans per week	Abstinence (i.e., ex-sniffers, mean of 2 years)	Dose response relationship. Neurological impairments in current and ex-sniffers but less severe in ex sniffers. Saccadic abnormalities in current sniffers but not ex sniffers.
(Maruff, et al., 1998)	97 (3)		Neurological, cognitive	Cross-sectional case control comparing current users, ex-users and healthy controls	≥6 months petrol use, (mean 6-10 years)	Abstinence (i.e., ex-sniffers, mean of 2 years)	Neurological and cognitive deficits in both current and ex sniffers compared to controls. Qualitatively similar but quantitatively less severe impairments in ex-sniffers compared to current sniffers.
(Dingwall, Maruff, Fredrickson, & Cairney, 2010)	78 (2)	16	Cognitive	Longitudinal case control study of petrol abusers and healthy controls	Mean 5 years use	Abstinence (2-11 months)	Cognitive impairments improved beginning week 2 with some recovered by 2 months. Residual visual motor and executive function speed problems at 11 months

Toluene

(Caldemeyer, et al., 1993)	1	31	Neurological, cognitive, physical, laboratory tests, MRI	Clinical case report	Chronic frequent toluene abuse	No treatment (Continued use)	Neurological, cognitive MRI abnormalities and reduced visual acuity. Further reductions in visual acuity after 4 months continued use. Progression of white matter abnormalities over 1 month
(Deleu & Hanssens, 2000)	1	21	Neurological, blood count, laboratory tests, EEG, MRI	Clinical case report	8 years daily toluene use	Abstinence (5 months) then Amantadine hydrochloride	No improvement in neurological signs with 5 months abstinence but improvement with amantadine hydrochloride treatment after 3 months. Deterioration upon withdrawal of treatment and improvement when treatment reinstated.
(Ehyai & Freeman, 1983)	1	27	Neurological, CT, EEG, nuclear brain scan, CSF test, laboratory tests.	Clinical case report	5 years daily toluene use	Abstinence (1 week - 1 month)	Cerebellar signs on neurological examination but brain scans normal. 1 week abstinence: gradual improvement in cerebellar functions. 2 years continued use: gradual decrease in hearing and vision, optic disc pallor. Another 2 years continued use: decreased mental/cognitive function, optic atrophy, neurological abnormalities, brain atrophy & enlarged ventricles, hearing loss.
(Kamran & Bakshi, 1998)	1	36	Neurological, cognitive, MRI	Clinical case report	15 years toluene use	Abstinence (4 months); then resumed	Neurological and neuroanatomical abnormalities, reduced visual acuity, optic disc pallor & opsoclonus, impaired calculation, short term memory, attention and vigilance, low IQ. Improved visual symptoms with 4 months abstinence. Resumed sniffing and neurological symptoms and MRI unchanged 3 years later.

(Keane, 1978)	1	20	Neurological, electroretinogram, Laboratory tests, CAT scan	Clinical case report	3 years daily toluene use	Abstinence (2 months)	Neurological abnormalities but normal CAT scan. Neurological symptoms subsided with abstinence. Minimal cerebellar dysfunction persisted.
(Kelly, 2001)	1	19	Neurological, EEG, brain scan, laboratory tests	Clinical case report	1.5 years daily paint sniffing	Abstinence (5 months)	Neurological impairments (reflecting cerebellar dysfunction) improved within 5 months but residual impairment (e.g. abnormal tandem gait) persisted
(Rosenberg, Kleinschmidt-DeMasters, et al., 1988; Rosenberg, Spitz, et al., 1988)	1	28	Neurological, MRI	Clinical case report	15 years toluene use	Residential rehabilitation Abstinence (18 months)	Improvement in neurological function but no improvement on repeated MRI
(Ryu et al., 1998)	1	17	Neurological, cognitive, laboratory tests, EEG, MRI, SPECT	Clinical case report	8 months frequent toluene use	Abstinence	Impaired cognitive function, mild cortical dysfunction on EEG, multifocal impairment of perfusion in frontal & parietal cortex, basal ganglia & thalami. No abnormalities on MRI. 14 months abstinence: nearly complete normalisation of perfusion on SPECT.
(Boor & Hurrig, 1977)	2	59 & 25	Neurological, cognitive, mental, blood counts, liver function tests, EEG, brain scans, ENG	Clinical case reports	Occupational toluene exposure (n = 1; > 3 months use) & intentional toluene abuse (n = 1; M = 15 years)	Abstinence	Occupational exposure: Neurological and cognitive abnormalities recovered within 1 month. Intentional abuse: Neurological improvements within 1 week but residual impairments that remained unchanged 9 months later

(Devathasan, Wan, Low, Wong, & Teoh, 1984)	2	15 & 18	Neurological, physical, cognitive, CT, EEG, CSF test, EMG,	Clinical case reports	5 years toluene use	Abstinence	Sensorimotor neuropathy, neurological & EEG abnormalities and intellectual deterioration. 18 months: full recovery of power, persistent areflexia, no change mentally
(King, 1982; King, et al., 1981)	19 (1)	11	Neurological, physical, laboratory tests, EEG	Clinical observations	Unspecified duration of toluene use	Abstinence	Neurological, behavioural and EEG abnormalities recovered in all but one case who showed persistent cerebellar signs
(Hormes, et al., 1986)	20 (1)	27	Neurological, cognitive, laboratory tests, CT, EEG	Clinical observation in treatment setting	Mean 12 years toluene use; 1 can/day	Abstinence	Neurologic, cognitive and neuroimaging abnormalities including atrophy at baseline. Subjective improvement in balance, smell and tremor after abstinence.
(Fornazzari, et al., 1983)	24 (1)	23	Neurological, cognitive CT, CSF tests	Clinical observations	Mean 6 years daily toluene use	Abstinence (2 weeks)	Little to no improvement observed on neurological or cognitive assessment during 2 weeks. 4/11 patients showed reduction of ataxia and improved locomotor coordination
(Streicher, et al., 1981)	25 (1)	25	Neurological, physical, laboratory tests	Clinical observations	4 days to several weeks toluene use	Abstinence	Altered mental status resolved over 1-8 days, persisting neuropathy and cerebellar abnormalities at discharge
<u>Mixed Solvents</u>							
(Feldman, et al., 1999)	1	57	Neurological, cognitive	Clinical case report	Occupational exposure to mixed solvents over 30 years	None (ceased exposure)	Impairments on verbal and nonverbal memory, attention executive function, visuomotor coordination impaired at baseline and remained impaired 1 year later
(Comstock & Comstock, 1977)	8 (1)	18	Neurological, physical, psychiatric	Multiple clinical case reports	Mean 3.5 years use mixed solvents	Abstinence	Acute organic brain syndrome that disappeared within several days

(Riedel, Hebert, & Byrd, 1995)	50 (1)	10-17 (range)	Neurological, cognitive	Longitudinal assessment in treatment setting	Mean 3.2 years use various solvents	Residential rehabilitation	44% with neurocognitive impairment. Mean average reductions from 23-28% in deficit score post-treatment
<u>n-Hexane</u>							
(Paulson & Waylonis, 1976)	2	22	Neurological, physical, laboratory tests	Clinical case report	Occupational exposure	Abstinence	Poly neuropathy including muscle ache, weakness in both legs, hyporeflexia recovered completely within 6 months.
(Tenenbein, deGroot, & Rajani, 1984)	2	16	Neurological, laboratory tests	Clinical case report	≥2 years use	Abstinence	Peripheral neuropathy incl. broad based high stepping gait, bilateral foot drop, no muscle stretch reflexes, decreased nerve conduction velocities. 10 months: normal muscle strength and tone, increased nerve conduction velocities.

Note. N = total sample size. k = number of groups. CT = computed tomography. EEG = electroencephalogram. ENG = electromyogram. MRI = magnetic resonance imaging. ALAD = delta aminolevulinic acid dehydrase. CANTAB = Cambridge Neuropsychological Test Automated Battery. CSF = cerebral spinal fluid. SPECT = single-photon emission computed tomography

7.2 RECOVERY OF COGNITIVE ABNORMALITIES

Cognitive abnormalities in the areas of psychomotor, attention, visuospatial, memory, learning and executive functions have been identified following chronic VSU (Cairney, et al., 2004a, 2005; Dingwall, Lewis, et al., 2010; Hormes, et al., 1986; Maruff, et al., 1998). Progressive decline of these cognitive functions may be the first sign of impairment in chronic users, and the severity of impairment may be directly related to the number of years of use (Cairney, et al., 2004a, 2005; Hormes, et al., 1986; Maruff, et al., 1998). Nevertheless, several studies and numerous case reports have observed cognitive recovery with abstinence. This review identified eight papers examining changes in cognitive performance following VSU.

Four case reports, examining petrol abuse and occupational exposure to toluene or mixed solvents, were merely suggestive of improvements in cognitive function with abstinence. One reported improved but not recovered calculation and memory abilities with five days chelation therapy following chronic petrol abuse of four years (Valpey, et al., 1978), while another suggested that concentration was diminished (among other neurological impairments) in a patient with occupational exposure to toluene, and nonspecific recovery was observed within a month (Boor & Hurtig, 1977). Another observed visuospatial impairments that resolved with two months abstinence from 'occasional' petrol inhalation (McGrath, 1986). A fourth report suggested some improvement but not complete recovery of cognitive deficits (i.e. memory, attention, executive function, visuospatial planning and organisation, and visuomotor coordination) after one year of ceasing chronic occupational exposure to mixed solvents (Feldman, et al., 1999). But it is unclear from this report how much

improvement was observed or in which cognitive domains the improvement occurred. A fifth case report showed that overall scores on the Wechsler Adult Intelligence Scale and the Wechsler Memory Scale had deteriorated after 1 year of continued glue (i.e., toluene) inhalation (Ehyai & Freemon, 1983). Together these reports suggest that recovery from VSU related cognitive impairments may begin in as little as one week after cessation of use and further deterioration is associated with continued use. The recovery reported is fairly non-specific however, and secondary to reporting of neurological findings. In some cases it is unclear whether formal evaluation of cognition was performed and the degree and duration of exposure is often ill-defined. These case reports are therefore of limited value for understanding the cognitive recovery associated with VSU.

Studies of groups of solvent users may be more insightful. A non-peer reviewed paper by Riedel et al. (1995) reports neurocognitive findings from a group of mixed solvent users attending treatment. They report a mean reduction (improvement) of 28% in total Halstead Reitan Neuropsychological Test Battery (HRB) scores, from admission to discharge, for children aged 10-14 years and a mean reduction of 23% for adolescents (aged 15-17). They also suggest that 30% of those impaired at admission (i.e. 44% of those tested were impaired) progress to the normal range of functioning by the time they are discharged. However, reporting of these findings lacked scientific rigour and neglected to specify for this particular group, how the 'impaired range' was defined, what the interval between admission and discharge was, and how the impacts of practice effects were controlled. Although the paper described age of first use (i.e. 10 years), 'estimated' duration of use (i.e. 3 years) and mean length of treatment stay (i.e. 97 days), based on data from the full 101 youths

who attended treatment, the precise characteristics for the specific group of 50 youths assessed were not adequately described. Conversely, in a peer reviewed paper, Fornazzari (1983) examined cognition using the Wechsler Adult Intelligence Scale, Wechsler Memory Scale, and HRB in a group of daily toluene abusers of 6 years. They found “little to no improvement” after two weeks abstinence, with no improvement on verbal learning and short term verbal memory tasks despite the authors expecting some improvement due to practice effects (Fornazzari, et al., 1983, p. 327). The interval between tests was short, however, and lack of improvement may relate to the greater duration of use (i.e. 6 years) compared to the reports above finding rapid recovery following ‘occasional’ or ‘occupational’ solvent exposure. Fornazzari et al. (1983) found impaired users (i.e., ≥ 4 abnormal findings) to have a significantly greater duration of abuse (i.e. 6.9 years) compared to unimpaired users (i.e., 4.6 years), but found no significant correlation between cognitive scores and consumption. The finding of no improvement with practice highlights a limitation of the above studies’ design in failing to employ the use of a healthy control group to adequately assess or control for practice effects.

Three case-control studies may therefore provide the best insight into the nature of cognitive recovery following abstinence from VSU (Cairney, et al., 2005; Dingwall, Maruff, Fredrickson, et al., 2010; Maruff, et al., 1998). Maruff et al. (1998) observed cognitive deficits reflecting frontostriatal brain abnormalities among current and ex-petrol abusers compared to healthy controls. The cognitive deficits (e.g., recognition memory, paired associate learning) among ex-users were qualitatively similar but quantitatively less severe than those of the current active sniffers. Furthermore, on some tasks (e.g. visual search), while current users were impaired, no significant

difference was observed between the ex-sniffers and healthy controls. This suggests that improvement and in some cases normalisation of functions had occurred with a mean abstinence period of two years. A longitudinal follow up of the same cohort confirmed that recovery of cognitive function does occur following cessation from further use (Cairney, et al., 2005). Chronic petrol sniffers and healthy controls were assessed at baseline, when a community intervention completely eradicated petrol sniffing, then again two years after sniffing cessation (Cairney, et al., 2004b, 2005). These data showed substantial recovery (i.e. on paired associate learning and visual search tasks) after two years of abstinence and almost complete recovery among some users. However, as a consequence of longer-term and heavier use, residual deficits (i.e. paired associate learning and pattern recognition memory deficits) were observed in individuals with more serious impairments prior to sniffing cessation or those with a history of petrol sniffing related lead encephalopathy (Cairney, et al., 2005). These same cohort have recently been reassessed after 15 years abstinence and although further recovery was observed, residual impairments remain for some users with greater abuse histories (Cairney, Berkhout, et al., 2009).

A recent study has monitored petrol abusers fortnightly during two months of residential treatment immediately following cessation of abuse, as well as approximately one year after treatment discharge (Dingwall, Maruff, Fredrickson, et al., 2010, see Chapter 8). Upon abuse cessation (i.e. treatment entry), petrol abusers, with a mean of five years use, showed significant deficits in attention, visual motor, learning and memory and executive functions compared to healthy controls. While deficits in visual motor and executive function speed persisted throughout the duration of treatment and beyond, learning and memory functions began to recover

within two weeks of abstinence and many had recovered by the end of treatment (i.e. 2 months). Compared with Cairney et al. (2005) and Maruff et al.'s (1998) studies, participants in this study were younger and had a lesser total time of abuse (Dingwall, Maruff, Fredrickson, et al., 2010). It is therefore likely that residual neurological abnormalities observed at two years in previous studies were a consequence of longer-term and heavier use (Cairney, et al., 2005). Furthermore, the individuals in the previous study had abused predominately leaded petrol whereas Dingwall, Maruff, Fredrickson, et al.'s (2010) group all used unleaded petrol.

Together these results suggest that recovery of cognition is possible with abstinence from further VSU. While it may begin within weeks of VSU cessation, it may also progress slowly over years and some impairment may be permanent. The degree or severity of impairment appears directly related to the quantity and number of years of VSU while recovery is related to the severity of initial impairment and length of abstinence (Cairney, et al., 2005; Maruff, et al., 1998; McGrath, 1986; Valpey, et al., 1978). The cognitive deficits observed in these studies reflect functional consequences of frontostriatal changes that may, as in the case with alcohol, precede longer term cerebellar changes that may be more permanent (Cairney, et al., 2007; Cairney, et al., 2005).

7.3 RECOVERY OF NEUROLOGICAL ABNORMALITIES

The progressive decline in cognitive function following VSU may precede more serious neurological abnormalities that affect movement and speech, and indicate disruption to cerebellar neural circuitry (Cairney, et al., 2004a, 2004c, 2005).

Neurologic signs associated with VSU include ataxia, visual deterioration, tremor, myopathy, nystagmus, palmomental reflexes, brisk deep reflexes, abnormal tandem gait, hearing loss, adiadochokinesis, dysarthria, and anosmia (Boeckx, et al., 1977; Cairney, et al., 2004a, 2004c, 2005; Ehyai & Freemon, 1983; Feldman, et al., 1999; Goodheart & Dunne, 1994; King, et al., 1981; Maruff, et al., 1998; McGrath, 1986).

Twelve case studies (Boeckx, et al., 1977; Boor & Hurtig, 1977; Devathanan, et al., 1984; Edminster & Bayer, 1985; Ehyai & Freemon, 1983; Kamran & Bakshi, 1998; Keane, 1978; Kelly, 2001; Paulson & Waylonis, 1976; Rosenberg, Kleinschmidt-DeMasters, et al., 1988; Tenenbein, et al., 1984; Valpey, et al., 1978), seven clinical group reports (Comstock & Comstock, 1977; Fornazzari, et al., 1983; Goodheart & Dunne, 1994; Hormes, et al., 1986; King, et al., 1981; Seshia, et al., 1978; Streicher, et al., 1981) and three case-control studies (Cairney, et al., 2004c, 2005; Maruff, et al., 1998) were identified in the literature that suggested recovery of neurological function may occur, beginning as soon as 1-2 weeks following cessation of VSU (see Table 2). However, although significant recovery and normalisation may be possible for some users, other users may experience residual, even permanent neurological abnormalities even after years of abstinence, and certainly with continued use (Boor & Hurtig, 1977; Cairney, et al., 2004c, 2005; Caldemeyer, et al., 1993; Devathanan, et al., 1984; Edminster & Bayer, 1985; Ehyai & Freemon, 1983; Fornazzari, et al., 1983; Goodheart & Dunne, 1994; Kamran & Bakshi, 1998; Keane, 1978; Kelly, 2001; King, et al., 1981; Maruff, et al., 1998; Seshia, et al., 1978; Streicher, et al., 1981; Valpey, et al., 1978).

Without prospective studies documenting recovery longitudinally, it is difficult to specify the specific time course for neurological recovery. One case study observed subjective improvements, but not resolution of neurological abnormalities after one week of abstinence from toluene abuse of 15 years duration (Boor & Hurtig, 1977). A clinical observation study of a group of toluene users, with a mean of six years duration, also demonstrated some reduction in ataxia and improved locomotor coordination after just two weeks of abstinence, however the specific degree of improvement was not clearly defined (Fornazzari, et al., 1983). Rapid recovery of neurological symptoms may reflect reversal of the acute biochemical effects of the solvents however this is thought to be complete within 5-7 days (Comstock & Comstock, 1977).

Three case studies and two multiple case reports observed complete recovery of some neurological abnormalities (i.e., dysarthria, ataxia, nystagmus, hyposmia, abnormally brisk reflexes, tremor, diadokinesis, and EEG abnormalities) within 1-2 months abstinence (Boeckx, et al., 1977; Boor & Hurtig, 1977; Keane, 1978; King, et al., 1981; Seshia, et al., 1978). One of these group studies followed 50 petrol abusers over approximately 3-5 months and observed a significant relationship between blood lead levels and neurological abnormalities (Seshia, et al., 1978). However the petrol abusers in that study and those in other case reports (Boeckx, et al., 1977; Valpey, et al., 1978) also received chelation therapy which reduced their blood lead burden. As blood lead levels correlate with functional impairments and recovery, it is unclear whether a similar time frame could be expected for recovery with abstinence alone. King et al. (1981) reported recovery of EEG abnormalities within three weeks of abstinence from toluene abuse and complete recovery of other

neurological abnormalities in 13 out of 19 patients within an unspecified period. But as with many of the case reports, the duration and severity of abuse was not adequately defined nor was the length of time symptoms persisted, so it is unclear whether the symptoms were the result of acute intoxication or reflected a persistent organic brain syndrome or encephalopathy (Boeckx, et al., 1977; Caldemeyer, et al., 1993; Goodheart & Dunne, 1994; King, et al., 1981; McGrath, 1986).

Other reports, including six case studies and three case-control studies have documented improvements and/or normalisation of impairments within 4–24 months following cessation of VSU (Cairney, et al., 2004c, 2005; Devathasan, et al., 1984; Kamran & Bakshi, 1998; Kelly, 2001; Maruff, et al., 1998; Paulson & Waylonis, 1976; Tenenbein, et al., 1984; Valpey, et al., 1978). The three case-control studies deserve specific mention, as they represent the most systematic studies of neurological recovery following VSU to date (Cairney, et al., 2004c, 2005; Maruff, et al., 1998). In association with the cognitive findings discussed above, these studies also demonstrated improvement, and in some cases normalisation of neurological abnormalities, including palmomental reflex, postural tremor, disdiadochokinesia, deep reflexes, and decreased antisaccade errors, following a mean of two years abstinence from petrol abuse (Cairney, et al., 2004c, 2005; Maruff, et al., 1998). Residual neurological impairments were observed for users with a history of lead encephalopathy however, that included abnormal tandem gait, deep tendon reflexes, and palmomental reflex, dysdiadochokinesia, postural tremor, nystagmus, dysmetria, and saccade slowing which reflected cerebellar damage (Cairney, et al., 2004c, 2005; Maruff, et al., 1998). Although these studies assessed individuals over 12 hours after cessation of abuse, the recovery observed may reflect

resolution of the residual biochemical effects of solvents (Comstock & Comstock, 1977). However, a further follow up after 15 years demonstrated further improvements in neurological function, but some residual impairments among the most severely impaired users (Cairney, Berkhout, et al., 2009). Prospective case control studies, examining neurological function over several test sessions, may help distinguish the short term acute intoxication effects which resolve within weeks of abstinence from the chronic effects which may be more persistent.

Nevertheless, this evidence suggests that cognitive changes reflecting frontostriatal abnormalities precede neurological impairments reflecting cerebellar abnormalities. Cognitive changes may be more reversible than neurological or cerebellar abnormalities which appear to be more persistent or even permanent. Cognitive and neurological impairments appear to follow a progression of decline (and progression of recovery) model, that is related to the duration and severity of abuse, and blood lead levels among leaded petrol abusers. By contrast, lead encephalopathy appears to be associated with more catastrophic or abrupt damage to cerebellar processes that may never fully recover.

7.4 RECOVERY OF NEUROIMAGING ABNORMALITIES

The neuroanatomical correlates of petrol abuse however have not been empirically investigated. Neuro-imaging studies in adults have generally assessed the impact of toluene, reporting primarily white-matter, periventricular and sub-cortical abnormalities (Lubman, et al., 2008). These abnormalities may include loss of grey-white matter differentiation, diminished white matter volume, demyelination and

myelin pallor, ventricular enlargement and widening of cortical and cerebellar sulci, decreased regional cerebral blood flow, hypointensities in the basal ganglia, midbrain, thalamus, globus pallidus, and substantia nigra (Boor & Hurtig, 1977; Caldemeyer, et al., 1993; Deleu & Hanssens, 2000; Filley, et al., 1990; Kamran & Bakshi, 1998; Rosenberg, et al., 2002; Rosenberg, Kleinschmidt-DeMasters, et al., 1988; Unger, et al., 1994; Yamanouchi, et al., 1995). Brain atrophy is also observed in the hippocampus, cerebellum, cerebrum, corpus callosum and brainstem (Boor & Hurtig, 1977; Ehyai & Freemon, 1983; Goodheart & Dunne, 1994; Hormes, et al., 1986; Kamran & Bakshi, 1998; Rosenberg, Kleinschmidt-DeMasters, et al., 1988; Unger, et al., 1994; Valpey, et al., 1978). Although the degree of functional impairment correlates well with the degree of neuroanatomical changes (Filley, et al., 1990; Fornazzari, et al., 1983; Rosenberg, Kleinschmidt-DeMasters, et al., 1988), the relationship between functional recovery and brain structure changes is currently unclear.

All of the reports identified examining neuroimaging data longitudinally were single case reports (Caldemeyer, et al., 1993; Ehyai & Freemon, 1983; Kamran & Bakshi, 1998; Rosenberg, Kleinschmidt-DeMasters, et al., 1988; Ryu, et al., 1998). Only one study examined magnetic resonance imaging (MRI) changes following abstinence, while three others reported changes following continued use. Rosenberg and colleagues (1988) conducted repeated MRI of one adult over 18 months of abstinence from toluene abuse. They observed no structural improvement despite improvement in neurological function suggesting that some VSU related anatomical changes may be irreversible. Conversely, Caldemeyer and colleagues (1993) and Ehyai and Freemon (1983) observed progression of white matter abnormalities and

emergence of brain atrophy with continued toluene abuse. Kamran and Bakshi (1998) observed no improvement in MRI abnormalities of a resumed sniffer reassessed after three years. These results support the finding of a dose response relationship by demonstrating that continued VSU may lead to further neuroanatomical damage.

Interestingly, Ryu and colleagues (1998) observed no abnormalities on MRI scans of a toluene user of eight months, but observed multifocal impairment of perfusion in bilateral frontal, parietal cortex, basal ganglia and thalami on single-photon emission computed tomography (SPECT) scans. Furthermore, these abnormalities showed almost complete normalisation with 14 months abstinence. The authors interpreted these abnormalities as reflecting functional, rather than structural, impairment and recovery. Previously, Unger and colleagues (1994) hypothesised that the toluene partitioned into brain lipids may account for white matter abnormalities observed on MRI scans of solvent abusers. It seems plausible then that elimination of stored toluene following abstinence may correlate with the functional (i.e. neurological and cognitive) recovery observed among solvent abusers. Research is however yet to investigate whether white matter abnormalities resolve following the elimination of residual toluene from the system. The available evidence therefore suggests that cognitive impairment precedes more severe neurological and neuroanatomical abnormalities and that while functional recovery may be possible, no evidence currently exists documenting structural recovery with abstinence.

7.5 CONCLUSIONS

Little empirical evidence exists regarding the nature of cognitive, neurological and neuroanatomical recovery following abstinence from further VSU. While many case reports exist, the majority of scientific knowledge regarding the CNS recovery associated with abstinence from VSU is based on four case-control studies. This available evidence suggests that cognitive impairment, suggesting frontostriatal changes, precedes neurological impairment reflecting cerebellar changes. The degree of impairment is related to the severity and duration of abuse and among leaded petrol abusers, correlates with blood lead levels. Moreover, the progression of cognitive and neurological recovery relates specifically to the degree of initial impairment and residual blood lead burden. While recovery may begin with just weeks of abstinence, residual impairments are likely that may continue to resolve with sustained abstinence over years, although some may never fully recover. Chronic VSU related organic brain syndromes may therefore consist of an acute intoxication phase which resolves within weeks of abstinence and a chronic phase which may be more persistent (Lolin, 1989). Alternately, lead encephalopathy may be associated with abrupt, catastrophic and potentially permanent changes involving cerebellar dysfunction. But until larger well controlled prospective studies are available the specific nature and time course for recovery of neurological function immediately following cessation of abuse will remain unclear. Importantly, this review identified a significant lack of empirical neuroimaging studies investigating the neuroanatomical correlates of the cognitive and neurological improvement associated with abstinence from VSU.

Chapter 8

Cognitive Recovery During and After Treatment for Volatile Solvent Abuse

Preface

Manuscript submitted for publication [see Appendix A].

As the previous review chapter clearly demonstrated, little empirical evidence exists regarding the recovery of CNS impairment following abstinence from solvent abuse. Nevertheless, the evidence that is available indicates that cognitive recovery and even normalisation of function occurs within two years of abstinence with the degree of recovery possible dependent on the duration of abuse and the initial degree of impairment. The following chapter presents a study that investigates the specific timeline for cognitive recovery immediately following cessation of abuse, amongst a group of chronic Aboriginal Australian solvent abusers who had inhaled predominately unleaded petrol. Cognition is monitored longitudinally during residential rehabilitation programs with community follow up assessments conducted approximately one year later. This provides insight into the cognitive recovery process, as presented here in Chapter 8, and in addition, enables the evaluation of factors that underlie effective rehabilitation as presented in Chapter 9. The cognitive assessment protocol that is established in Part A and assessed for use with Indigenous people is used in the following chapters to monitor cognition and associated psychological factors.

Cognitive recovery during and after treatment for volatile solvent abuse.

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ABSTRACT

Background: Cognitive impairment reflecting CNS disruption in chronic solvent abusers can resolve within two years of abstinence. However, the specific time course for recovery has yet to be determined empirically. This study monitored cognition among solvent (i.e. petrol) abusers throughout 8 weeks of residential treatment. It also investigated the extent to which solvent related cognitive impairments persisted following discharge. **Methods:** Non-drug using healthy controls (n=40) and solvent abusers (n=38) who had inhaled petrol, regularly or episodically, for an average of 4.8 years (SD = 3.3) were assessed. Using linear mixed model analyses, solvent abusers were compared to healthy controls throughout treatment at baseline, 2 weeks, 4 weeks and 6 weeks, on visual motor, attention, learning, memory, and executive function tasks. Forty-six participants were reassessed an average of 12 months later (SD = 4.6) and the performances of abstinent users (n = 11) and relapsed users (n = 16), were compared to healthy controls (n = 19) using ANCOVA while controlling for age and baseline performance. **Results:** At baseline, solvent abusers showed cognitive deficits on visual motor, learning and memory, paired associate learning, and executive functions. Learning and memory performance improved within 2-8 weeks of abstinence however, impairments in visual motor and executive function speed persisted throughout and beyond treatment, for both abstinent and relapsed users. **Conclusions:** Cognitive deficits exist for solvent abusers upon treatment entry. Some impairments resolve within weeks of abstinence, while processing speed improves gradually over months to years of abstinence, and might never fully recover. **Keywords:** petrol, petrol, solvents, cognitive recovery, Aboriginal

8.1 INTRODUCTION

Volatile solvents, such as paint, glue or petrol (i.e. petrol), can be inhaled to achieve intoxication (National Inhalant Abuse Taskforce, 2005; Steffee & Davis, 1996). The Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) classifies these behaviours as ‘inhalant abuse’ (American Psychiatric Association, 2000), although this term may also be applied to the use of anaesthetic gases or aliphatic nitrates. The term ‘volatile solvent abuse’ is therefore often applied more specifically (Beauvais, 1992e). Volatile solvent abuse studies indicate that the practice is prevalent in marginalised, remote or rural, and non-English speaking communities (Edwards et al., 2007; Gilbert, 1983; Goodheart & Dunne, 1994). Of the various solvents inhaled, petrol is more commonly used in remote regions where access to other drugs and alcohol can be limited by strict regulation or geography (Brady & Torzillo, 1994). In these communities the individuals who abuse petrol typically have low involvement in education and employment, and petrol abuse is associated with substantial social disruption in affected communities (Cairney & Dingwall, In Press).

Petrol and other solvents contain complex mixtures of aliphatic, aromatic and chlorinated hydrocarbons, which are highly lipid soluble and absorbed rapidly into the central nervous system (CNS) (Brouette & Anton, 2001; Dinwiddie, 1994; Goodheart & Dunne, 1994). The similarities in composition between petrol and other solvents are reflected in their similar pharmacological and neurotoxic effects (Dingwall, Lewis, et al., 2010; Press & Done, 1967a, 1967b). Petrol inhalation causes intoxication quickly with euphoria or excitability followed by CNS

depression at larger doses (Goodheart & Dunne, 1994). Acutely petrol abuse can also give rise to status epilepticus, coma and even death (Goodheart & Dunne, 1994). Longer term CNS changes associated with chronic abuse include nystagmus, ataxia and other cerebellar signs as well as dementia, depression and psychosis (Cairney, Clough, et al., 2003; Cairney & Dingwall, In Press; Jacobs & Ghodse, 1987; Maruff, et al., 1998). One of the earliest signs of CNS disruption in petrol abusers is cognitive impairment particularly in the areas of memory, attention and motor function (Cairney, et al., 2004a; Dingwall, Lewis, et al., 2010; Maruff, et al., 1998).

There have been very few systematic studies of the CNS consequences of chronic petrol abuse although the prognosis for petrol abusers with CNS changes was typically considered to be poor (Boeckx, et al., 1977; Brady & Torzillo, 1994; Kaufman, 1973). However, recent cross-sectional and prospective studies have indicated that impairments in cognitive function and neurological signs can resolve with abstinence from petrol abuse, although the time frame over which this improvement was observed was two years (Cairney, et al., 2004b, 2005; Maruff, et al., 1998). This finding is important as it informs health goals for treatment strategies designed to minimise petrol abuse and it also informs models of hydrocarbon neurotoxicity in humans (Cairney & Fitz, 2005; Cairney, et al., 2005). However, a more thorough understanding of the course of changes in cognitive function immediately after abstinence is warranted to understand more thoroughly petrol's effects on the CNS. Knowledge of the shorter terms changes in cognitive function following abstinence could also help inform the design of petrol rehabilitation programs (Takagi, et al., 2007).

The first aim of this study was to characterise the nature and magnitude of changes in cognitive function that occur among individuals who were previously active petrol abusers but who recently abstained from petrol abuse as part of a residential treatment program. The second aim was to determine the extent to which petrol related cognitive impairments persisted with continued abstinence following discharge from treatment.

8.2 METHODS

8.2.1 Participants

Participants were 38 Aboriginal Australians aged between 11-25 years, from remote Aboriginal communities in northern and central Australia where petrol abuse is common and where there is significant social, economic and political disadvantage (Brady, 1992). All participants met the DSM-IV criteria for 'inhalant abuse' and were attending residential rehabilitation at the time of the study (American Psychiatric Association, 2000). Assessment of the history of petrol abuse indicated that all had actively inhaled petrol regularly or episodically and had done so within the past 60 days. The mean number of years of active petrol abuse was 4.8 (SD = 3.3). No participants had recorded histories of hospitalization due to lead encephalopathy resulting from chronic leaded petrol abuse (see Cairney, et al., 2004a; and Maruff, et al., 1998 for a discussion of cognitive and neurological effects of abuse of petrol containing lead). A healthy control group of 40 healthy Aboriginal Australians, from remote communities, and aged between 12-25 years were also recruited. The inclusion criteria for this group were that: (1) they had never inhaled

petrol or any other volatile solvents regularly (i.e. > 1 time); (2) their usual alcohol consumption was less than six drinks per occasion and (3) they had not used any other drugs regularly (i.e. > 1 time).

Participants represented over 25 different language groups, 60 distinct communities, and diverse geographical regions including the arid desert of central Australia and the tropics of northern Australia. Demographic information for the two groups is presented in Table 1. Although concurrent cannabis use was prevalent in the petrol abusers, previous studies in this population and this specific group have revealed no significant impact of cannabis use on cognition (Cairney, et al., 2007; Dingwall, Lewis, et al., 2010). Furthermore, recent research suggests that 10-20 years of daily cannabis use is required before even subtle cannabis related cognitive impairments are detected (Solowij et al., 2002).

Table 1. Demographic Information for Healthy Controls and Petrol Abusers

	Healthy Controls (n = 33)	Petrol Abusers (n = 26)
Mean Age in years (SD; Range)	15.5 (3.2; 12-25)	17.0 (3.5; 11-25)
Mean Education in years (SD; Range)	7.7 (2.6; 3-12)	8.1 (2.4; 0-12)
Mean years petrol abuse (SD)	-	4.8 (3.3)
Mean age started using petrol (SD)	-	12.1 (2.2)
Mean years cannabis use (SD)	-	2.2 (2.7)
No. previous computer use (%)	37 (92.5%)	31 (82%)
No. males (%)	12 (30%)	29 (76%)*
No. living remote (%)	39 (97.5%)	33 (87%)

*scores for petrol abusers were significantly different to controls at $p < .01$.

8.2.2 Procedure

The joint Human Research Ethics Committee (including the Aboriginal Ethics Sub Committee) for the Department of Health and Community Services and Menzies School of Health Research granted ethical approval for the study. To monitor cognition during treatment, researchers assessed individuals admitted for rehabilitation of petrol abuse at two urban based residential rehabilitation centres on a fortnightly basis during 2007-2009. They also assessed petrol abusers at a remote community-based rehabilitation centre, approximately 300km from a regional centre, opportunistically (nine times) over 12 months. The control group was assessed at Aboriginal residential education institutions located in regional centres. All individuals who were present during a study visit were informed that participation was voluntary and gave written informed consent (along with their legal guardian if under 18 years of age) prior to participation.

At baseline, upon entry to treatment, questionnaires eliciting demographic information (including age, education, community, medical history, etc) and substance use histories (including frequency, amount, first and last use of alcohol, cannabis, solvents, cigarettes, kava or other drugs) were completed with all participants by trained researchers (Dingwall, Lewis, et al., 2010). Participants also completed a computerised cognitive assessment at baseline ($M = 8$ days; $SD = 6.2$) then fortnightly, at two weeks ($M = 16$ days; $SD = 3.3$), four weeks ($M = 29$ days; $SD = 1.6$) and six weeks ($M = 43$ days; $SD = 1.3$), during the eight week treatment (for petrol abusers) or testing period (for healthy controls).

To monitor longer term cognitive changes, researchers re-visited participants (n = 29 petrol abusers and 19 healthy controls) at their home community or educational institution an average of 12 months after their baseline assessment (SD = 4.6). At this time, participants were reassessed with the cognitive assessment. The petrol abusers and key informants (usually a community health worker) were also re-interviewed about the participants' subsequent drug use (Dingwall, et al., In Press). For those participants' who gave consent, researchers also examined their medical records. Information from key informants and medical records was used to verify self report substance use data (Dingwall, Lewis, et al., 2010). This consensual methodology has proven appropriate and effective for verifying substance use histories in this population (Clough, Bailie, et al., 2002; Clough, Cairney, et al., 2004). Twelve petrol abusers had abstained from further petrol abuse at follow up (abstainers), while 17 had continued use (relapsed users).

8.2.3 Cognitive Assessment

The CogState computerised test battery consisted of the seven cognitive tasks listed below, and used playing cards and other game-like stimuli. These tasks have shown validity for the assessment of remote Aboriginal Australians and are described in detail elsewhere and briefly below (Cairney, et al., 2007; Dingwall, et al., 2009; Dingwall, Lewis, et al., 2010; Lewis, et al., 2010). For the first three tasks, the 'K' and 'D' keys on the keyboard are used for 'yes' and 'no' respectively (reversed if left hand dominant).

Detection Task (Psychomotor function): A playing card is presented facedown on-screen. The participant is required to press 'yes' as fast as possible when the card turns face up. Mean reaction time is recorded in milliseconds.

Identification Task (Visual attention): A playing card is presented facedown on-screen. When the card turns face up, the participant is required to press 'yes' if the card's suit is red or 'no' if it is not red (i.e. black). Mean reaction time is recorded in milliseconds.

Visual Learning Task (Working memory): A playing card is presented facedown on-screen. When the card turns face-up, the participant is required to press 'yes' if the card has been presented before and 'no' if the card has not been seen before. Percentage accuracy (i.e. number correct divided by number of presentations) is recorded.

Groton Maze Chase Test (GMCT; Visual motor function): A target tile is presented on a grid 10 tiles by 10 tiles. The participant is required to click on the target tile as fast as possible and 'chase' it around the grid as it moves one tile at a time. The task continues for 30 seconds and records the total number of correct movements per second.

Groton Maze Learning Test (GMLT; Executive function): Using the same grid as the GMCT, the participant uses the mouse to uncover a circuitous path, moving one tile at a time (across 28 correct tiles), from one corner of the grid to the diagonally opposite corner. Once the pathway has been uncovered and completed, the task is

repeated for four more rounds along the same path. Total duration to complete the task and total number of errors made are recorded.

Groton Maze Learning Test – Delayed Recall (GMLT-Recall; Visual learning and memory): Approximately ten minutes after completing the GMLT, and with other tasks being completed in the interim, the grid is presented once more. The participant is required to remember the same hidden pathway as presented on the initial trials and complete it as quickly and accurately as possible. Total duration and errors are recorded.

Continuous Paired Associate Learning (CPAL; Learning and spatial awareness): Eight balls are presented on-screen and, during the acquisition round, participants are required to learn the location of six patterns presented serially under six individual balls. Each of the patterns is then presented in a central location and the location of that pattern's matching pair has to be recalled. The task is repeated for five rounds (locating all six patterns) with the patterns in the same location for each round. Total duration and errors are recorded.

8.2.4 Data Analysis

Of the 78 study participants, 70% had completed a week two assessment, 58% completed a week four assessment and 61% completed a week six assessment. The data for all subjects with a baseline and at least one other assessment during treatment (n = 26 petrol abusers and 33 healthy controls) were submitted to a series of linear mixed model (LMM) analyses with group (controls or petrol abusers) and

time (baseline, 2 weeks, 4 weeks, 6 weeks) as fixed effects, participant as a random effect and age as a covariate. Post hoc comparisons compared performances between groups at baseline, two weeks, four weeks and six weeks.

To determine the extent to which cognitive impairment persisted after discharge, cognitive data from those individuals who had completed a community follow up assessment (i.e. 60% of participants) were submitted to a series of ANCOVAs. Data from abstainers (n = 11) and relapsed users (n = 16) were compared to healthy controls (n = 19) to examine both the impact of abstinence and relapse on recovery. Age and baseline performance were included as covariates. All except 12 petrol abusers and five healthy controls had been included in the earlier analyses. These were excluded from the previous analyses as they had completed only one (baseline) assessment during the initial eight week testing period.

Pearson's product moment correlations between number of years of petrol abuse, age of first use and each of the performance measures for each time point were also conducted on the petrol abusers data to determine if severity of abuse was related to performance. To determine if impairment at baseline was related to the degree of recovery during or after treatment, Pearson's product moment correlations were conducted between scores at baseline and six weeks, and scores at baseline and community follow up (12 months).

Speed (reaction time and duration) measures were recorded in milliseconds. For the Detection and Identification tasks, reaction time was transformed using logarithmic (base 10) transformations and accuracy data for the Visual Learning task were

transformed using arcsine transformations as prescribed by the test developers to achieve normal distributions (Collie, Maruff, Makdissi, et al., 2003; Falletti, et al., 2006; Mollica, et al., 2005; Straume-Naesheim, et al., 2005).

8.3 RESULTS

Significant main effects for group were identified for the Identification task ($F_{(1, 57)} = 4.23$; $p < 0.05$) and all of the complex task measures (i.e. GMCT, GMLT, GMLT-Recall & CPAL; $F_{(1, 26-63)} = 6.41-49.84$; $p < 0.05$). Significant main effects were also observed for time on all complex tasks ($F_{(3, 95-116)} = 2.85-47.60$; $p < 0.05$), and significant interactions between time and group for GMLT duration ($F_{(3, 109)} = 2.86$; $p < 0.05$), CPAL duration ($F_{(3, 95)} = 6.22$; $p < 0.05$) and CPAL errors ($F_{(3, 103)} = 2.82$; $p < 0.05$) were also found. Post hoc comparisons revealed significant differences between the groups at baseline on the Identification task, and all measures for the complex tasks (GMCT, GMLT, GMLT-Recall and CPAL). By two weeks, there was no significant difference between the groups on the Identification task or the error measures on the GMLT and GMLT-Recall. At six weeks, there was no significant difference between the groups on the CPAL (duration and errors) task and GMLT-Recall duration, but petrol abusers remained impaired compared to controls on the other speed measures (i.e. GMCT, GMLT duration).

Table 2. Summary Statistics for Linear Mixed Model (LMM) Analysis and Post Hoc Comparisons

	Baseline	2 weeks	4 weeks	6 weeks	LMM p value	
	EM	EM	EM	EM	Group	Group x Time
Simple Tasks						
Detection Speed (Psychomotor)						
Healthy Controls	2.51	2.55	2.58	2.57	ns	ns
Petrol Abusers	2.60	2.61	2.59	2.58		
Identification Speed (Attention)						
Healthy Controls	2.74	2.79	2.78	2.78	.04	ns
Petrol Abusers	2.82*	2.80	2.83	2.82		
Visual Learning Accuracy (Working Memory)						
Healthy Controls	0.63	0.71	0.60	0.65	ns	ns
Petrol Abusers	0.61	0.62	0.66	0.61		
Complex Tasks						
Groton Maze Chase Test (Visual Motor)						
Healthy Controls	1.67	1.54	1.62	1.78	<.001	ns
Petrol Abusers	1.00*	1.04*	1.11*	1.20*		
Groton Maze Learning Test (GMLT; Executive Function)						
<i>Duration (seconds)</i>						
Healthy Controls	230.71	176.80	163.39	156.22	<.001	.04
Petrol Abusers	328.27*	251.41*	255.53*	203.88*		
<i>Total Errors</i>						
Healthy Controls	73.30	67.02	65.32	56.22	.01	.06
Petrol Abusers	106.66*	76.81	80.38	63.68		
GMLT-delayed recall (Learning and Memory)						
<i>Duration (seconds)</i>						
Healthy Controls	35.68	26.75	26.05	23.98	<.001	ns
Petrol Abusers	52.17*	40.85*	39.98*	32.01		
<i>Total Errors</i>						
Healthy Controls	9.65	6.78	7.64	7.26	.004	ns
Petrol Abusers	15.76*	9.32	11.49	9.44		
Continuous Paired Associate Learning						
<i>Duration (seconds)</i>						
Healthy Controls	171.78	150.65	147.56	143.41	<.001	.001
Petrol Abusers	258.64*	217.33*	198.61*	169.23		
<i>Total Errors</i>						
Healthy Controls	31.37	30.60	27.02	21.75	.003	.04
Petrol Abusers	68.04*	52.26*	48.83*	31.78		

Note. LMM = linear mixed model. EM = estimated marginal mean. ns = not significant
*significantly different to healthy controls at $p < .05$.

At the 12 month community follow up, petrol abusers who remained abstinent continued to show impairments compared to controls on GMLT duration, GMLT-Recall duration, and GMLT-Recall errors after controlling for age and baseline performance. Performance on the Detection, Identification, Visual Learning, GMCT, CPAL task, and GMLT errors were not significantly different from controls. These data are summarised in Table 3. For petrol abusers who relapsed after treatment, performance also remained impaired compared to controls on speed measures for the GMLT and GMLT-Recall. There was no significant difference between controls and relapsed users on the Detection, Identification, Visual Learning, GMCT and CPAL tasks, nor for GMLT errors or GMLT-Recall errors (see Table 3).

There were significant positive correlations between number of years petrol abuse and Detection speed at two weeks ($r = .66$), GMLT-Recall errors at two weeks ($r = .68$), CPAL errors at baseline and 12 months ($r = .42$ and $.49$ respectively) and CPAL duration at 12 months ($r = .49$). Age of first use was significantly negatively correlated with Detection speed ($r = -.37$) and CPAL errors ($r = -.44$) at baseline. Significant positive correlations were also found between baseline performance and performance at six weeks for Detection speed ($r = .59$), Visual Learning accuracy ($r = .85$) and GMCT ($r = .75$). Baseline performance and performance at 12 months were significantly correlated for Visual Learning accuracy ($r = .53$), GMCT ($r = .42$) and GMLT-Recall duration ($r = .43$). The correlation between baseline and 12 month performance on GMLT errors was marginally significant ($r = .41$; $p = 0.056$).

Table 3. F-Statistics (F), Estimated Marginal Means (EM), and Eta Squared (η^2) for Control and Petrol Sniffing Groups at Community Follow Up (12 months)

Simple Tasks	Group F-statistic	EM	η^2
Detection Speed (Psychomotor)			
Healthy Controls	0.51	2.59	0.02
Petrol - Abstinent		2.62	
Petrol - Relapsed		2.57	
Identification Speed (Attention)			
Healthy Controls	0.09	2.80	<0.01
Petrol - Abstinent		2.81	
Petrol - Relapsed		2.81	
Visual Learning Accuracy (Working Memory)			
Healthy Controls	0.21	0.63	0.01
Petrol - Abstinent		0.61	
Petrol - Relapsed		0.67	
Complex Tasks			
Groton Maze Chase Test (Visual Motor)			
Healthy Controls	0.52	1.47	0.03
Petrol - Abstinent		1.40	
Petrol - Relapsed		1.33	
Groton Maze Learning Test (GMLT; Executive Function)			
<i>Duration (Seconds)</i>			
Healthy Controls	6.47*	170.74	0.27
Petrol - Abstinent		264.76**	
Petrol - Relapsed		235.48**	
<i>Total Errors</i>			
Healthy Controls	1.15	59.28	0.06
Petrol - Abstinent		69.97	
Petrol - Relapsed		65.30	
GMLT-Delayed Recall (Learning and Memory)			
<i>Duration (Seconds)</i>			
Healthy Controls	5.94*	26.43	0.24
Petrol - Abstinent		37.17**	
Petrol - Relapsed		32.98**	
<i>Total Errors</i>			
Healthy Controls	3.82*	6.58	0.17
Petrol - Abstinent		10.64**	
Petrol - Relapsed		7.04	
Continuous Paired Associate Learning			
<i>Duration (Seconds)</i>			
Healthy Controls	0.74	167.75	.03
Petrol - Abstinent		185.68	
Petrol - Relapsed		190.87	
<i>Total Errors</i>			
Healthy Controls	0.49	36.18	.02
Petrol - Abstinent		26.16	
Petrol - Relapsed		35.34	

Note. * $p < .05$. ^ $p = .06$. **significantly different to healthy controls at $p < .05$.

8.4 DISCUSSION

Upon entry to treatment, petrol abusers showed significant deficits in areas of visual attention, visual motor and executive functions, visual learning and memory, and paired associate learning. Impairments in accuracy on the executive function and learning and memory tasks had recovered within two weeks while both speed and accuracy on the paired associate learning task had recovered within six weeks.

However, deficits in visual motor, memory and executive function speed persisted throughout the duration of treatment and beyond. Together these results suggest that the majority of solvent related cognitive impairments recover within two months of abstinence, but speed deficits on visual motor, memory, and executive function task persist even after 12 months.

In a previous study of chronic petrol abusers, normalization of many cognitive functions had occurred after two years of abstinence, although impairments in recognition memory and associate learning remained for some users (Cairney, et al., 2004b, 2005). In the current study, paired associate learning deficits had ameliorated within six weeks of abstinence. Compared with the petrol abuse group in the previous study noted above, participants in the current study were younger and had a lesser total time of abuse. It is therefore likely that residual neurological abnormalities observed at two years in the previous study were a consequence of the longer-term and heavier use in that group (Cairney, et al., 2005). Furthermore, the individuals in the previous study had abused predominately leaded petrol whereas the current group had all abused unleaded petrol. The tetraethyl lead in leaded petrol is thought be the main cause of long term neurotoxicity in chronic leaded petrol abusers

(Boeckx, et al., 1977; Coulehan, et al., 1983; Fortenberry, 1985; Harper, 1994) and blood lead levels correlate reliably with cognitive and neurological impairments in leaded petrol abusers (Cairney, et al., 2005; Maruff, et al., 1998). Nevertheless, this study has demonstrated that significant visual motor, memory, learning and executive impairments are also associated with unleaded petrol inhalation and that cognitive processing speed may take longer to recover compared to accuracy deficits.

These results must be considered in light of this study's limitations. While the prospective design is a strength of this study, the inevitable attrition associated with longitudinal assessment is also a minor limitation (Dingwall & Cairney, 2009). Although reassessment rates of between 58-70% were acceptable, it is likely that incomplete data across time contributed to minor anomalies in the data. For example, the initial difference between the groups in visual attention had ameliorated by week two. However, examination of the means suggested that this may reflect change or regression to the mean in the control group rather than recovery amongst the petrol group. In addition, reappearance of a significant difference in GMLT-Recall errors at the community follow up in (presumed) abstinent users may reflect under-reporting of substance use following treatment or an inability to appropriately control other environmental factors associated with remote Aboriginal community life, which might also impact on cognition (e.g. nutrition, sleep deprivation etc) (Dingwall & Cairney, 2009).

Nevertheless, underlying abnormalities of prefrontal cortical and hippocampal brain regions are implicated by the performance deficits observed here. Neuroimaging studies of solvent abusing adults have reported primarily white matter abnormalities

including demyelination and myelin pallor, ventricular enlargement, widening of cortical and cerebellar sulci. Brain atrophy in the hippocampus, cerebellum, cerebrum, corpus callosum and brainstem has also been observed (Deleu & Hanssens, 2000; Filley, et al., 1990; Fornazzari, et al., 1983; Hormes, et al., 1986; Rosenberg, et al., 2002; Rosenberg, Kleinschmidt-DeMasters, et al., 1988; Rosenberg, Spitz, et al., 1988; Unger, et al., 1994). Although research indicates that the degree of functional impairment correlates with the degree of white matter changes (Filley, et al., 1990; Rosenberg, Kleinschmidt-DeMasters, et al., 1988), the relationship between functional recovery and brain structure changes is unclear.

Rosenberg and colleagues (Rosenberg, Kleinschmidt-DeMasters, et al., 1988) conducted repeated magnetic resonance imaging (MRI) of one adult over 18 months of abstinence from toluene abuse with no structural improvement despite improvement in neurological function. This suggests that some solvent related impairment may be irreversible. Neuroimaging studies of chronic alcoholics, on the other hand, have demonstrated reversibility of brain atrophy following abstinence from further alcohol use with concurrent biochemical and neuropsychological improvements (Bendszus et al., 2001; Carlen, Wortzman, Holgate, Wilkinson, & Rankin, 1978). Future research should investigate the underlying neuroanatomical correlates of the cognitive recovery associated with abstinence from solvent abuse in a larger sample to determine the permanence of any solvent related brain changes.

The findings from the current study have important implications for solvent abuse treatment. Upon entry to treatment, solvent abusers may experience cognitive impairments that might limit their ability to retain new information. The current

study showed that improvements in learning and memory begin to occur within just two weeks of abstinence with others fully recovered by six weeks. Solvent abuse treatment approaches in the USA suggest that an extended period of ‘treatment readiness’ lasting at least two to four weeks is required for solvent abusers upon admission (Fornazzari, 1988; Jumper-Thurman, Plested, & Beauvais, 1995). This allows time for the body to detoxify from the chemical effects of solvents and during this time, treatment focuses on basic supportive care including nutrition, exercise, sleep, and building relationships between staff and clients (Fornazzari, 1988; Jumper-Thurman, et al., 1995). The current results support this approach and indicate that ongoing neuropsychological assessment may provide important information for tailoring treatment to meet the specific needs of the individual, as well as providing motivation for maintaining abstinence.

In addition, some authors recommend an extended length of stay in treatment, from 90-120 days, for solvent abusers which is also supported by the current study (Riedel, et al., 1995). Cognitive recovery continued across the duration of treatment and some impairments persisted even after 12 months of abstinence. Future research could investigate the impact of cognitive deficits on treatment outcomes and explore the value of developing community-based, follow up treatment services for solvent abusers.

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Chapter 9

Factors Associated with Continued Solvent Use in Indigenous Petrol Sniffers Following Treatment.

Preface

Manuscript 'in press' at Drug and Alcohol Review [see Appendix A]

The previous chapter demonstrated that while many of the impairments associated with petrol and other solvent abuse had ameliorated within two to eight weeks of abstinence, visual motor, memory and executive function speed deficits persisted even after 12 months abstinence. However, the impact of these impairments on treatment outcomes remained unclear. In addition, it is likely that other pre- and post-treatment psychosocial factors would impact significantly on continued solvent use upon return to the community although this has received very little research focus. Without an adequate understanding of the potential factors that influence rehabilitation outcomes for Indigenous substance users, any governmental or treatment responses cannot be targeted appropriately and may therefore be limited in their success. Chapter 9 aims to identify specific demographic, contextual, and neuropsychological factors that may impact on continued solvent use post-treatment. Data was collected from participants in their home communities approximately nine months after treatment. While 58% of the Indigenous solvent users continued use after treatment, 42% had remained abstinent at follow up. This chapter therefore identifies potential risk or protective factors that may be associated with relapse following treatment.

**Factors associated with continued solvent use in Indigenous petrol sniffers
following treatment**

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ABSTRACT

Introduction and Aims: While petrol sniffing afflicts several isolated Indigenous groups internationally, few studies have examined the factors contributing to continued sniffing following treatment. This study aims to describe those factors in a group of Aboriginal Australian users. **Design and Methods:** During residential treatment, 56 petrol sniffers completed baseline demographic and substance use questionnaires and cognitive and psychological assessments. Eighty percent were reassessed and interviewed an average of 9 months (SD = 4) later. Cognitive, psychological, substance use and sociocultural factors were compared between those who relapsed at follow up and those who maintained abstinence. **Results:** More males (n = 44) than females (n = 12) were studied. Of the 45 individuals followed up, 58% (n = 26) relapsed. Significant risk factors for relapse included the ready availability of petrol, living in urban centres, being unmarried, and living with fewer people (p < 0.05). Other potential risk factors, indicated by p-values < 0.10, included younger age of first petrol use, having sniffed within 14 days prior to treatment, poly substance use, sniffing in response to negative emotions, and feeling lonely at baseline and having sleep problems at follow up. **Discussion and Conclusion:** This study identified psychosocial factors that may be associated with continued petrol sniffing among Aboriginal Australians post treatment. Future research, interventions and policy relating to petrol sniffing should consider these factors.

Keywords: petrol sniffing, Indigenous, solvents, relapse

9.1 INTRODUCTION

Petrol inhalation or ‘petrol sniffing’ is a form of volatile solvent abuse that occurs almost exclusively in marginalised, isolated or Indigenous groups such as the American Indians, Aboriginal Canadians, and Aboriginal Australians (Cairney & Dingwall, In Press). Many of the Indigenous groups affected share unique cultural, geographical, and social characteristics, including histories of cultural oppression and dispossession, geographical isolation, and significant economic, social and cultural disadvantage (Beauvais, Oetting, & Edwards, 1985; Cairney & Dingwall, In Press). Petrol sniffing occurs in these contexts primarily among individuals aged between 7–30 years with peer pressure, boredom or curiosity, accessibility, familial disruption, escape from despair or worry, rebellion, and high acculturative stress commonly espoused as contributing factors (Barnes, 1989; Brady, 1992; Cairney & Dingwall, In Press; Senior, et al., 2006; Trotter, et al., 1997). Occasional or experimental use patterns appear most common, however where chronic or long-term use occurs this can be associated with significant cognitive and neurological impairments (Barnes, 1989; Cairney, et al., 2002; Coulehan, et al., 1983; Nurcombe, et al., 1970). Importantly, increasing exposure to petrol is associated with a greater degree of brain dysfunction and reduced chances that brain function will fully recover with abstinence (Cairney, Berkhout, et al., 2009; Cairney, et al., 2004b, 2005).

Treatment for petrol sniffing can be complex, with traditional treatment programs unlikely to be effective in solvent users who are described as among the most difficult and refractory drug users to treat (Beauvais, Jumper-Thurman, Plested, & Helm, 2002; Jumper-Thurman, et al., 1995). Solvent users are often involuntary

clients, admitted by family or community workers, and usually present with a wide variety of issues impacting cognitive, mental, physiological, social, educational and economic domains (Beauvais, Jumper-Thurman, et al., 2002; Jumper-Thurman, et al., 1995). While some treatment programs have been developed specifically for solvent abuse, knowledge about post treatment outcomes of these programs is limited (Jumper-Thurman, et al., 1995; MacLean & d'Abbs, 2002) and few studies have examined factors that may contribute to continued solvent use following treatment (Coleman, et al., 2001). Hence, the aim of this prospective but exploratory study was to identify baseline and post-treatment factors that are related to continued petrol sniffing in an Aboriginal Australian group following discharge from treatment. Substance use, sociocultural, cognitive and psychological factors were assessed for petrol sniffers upon entering treatment and again approximately nine months later.

9.2 METHODS

9.2.1 Participants

Participants were 44 males and 12 females (mean age = 18 years; SD = 5.16) attending rehabilitation for petrol sniffing in the Northern Territory between 2007 and 2009. The majority (86%; n = 48) came to rehabilitation from remote communities. The average age of first petrol use was 13 years (SD = 3.07) with an average of five years use (SD = 4.83). Five participants had inhaled substances other than petrol (i.e. paint, glue or aerosols). Frequency of use ranged from once per week to everyday with the majority (54%; n = 30) sniffing 4–7 days per week.

9.2.2 Procedure

The joint Human Research Ethics Committee (including the Aboriginal Ethics Sub Committee) for the Department of Health and Community Services and Menzies School of Health Research granted ethical approval for the study. Researchers visited two urban based residential rehabilitation centres fortnightly during 2007–2009. During 2008, they also visited opportunistically (nine times), a remote outstation for petrol sniffers approximately 300 km from an urban centre. The urban based rehabilitation programs incorporated three main components: drug education and goal planning sessions, life skills (e.g., health, hygiene, budgeting, nutrition) sessions and recreational sessions including cultural activities. The outstation program involved education, as well as personal and skills development including participation in practical pastoral activities. All treatment programs prohibited substance use apart from tobacco whilst in treatment. All individuals attending treatment for petrol sniffing, who were present on the study days were invited to participate. Individuals (and their legal guardian if under 18 years of age) were informed that participation was voluntary and gave written informed consent prior to participation.

At baseline, an average of 11 days ($SD = 9.4$) from admission to treatment, participants completed demographic and substance use questionnaires, and psychological and cognitive assessments.

An average of 9 months ($SD = 4$) after treatment, 21 participants were reassessed in their home communities with the cognitive and psychological assessments, and were

interviewed about the context of their petrol and other drug use. Researchers also examined clinic notes and interviewed up to three key informants (usually a community health worker, or friend or family member), either face-to-face or via the telephone, regarding all participants' continued use of any substance (42 participants gave consent to this process at baseline). This information was used to categorise unreachable participants (n = 24) as abstainers or relapsed users and also to verify self report substance use data. The use of proxy assessments in this population has been described elsewhere, and good agreement with self reported substance use is generally observed (Clough, Bailie, et al., 2002; Clough, Cairney, et al., 2004).

9.2.3 Demographic Questionnaire

Participants completed this questionnaire at baseline, that included information about age, gender, medical history, languages spoken, English proficiency, community, and employment status.

9.2.4 Substance Use History Questionnaire

This questionnaire was completed at baseline and investigated current or previous use, frequency of use, age of first use, days since last use and amount usually consumed for each substance (i.e. petrol and other solvents, alcohol, tobacco, cannabis and 'other').

9.2.5 Psychological Screening Tool

This measure consisted of eight items based on the Strong Souls Inventory that detects anxiety, depressive, and psychotic symptoms and was completed at baseline and follow up. It has demonstrated suitability for use with Aboriginal Australians and is described in detail elsewhere (Dingwall & Cairney, 2010a; Thomas, et al., 2010). Items asked about participants' experience of specific psychological symptoms in the past week and response options were 'not much', 'sometimes', 'fair bit', 'lots' or 'no response'.

9.2.6 Cognitive Screening Tool

Participants completed the CogState computerised test battery at baseline and follow up, which consisted of seven cognitive tasks developed and validated for use with Aboriginal people (Dingwall, et al., 2009; Dingwall, Lewis, et al., 2010; Lewis, et al., 2010). The tests use playing cards and other game-like stimuli to measure simple reaction time, visual attention, working memory, visuomotor function, executive function, learning and memory and paired associate learning.

9.2.7 Follow-up Interview

Participants were interviewed at follow up using a standard set of questions regarding their continued use of any substance, the context surrounding their use of petrol, and their social situation (see Appendix B). This interview was designed for quantitative analysis, so a fixed number of response options were generally

presented. If none of the response options were applicable, participants were given the opportunity to provide their own response.

It is understood that self report questionnaires are subject to a number of limitations, including social desirability response sets and under-reporting of consumption (Burns, et al., 1995). The current research was not exempt from these constraints however, efforts were made to establish a friendly atmosphere, promote honesty, and assure participants' that any answers given would remain confidential.

9.2.8 Data Analysis

The analyses were primarily quantitative and descriptive. Categorical data were described in percentages and relative risk ratios (RR) were calculated with Fisher's exact test of significance reported. Means or medians were reported for continuous data, and simple comparisons between individuals who relapsed (relapsing users) and those who maintained abstinence (abstainers) at follow up were conducted using *t*-tests or Mann-Whitney tests for non-parametric data. Due to some cells with zero frequencies, response categories for each of the psychological items were collapsed to form dichotomous variables with responses of 'not much' categorised as a 'negative' response and responses of 'sometimes', 'fair bit' and 'lots' categorised as a 'positive' response.

Table 1. Comparisons between Relapsing Users and Abstainers on Categorical Variables

	Relapsing users (%)	Abstainers (%)	RR	95%CI	P-value†
<u>Demographic and Sociocultural factors</u>					
	N = 26	N = 19			
'Sniffable' petrol easily accessible	21 (81%)	9 (47%)	1.7	1.02-2.84	0.021*
Mandated to treatment	5 (21% [‡])	3 (17% [‡])	1.3	0.34-4.56	0.527
Male	22 (85%)	15 (79%)	0.7	0.21-2.56	0.456
Unemployed at baseline	20 (77%)	12 (75%)	0.9	0.31-2.78	0.585
Attends Aboriginal ceremony	16 (70% [‡])	7 (50% [‡])	0.4	0.77-2.51	0.200
Live Remote	12 (77%)	19 (100%)	-	-	0.028*
<u>Psychological Factors at Baseline</u>					
SLEEP problems	11 (61% [‡])	14 (82% [‡])	0.7	0.48-1.14	0.155
Problems THINKING	13 (54% [‡])	10 (53%)	1.2	0.58-1.81	0.582
Feel ANGRY	11 (46% [‡])	9 (47%)	1.0	0.51-1.84	0.582
Feel WORRIED	9 (37.5% [‡])	5 (28% [‡])	1.4	0.55-3.34	0.373
Feel SAD	11 (48% [‡])	8 (42%)	1.1	0.58-2.24	0.477
Hear VOICES	8 (33% [‡])	2 (11% [‡])	2.8	0.69-11.72	0.111
Feel LONELY	16 (64% [‡])	7 (37%)	1.7	0.90-3.35	0.069 [^]
Feel like too much TROUBLE	2 (8% [‡])	1 (5%)	1.5	0.15-15.55	0.604
<u>Psychological Factors at Follow up</u>					
	N = 15	N = 13			
SLEEP problems	10 (67%)	3 (27% [‡])	2.4	0.87-6.84	0.055 [^]
Problems THINKING	4 (27%)	3 (27% [‡])	1.0	0.27-3.51	0.655
Feel ANGRY	5 (38.5% [‡])	4 (33% [‡])	1.2	0.40-3.31	0.560
Feel WORRIED	3 (20%)	3 (25% [‡])	0.8	0.19-3.27	0.557
Feel SAD	5 (33%)	4 (33% [‡])	1.0	0.34-2.93	0.657
Hear VOICES	4 (27%)	2 (15%)	1.7	0.38-7.98	0.400
Feel LONELY	6 (40%)	3 (25% [‡])	1.6	0.50-5.10	0.343
Feel like too much TROUBLE	3 (20%)	4 (33% [‡])	0.6	0.17-2.18	0.364

Substance use factors	N = 19	N = 16			
Using both cannabis and alcohol at follow-up					
Sniffing 14 days before treatment	12 (67% [†])	6 (37.5%)	1.8	0.87-3.62	0.087 [^]
Interview data	17 (89.5%)	6 (60% [†])	1.5	0.87-2.53	0.086 [^]
Sniff because bored	N = 13 9 (69%)	N = 10 7 (87.5% [†])	0.8	0.51-1.24	0.344
Sniff because of friends	8 (61.5%)	4 (50% [†])	1.2	0.55-2.78	0.604
Sniff response to affect	9 (69%)	2 (25% [†])	2.8	0.79-9.70	0.063 [^]
Sniff because ran out of other drug	3 (23%)	1 (12.5% [†])	1.9	0.23-14.84	0.502
Sniff with others	12 (92%)	8 (100% [†])	-	-	0.619
Sniffing feels bad	9 (69%)	2 (25% [†])	2.8	0.79-9.70	0.063 [^]
Had injuries from sniffing	5 (38.5%)	3 (37.5% [†])	1.0	0.33-3.17	0.664
Attitude to sniffing before treatment					
No Good	6 (54.5% [†])	3 (37.5% [†])	1.5	0.51-4.13	0.395
Attitude to sniffing after treatment					
No Good	11 (92% [†])	9 (100% [†])	-	-	0.571
Reasons for attending treatment					
Own decision	7 (58% [†])	7 (78% [†])	0.8	0.41-1.36	0.324
Family influence	5 (42% [†])	5 (56% [†])	0.8	0.31-1.82	0.425
Friend influence	0 (0% [†])	4 (44% [†])	-	-	0.021*
Community pressure	3 (25% [†])	1 (11% [†])	2.3	0.28-18.22	0.414
School reasons	3 (25% [†])	1 (11% [†])	2.3	0.28-18.22	0.414
Health reasons	2 (17% [†])	1 (11% [†])	1.5	0.16-14.08	0.612
Learnt about effects	0 (0% [†])	1 (11% [†])	-	-	0.429
Trouble with the law	6 (54.5% [†])	3 (33% [†])	1.6	0.56-4.77	0.311
Married	0 (0%)	4 (44% [†])	-	-	0.017*
Finished treatment program	4 (36%)	4 (40%)	0.9	0.31-2.70	0.608

Note. †Fishers exact test. *p = .05. ^p > .10.

9.3 RESULTS

Of the 56 participants assessed at baseline, 45 (80%) were reassessed an average of 9 months ($SD = 4$) after treatment. Twenty-one (37%) were reinterviewed personally and proxy assessments provided continued substance use information for the remaining 24 (43%). Of the 11 (20%) lost to follow up, seven were male and four were female. One female was deceased. Of those re-assessed, 26 (58%) had relapsed and 19 (42%) had abstained from further petrol sniffing. In addition, 34 (75%) were using either cannabis, alcohol or both at follow up. Categorical and continuous variables are presented in Tables 1 and 2 respectively, comparing relapsing users and abstainers.

Significant relationships were found between relapse and easy accessibility to petrol, being unmarried, living in urban centres, and living with fewer people at follow up ($p < 0.05$). Relapsed users were significantly less likely than abstainers to report friends influence as a reason for attending treatment ($p < 0.05$). Possible relationships between relapse with sniffing in response to negative affect, sniffing feeling bad, feeling lonely at baseline, having trouble sleeping at follow up, using both alcohol and cannabis at follow up, using petrol within 14 days prior to treatment, starting sniffing at an earlier age and spending fewer days in treatment were indicated by p -values less than 0.10 on these variables (see Tables 1 & 2).

For the cognitive data, univariate comparisons showed that relapsing users had faster performance on the reaction time ($t_{(41)} = 2.09$; $p = 0.04$) and paired associate learning

tasks ($t_{(39)} = 2.16$; $p = 0.04$) at baseline compared to abstainers. There were no other significant differences in cognitive performance between the two groups.

Of those followed up, 28 (62%) did not complete the treatment program. Reasons given for leaving prior to completion included six who returned to their community for a funeral, one was caught using cannabis, and four dropped out/ran away (other reasons unknown).

During the follow up interview, two open ended questions were asked: “what would make it easier to stop sniffing” and what “helped you stop sniffing” (see Appendix B). Family support was commonly mentioned as an important factor. The influence of friends or other sniffers also featured prominently with common responses including “getting away from other sniffers” or “if friends stopped sniffing”. Attending treatment was also reported to help or make it easier to stop.

Table 2. Comparisons between Relapsing Users and Abstainers on Continuous Variables

	Relapsing Users Mean (SD) (n = 26)	Abstainers Mean (SD) (n = 19)	t df	p statistic	p value
<u>Sociocultural and demographic factors</u>					
Age	17.38 (3.63)	20.06 (6.92)	26 [†]	-1.54	0.136
Education	7.92 (1.96)	7.74 (2.60)	42	-0.27	0.791
No. of days in treatment	32.28 (18.30)	44.06 (20.73)	35	1.83	0.076 [^]
No. of people living in the house	6.3 (1.94)	8.57 (2.15)	14	2.19	0.046*
<u>Substance Use factors</u>					
	Median	Median	Z	p statistic	p Value
No. years using petrol at baseline	4.00	5.5	-	-0.77	0.444
No. years using cannabis at baseline	1.00	0.97	-	-0.19	0.851
No. years using alcohol at baseline	0.5	0	-	-0.97	0.332
Age 1 st used petrol	12.00	14.00	-	-1.90	0.058 [^]
Age 1 st used cannabis	15.00	16.00	-	-0.86	0.387
Age 1 st used alcohol	14.50	16.00	-	-1.61	0.108

Note. *p < .05. [^]p > .10. [†]Equal variances not assumed.

9.4 DISCUSSION

This is one of few studies internationally to investigate prospectively the factors contributing to continued petrol sniffing following treatment (Coleman, et al., 2001). While exploratory in nature and limited by a small sample size, the study has yielded some valuable data. The group examined appeared to share characteristics of Aboriginal petrol sniffers defined in existing literature (Burns, et al., 1995; Cairney & Dingwall, In Press; Winch, et al., 2010). Participants were youth engaged in delinquent behaviour (in trouble with the law; 45%), who sniffed in groups (95%), primarily because they were bored (76%) or because of peer pressure (57%), with

more males (82%) than females engaging in the practice. The average age of first petrol use was 13 years. These results align with established profiles of Aboriginal solvent users and similar studies of petrol sniffing patterns in remote communities (Burns, et al., 1995; Cairney & Dingwall, In Press; Coleman, et al., 2001; Winch, et al., 2010). Findings suggested that petrol availability, peer pressure, and social disengagement may be important risk factors for relapse following treatment. Other findings with p-values less than 0.10, suggested that psychologically distressed individuals, with more severe substance use histories including starting at a younger age and using multiple substances, might also be more likely to relapse, however further research in a larger sample is required to confirm these associations.

A key environmental factor significantly influencing relapse was petrol availability. Relapsed users were almost twice as likely to return to a community where sniffable petrol was readily available compared to abstinent users. 'Opal' fuel is a low aromatic fuel replacement recently introduced as a supply reduction strategy in petrol sniffing affected regions of Australia. The significant success of the fuel in reducing the impact of petrol sniffing in remote Aboriginal communities is also reflected in the current results (d'Abbs & Shaw, 2008). Nevertheless, some individuals returning to a community with Opal fuel did continue sniffing at follow up. This could reflect differences between communities in their attitudes or ability to respond to sniffing, as community resolve and support have been suggested as important accompanying elements in the success of fuel replacement strategies (MacLean & d'Abbs, 2002). Some Australian studies suggest that petrol sniffing is seen by some users as an opportunity to define their identity, belong to a social group, resist authority or create a sense of power in an otherwise powerless environment (Brady, 1991, 1992;

McCoy, 2008; Winch, et al., 2010). Future cross-sectional surveys could examine community and peer group attitudes toward sniffing to determine the potential social acceptability of the practice and its impact on petrol sniffing behaviours.

Solvent abuse often occurs in the context of a disrupted family structure, child abuse or other social stressors (Cairney & Dingwall, In Press; Oetting, et al., 1988; Winch, et al., 2010). Relapsing users in this study more likely to sniff in response to negative affect and experience psychological symptoms such as feelings of loneliness at baseline and trouble sleeping at follow up, however these results just failed to reach statistical significance ($p < 0.10$). While feelings of loneliness may relate to their potential social isolation (i.e. unmarried and living with fewer people) they might equally relate to a poorer ability to cope with isolation during treatment compared to abstinent users. These findings compliment those of another study identifying a lack of family support and high levels of stress as common reasons to begin sniffing (Winch, et al., 2010). However, future research is needed to confirm and further examine any relationships between psychological distress and petrol sniffing behaviour, using a more in depth assessment process based on comprehensive clinical interviews.

The apparent psychosocial differences between relapsing users and abstainers may reflect observed differences in other studies between occasional and heavy users. One study found that peer influence was the most common reason for sniffing given by light users, but heavy users were more likely to sniff in response to affect (Zebrowski & Gregory, 1996). In the current study, abstainers appeared more likely to be influenced by friends than relapsed users. Additionally, relapsed users

continued to sniff despite a slightly greater proportion ($p = 0.06$) reporting that it felt bad, compared to abstainers, suggesting addiction. Furthermore, more severe solvent use, that included starting at a younger age, sniffing immediately prior to treatment, and poly-substance use, also appeared to be associated with relapse, although these factors just failed to reach statistical significance ($p < 0.10$). A similar, retrospective study of relapse rates in Canadian solvent users identified sniffing immediately prior to rehabilitation as a significant risk factor for continued solvent use two years after treatment (Coleman, et al., 2001). While this factor failed to reach statistical significance here, it may be that our small sample size meant that we lacked sufficient power to reliably detect such associations. Future research in a larger sample is therefore warranted.

Attendance at treatment appeared to produce a change in attitude toward sniffing, with 90% of those followed up reporting that they thought sniffing was no good after attending treatment compared to 47% before treatment. While this result may reflect a social desirability response set (Gregory, 2000) (as both responses were given at follow up), it might equally reflect increased knowledge of the health effects of sniffing presented during treatment. Nevertheless, despite this reported attitude change, 58% of participants continued use after treatment. This outcome may reflect the poor treatment completion rates with relapsing users spending slightly fewer days in treatment than abstainers, although this finding failed to reach statistical significance ($p = 0.08$). Actually, both groups exhibited poor treatment completion rates, which may relate to the urban location of two of the rehabilitation centres. The most common reason for leaving treatment early was to return home for a funeral. Recent studies suggest that effective petrol sniffing interventions should be both

multifaceted and community-based (MacLean & d'Abbs, 2002; Preuss & Brown, 2006). Nevertheless, an important aspect of urban based residential treatment programs might be to increase awareness of potential risk factors to improve resilience and coping mechanisms among petrol sniffers and reduce their susceptibility to further petrol abuse upon return to their communities.

While this study was exploratory and descriptive in nature, aiming to highlight potential psychosocial and environmental risk factors for continued use, its findings must be considered in light of several limitations. Given the small sample size, and the large number of statistical comparisons, the risk for Type 1 error may be substantial. Future research in a larger sample under more controlled conditions is warranted in order to confirm the associations found here and identify the most important predictors of relapse, although, this may be difficult for this population (Dingwall & Cairney, 2009). The current study assessed a vast majority of youth attending treatment for petrol sniffing in the Northern Territory over 3 years, and followed up approximately 80% of these at great time and logistical expense. In the absence of larger, more controlled studies, this research provides important indicators for treatment providers, policy makers, and researchers to consider in managing and understanding the impact of petrol sniffing for Aboriginal Australians.

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Chapter 10

Similar Profile of Cognitive Impairment and Recovery for Aboriginal Australians in Treatment for Episodic or Chronic Alcohol Use

Preface

Manuscript submitted for publication [see Appendix A]

While it is predominantly young Aboriginal people who engage in petrol sniffing, alcohol use has become a significant problem among Aboriginal adults. As discussed previously, Aboriginal drinkers often consume alcohol at hazardous levels, with significant physical, mental and social impacts including high rates of morbidity, mortality and community and cultural disruption. Both alcohol and solvents share similar psychoactive effects and both can have a detrimental impact on the CNS. In order to develop effective interventions and target them appropriately, it is important to understand the precise impact of alcohol use on cognitive functioning in this population using culturally appropriate strategies to assess cognition. Previous research, predominantly among non-Indigenous people, suggests that impairments resembling those identified among solvent users (see Chapter 7) can also be associated with chronic alcohol abuse, with corresponding recovery following abstinence. However, little research has investigated impairment and recovery among Aboriginal alcohol users. Furthermore, virtually no research exists examining the impairment and recovery associated with the heavy episodic alcohol use patterns (i.e. binge drinking) that are more common among Aboriginal alcohol users. Considering the high rates of alcohol misuse in this population and its known detrimental health outcomes, cognitive deficits as a consequence of alcohol misuse are likely to be a significant health issue for Aboriginal groups despite being scarcely studied. This chapter therefore aims to investigate and compare the cognitive recovery profiles of both chronic and episodic alcohol use among Aboriginal users from the NT.

**Similar profile of cognitive impairment and recovery for Aboriginal Australians
in treatment for episodic or chronic alcohol use**

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ABSTRACT

Background: The cognitive impairment and recovery associated with chronic alcohol abuse and subsequent abstinence is well understood. However the recovery profile following heavy episodic or ‘binge’ use, which is common amongst some Australian Aboriginal users, has not been thoroughly investigated and no empirical studies have examined chronic use in this population. **Aims:** To identify and compare cognitive impairment and recovery associated with chronic and episodic alcohol use among Aboriginal Australians. **Design:** Longitudinal case-control design. **Setting:** Residential alcohol treatment programs in northern Australia. **Participants:** Forty chronic alcohol users, 24 episodic users and 41 healthy controls (M age = 34.24; SD = 9.73). **Measurements:** Cognitive assessments of visual motor, attention, memory, learning and executive functions at baseline (start of treatment), then 4 weeks and 8 weeks later. Reassessment of 31% of participants an average of 11 months later (SD = 4.4) comparing those who remained abstinent (n = 5), those who relapsed (n = 11) and healthy controls (n = 19). **Findings:** At baseline, chronic and episodic alcohol users showed impaired visual motor, learning, memory and executive functions. With the exception of visual motor impairment, all deficits had improved to normal levels within 4 weeks. Visual motor deficits had normalised within 11 months. Performances did not differ at any time between chronic and episodic alcohol groups. **Conclusions:** Episodic drinking was associated with similar patterns of impairment and recovery as chronic alcohol use. Most cognitive deficits recovered within the first month of abstinence while persisting visual motor problems recovered within one year.

Keywords: Alcohol, cognitive recovery, episodic, chronic, Aboriginal

10.1 INTRODUCTION

Excessive alcohol consumption is associated with significant risk of harm which may include neurological abnormalities and impaired mental functioning (Courtney & Polich, 2009; National Health and Medical Research Council, 2009; Oscar-Berman, Shagrin, Evert, & Epstein, 1997; D. A. Parker, Parker, Brody, & Schoenberg, 1983). Neuroimaging studies of chronic alcohol users have identified diffuse brain atrophy, including ventricular enlargement and widening of cerebral sulci (Carlen, et al., 1978; Pfefferbaum, Sullivan, Mathalon, & Lim, 1997; Rosenbloom & Pfefferbaum, 2008; Sullivan, Rosenbloom, Pfefferbaum, & Lim, 2000). Furthermore, impairments in areas of visuo-spatial (Brandt, et al., 1983; Fein, et al., 2006; Goldman, et al., 1983; Rosenbloom, Pfefferbaum, & Sullivan, 2004), learning (Cairney, et al., 2007; Grant, Adams, & Reed, 1984), memory (Brandt, et al., 1983; Cairney, et al., 2007; Mann, Gunther, Stetter, & Ackermann, 1999; Pitel et al., 2009; Rosenbloom, et al., 2004; Sullivan, Rosenbloom, Pfefferbaum, et al., 2000; Zinn, Bosworth, Edwards, Logue, & Swartzwelder, 2003), visuo-motor (Brandt, et al., 1983; Cairney, et al., 2007; Goldman, et al., 1983; Mann, et al., 1999) and executive functions (Cairney, et al., 2007; Johnson-Greene et al., 1997; Pitel, et al., 2009; Sullivan, Rosenbloom, & Pfefferbaum, 2000) are reliably identified following chronic alcohol use (see Fein, et al., 1990; Oscar-Berman & Marinkovic, 2003 for reviews).

Chronic alcohol use is broadly defined as consumption of large amounts of alcohol on a near daily basis (Australian Bureau of Statistics, 2008; Kokavec & Crowe, 1999; D. A. Parker, et al., 1983). However, some studies report significant associations between cognitive function and the amount of alcohol consumed per

occasion, regardless of frequency (E. S. Parker & Noble, 1977). This suggests that episodic alcohol users may be as vulnerable as chronic users to the cognitive effects of heavy alcohol use (Kokavec & Crowe, 1999). Episodic or 'binge' drinking involves the consumption of large amounts of alcohol in one sitting on an irregular or episodic basis (Australian Bureau of Statistics, 2008; Kokavec & Crowe, 1999; Stephens & Duka, 2008). While very few studies have investigated the impact of episodic drinking on neuropsychological performance, those that have indicate frontal lobe abnormalities with impaired visual motor speed, attention, visuo-spatial abilities, learning memory and executive functions (Cairney, et al., 2007; Courtney & Polich, 2009; Kokavec & Crowe, 1999; Stephens & Duka, 2008).

In chronic users, there is considerable evidence to suggest that the alcohol related neuropsychological and neuroanatomical impairments may resolve with sustained abstinence (M. E. Bates, et al., 2002; M. E. Bates, Voelbel, Buckman, Labouvie, & Barry, 2005; Bendszus, et al., 2001; Brandt, et al., 1983; Carlen, et al., 1978; Fein, et al., 2006; Goldman, et al., 1983; Grant, et al., 1984; Moriyama, Kato, Mimura, & Kashima, 2006; Pitel, et al., 2009; Rosenbloom & Pfefferbaum, 2008; Rosenbloom, et al., 2004; Ryan, DiDario, Butters, & Adinolfi, 1980; Sullivan, Rosenbloom, & Pfefferbaum, 2000; Sullivan, Rosenbloom, Pfefferbaum, et al., 2000). Much of this recovery is rapid, occurring within the first month of abstinence, particularly for younger users (Brandt, et al., 1983; Fein, et al., 1990; Mann, et al., 1999). However, for impairments that persist beyond the initial detoxification period, recovery is more gradual occurring over many months or years (Fein, et al., 1990). Some studies have identified correlations between duration of abuse and degree of cognitive impairment or recovery (Eckardt, et al., 1995; Pitel, et al., 2009). Others have found

factors such as age or family history to be more important predictors of impairment and recovery (Goldman, et al., 1983; Moriyama, et al., 2006). The bulk of this research involves chronic alcohol users with greater than 10 years of alcohol abuse. In fact, reversibility studies among heavy episodic alcohol users are virtually non-existent (Courtney & Polich, 2009). However, it is reasonable to expect that some cognitive improvement may also be detected among abstinent episodic users with extended alcohol use histories (D. A. Parker, et al., 1983).

National surveys demonstrate comparable rates of chronic alcohol abuse across Australian populations, however Aboriginal people are almost twice as likely to engage in episodic or 'binge' drinking compared to other Australians (Australian Bureau of Statistics, 2008). Amongst some Aboriginal drinkers, heavy episodic drinking reflects the varying availability of financial resources and alcohol, particularly in remote areas where alcohol restrictions may apply (Australian Bureau of Statistics, 2008; Cairney, et al., 2007; Margolis, Ypinazar, Clough, & Hunter, 2008). Despite the devastating impact of alcohol misuse among Aboriginal groups, only one study to date has investigated the cognitive implications for this population (Cairney, et al., 2007). The impact of chronic alcohol use among Aboriginal groups specifically, and the timeline for cognitive recovery associated with heavy episodic alcohol use generally, remain to be determined.

High rates of substance misuse occur in the study region, particularly of tobacco, cannabis, and volatile solvents (i.e., petrol sniffing), and polysubstance use is also common (Clough, d'Abbs, et al., 2004). However their impact is unlikely to confound any central nervous system (CNS) changes observed in relation to alcohol

misuse. For example, although rates of long term cannabis use are high, recent evidence suggests that 10-20 years of daily cannabis use is required before even subtle cognitive impairments are observed (Solowij, et al., 2002). Our own research found no significant impact of cannabis use on cognition in comparable Aboriginal groups using the same measures as the current study (Cairney, et al., 2007; Dingwall, Lewis, et al., 2010). Similarly, although high levels of petrol sniffing gives rise to substantial CNS impairment, these occur after many years of abuse and also resolve with abstinence from further use (Cairney, et al., 2005). A brief history of petrol sniffing is therefore also unlikely to affect the presentation of alcohol related cognitive impairment.

Thus, the objective of the current study was to assess cognitive performance longitudinally among Aboriginal people attending treatment for chronic or episodic alcohol use. The aims were to identify and compare profiles of impairment and subsequent recovery associated with these differing patterns of heavy alcohol use.

10.2 METHOD

10.2.1 Participants

Participants were either individuals attending rehabilitation for alcohol use (n = 64) or healthy controls (n = 41) between 18 and 60 years of age (M = 34.24; SD = 9.73). Alcohol users were classified as either chronic alcohol users (n = 40) or heavy episodic alcohol users (n = 24) on the basis of national alcohol guidelines where one standard drink is equivalent to 10g of pure ethanol (National Health and Medical

Research Council, 2009). Thus, chronic alcohol users were defined as those who drank greater than six standard drinks per occasion and did so everyday or most days (i.e. ≥ 4 days/week) and episodic alcohol users were defined as those who drank greater than six standard drinks per occasion and did so intermittently (i.e. < 4 days per week). Over 90% of both chronic and episodic users reported consuming greater than 10 standard drinks per occasion (see Table 1). Eighty-eight percent of chronic users drank everyday while 12% drank 4–6 days per week. Among episodic users 78% used alcohol 1–3 times per week and 22% used it less than once per week (e.g. fortnightly).

Participants were classified as healthy controls if: (a) their usual alcohol consumption was less than six standard drinks per occasion; (b) they had never used petrol or other volatile solvents regularly (i.e. > 1 time); and (c) they had not used any other drugs regularly (i.e. > 1 time). Demographic information for the three groups is presented in Table 1. Although cannabis use was higher amongst alcohol users than healthy controls, previous research among alcohol users in this population have revealed no significant impact of cannabis use on cognition (Cairney, et al., 2007). While some users had a history of petrol sniffing, their mean duration of use was less than one year and was, on average, 15 years ago.

Table 1. Demographic Information for Alcohol Users and Healthy Controls

	Healthy Controls (n = 41)	Chronic Alcohol (n = 40)	Episodic Alcohol (n = 24)
Mean age in years (SD)	35.77 (10.84)	32.67 (9.01)	34.25 (8.87)
Mean education in years (SD)	11.88 (14.21)	9.00 (1.99)	9.25 (3.04)
No. with previous computer use (%)	29 (72.5)	25 (64.1)	15 (62.5)
No. males (%)	12 (29.3)	30 (75)*	14 (58.3)
Mean age 1 st alcohol use (SD)	22.20 (7.70)	16.82 (4.30)*	18.17 (4.83)*
Mean no. years alcohol use (SD)	6.29 (8.12)	16.12 (8.19)*	15.11 (9.16)*
% greater than 10 standard drinks per occasion	0	91%	93%
Mean age 1 st cannabis use (SD)	16.25 (0.5)	16.75 (4.24)	18.54 (4.94)
Mean no. years cannabis use (SD)	0.52 (2.17)	8.04 (7.69)*	8.00 (8.02)*
Mean age 1 st petrol use (SD)	-	14.20 (2.58)	19.33 (5.86)
Mean no. years petrol use (SD)	-	0.19 (0.98)	0.15 (0.56)

Note. No difference between alcohol use groups. *significantly different to controls at $p < 0.05$

10.2.2 Procedure

The joint Human Research Ethics Committee (including the Aboriginal Ethics Sub Committee) for the Department of Health and Community Services and Menzies School of Health Research granted ethical approval for the study. Researchers visited two urban based residential rehabilitation centres on a fortnightly basis during 2007-2009. All individuals attending treatment for alcohol use, who were present during a study visit, were invited to participate. The control group were recruited from Indigenous specific residential education institutions located in regional centres. All individuals attending health certificate courses at the adult education institutions and the entire student population of a secondary boarding school who were present on the study visits were invited to participate. Only data from those

aged over 18 were included in the study. Participants represented over 37 different language groups, 60 distinct communities, and diverse geographical regions including the arid desert of central Australia and the tropics of northern Australia. Individuals were informed that participation was voluntary and gave written informed consent prior to participation.

At baseline, upon entry to treatment, all participants completed questionnaires eliciting demographic information (including age, education, community and medical history) and substance use histories (including frequency, amount, first and last use of alcohol, cannabis, petrol or other solvents, cigarettes, kava or other drugs). A validated consensual methodology using proxy respondents was utilised to verify self report substance use data. This process has proven appropriate for measuring substance use history among Aboriginal Australians and has been described in detail elsewhere (Clough, Cairney, et al., 2004; Dingwall & Cairney, 2010a; Dingwall, et al., In Press). Participants also completed a computerised cognitive assessment at baseline, an average of 10 days ($SD = 6.5$) from treatment admission, and again both four weeks ($M = 24$ days; $SD = 8.7$) and eight weeks ($M = 55$ days; $SD = 18.8$) later.

An average of 11 months ($SD = 4.4$) following treatment, a smaller group of alcohol users ($n = 16$) and healthy controls ($n = 19$) were reassessed in their home communities. Those who continued using alcohol were classified as relapsed users ($n = 11$) and those who ceased alcohol use after treatment were classified as abstainers ($n = 5$). This categorisation was made based on self-report data and interviews with key informants as per the consensual methodology described above (Dingwall, et al., In Press).

10.2.3 Cognitive Assessment

The CogState computerised test battery consisted of seven cognitive tasks that have proven suitable for the assessment of Indigenous Australians. These tasks are described briefly below and in detail elsewhere (Dingwall, et al., 2009; Dingwall, Lewis, et al., 2010; Lewis, et al., 2010). For the first three tasks, the ‘K’ and ‘D’ keys on the keyboard are used for ‘yes’ and ‘no’ respectively (reversed if left hand dominant).

Detection Task (simple reaction time, psychomotor function): A playing card is presented facedown on-screen. The participant is required to press ‘yes’ as fast as possible when the card turns face up. Mean reaction time is recorded in milliseconds.

Identification Task (choice reaction time, visual attention): A playing card is presented facedown on-screen. When the card turns face up, the participant is required to press ‘yes’ if the card’s suit is red or ‘no’ if it is not red (i.e. black). Mean reaction time is recorded in milliseconds

Visual Learning Task (working memory): A playing card is presented facedown on-screen. When the card turns face-up, the participant is required to press ‘yes’ if the card has been presented before and ‘no’ if the card has not been seen before. Percentage accuracy (no correct divided by number of presentations) is recorded.

Groton Maze Chase Test (GMCT; visual motor function): A target tile is presented on a grid 10 tiles by 10 tiles. The participant is required to click on the target tile as fast as possible and ‘chase’ it around the grid as it moves one tile at a time. The task continues for 30 seconds and records the total number of correct movements per second.

Groton Maze Learning Test (GMLT; executive function and spatial problem solving): Using the same grid as the GMCT, the participant uses the mouse to uncover a circuitous path, moving one tile at a time (across 28 correct tiles), from one corner of the grid to the diagonally opposite corner. Once the pathway has been uncovered and completed, the task is repeated for four more rounds along the same path. Duration to complete the task and total number of errors made are recorded.

Groton Maze Learning Test – Delayed Recall (GMLT-Recall; visual learning and memory): Approximately ten minutes after completing the GMLT, and with other tasks being completed in the interim, the grid is presented once more. The participant is required to remember the same hidden pathway as presented on the initial trials and complete it as quickly and accurately as they can. Duration and errors are recorded.

Continuous Paired Associate Learning (CPAL; learning and memory): Eight balls are presented on-screen and, during the acquisition round, participants are required to learn the location of six patterns presented serially underneath six individual balls. Each of the patterns is then presented in a central location and the location of that pattern’s matching pair has to be recalled. The task is repeated for five rounds

(locating all six patterns) with the patterns in the same location for each round.

Duration and errors are recorded.

10.2.4 Data Analysis

Of the total group tested at baseline, 61% were assessed at 4-weeks, 54% at 8-weeks and 31% were followed up in the community 11 months later. The data for all subjects with a baseline and at least one follow up assessment during treatment (i.e. 4 or 8 weeks) were submitted to a series of linear mixed model (LMM) analyses with each cognitive measure as the dependent variables. Age was a covariate, time (baseline, 4-weeks, 8-weeks) and substance use group (healthy controls, chronic alcohol, episodic alcohol) were fixed effects, and participant was treated as a random effect. Post hoc pairwise comparisons were conducted at each time point between each alcohol group and healthy controls. Speed (reaction time and duration) measures were recorded in milliseconds and transformed using logarithmic (base 10) transformations and accuracy data for the Visual Learning task was transformed using arcsine transformations as prescribed by the test developers, to achieve normal distributions (Collie, Maruff, Makdissi, et al., 2003; Falleti, et al., 2006; Mollica, et al., 2005; Straume-Naesheim, et al., 2005).

At the community follow up, participants who relapsed and participants who remained abstinent were compared to healthy controls using ANCOVA, with age and baseline score as covariates. Six healthy controls and three alcohol users were excluded from the previous analyses as they had completed only one (baseline) assessment during the initial eight week testing period. The baseline performance of

alcohol users who were followed up after 11 months were compared to those who were unable to be located at follow up to examine the impact of attrition.

10.3 RESULTS

The LMMs revealed significant main effects for group on the GMCT ($F_{(2, 97)} = 10.25$; $p < 0.01$), GMLT errors ($F_{(1, 26-63)} = 6.41-49.84$; $p < 0.05$), GMLT-Recall speed ($F_{(2, 95)} = 3.84$; $p < 0.05$). Significant main effects for time were found on GMCT ($F_{(2, 128)} = 6.57$; $p < 0.01$), GMLT speed ($F_{(2, 107)} = 72.14$; $p < 0.01$) and GMLT errors ($F_{(2, 124)} = 18.30$; $p < 0.01$), GMLT-Recall speed ($F_{(2, 107)} = 13.41$; $p < 0.01$), and CPAL speed ($F_{(2, 123)} = 6.28$; $p < 0.01$). Significant interactions were found for GMLT errors ($F_{(4, 123)} = 3.63$; $p < 0.01$) and GMLT-Recall speed ($F_{(4, 106)} = 2.84$; $p < 0.05$) and errors ($F_{(4, 111)} = 2.81$; $p < 0.05$). Summary data for LMMs and post hoc comparisons are presented in Table 2. Post hoc tests revealed significant differences between the chronic alcohol users and healthy controls at baseline on the GMCT, GMLT errors, and GMLT-Recall speed. The episodic alcohol users were significantly impaired compared to controls on the GMCT, GMLT errors, GMLT-Recall speed and GMLT-Recall errors. By the eight-week assessment, scores on the GMCT remained different between controls and both alcohol groups, but all other differences had ameliorated by week four for both groups. Chronic and episodic users did not differ on any measure at any time point.

Table 2. Summary Statistics for Linear Mixed Model (LMM) Analysis

	Baseline	4 weeks	8 weeks	LMM p value	
	EM	EM	EM	Group	Group x time
<u>Detection speed (log reaction time)</u>					
Healthy Controls	2.54	2.54	2.57	ns	ns
Alcohol – Chronic	2.54	2.54	2.55		
Alcohol – Episodic	2.56	2.58	2.58		
<u>Identification Speed (log reaction time)</u>					
Healthy Controls	2.78	2.80	2.80	ns	ns
Alcohol – Chronic	2.79	2.80	2.78		
Alcohol – Episodic	2.79	2.80	2.78		
<u>Visual learning Arcsine Accuracy</u>					
Healthy Controls	0.75	0.75	0.75	ns	ns
Alcohol – Chronic	0.72	0.70	0.70		
Alcohol – Episodic	0.72	0.70	0.72		
<u>Groton Maze Chase Test</u>					
Healthy Controls	1.16	1.28	1.24	<.001	ns
Alcohol – Chronic	0.81*	0.95*	0.93*		
Alcohol – Episodic	0.81*	1.04^	0.99*		
<u>Groton Maze Learning Test</u>					
<i>Speed (log duration)</i>					
Healthy Controls	5.51	5.41	5.39	ns	ns
Alcohol – Chronic	5.61*	5.47	5.40		
Alcohol – Episodic	5.59^	5.44	5.41		
<i>Total Errors</i>					
Healthy Controls	76.78	64.45	71.33	ns	.008
Alcohol – Chronic	102.93*	76.62	75.94		
Alcohol – Episodic	94.11*	80.28	59.26		
<u>Groton Maze Learning Test - Recall</u>					
<i>Speed (log duration)</i>					
Healthy Controls	4.60	4.57	4.60	.025	.028
Alcohol – Chronic	4.74*	4.66^	4.62		
Alcohol – Episodic	4.77*	4.66	4.64		
<i>Total Errors</i>					
Healthy Controls	9.86	9.21	10.97	ns	.029
Alcohol – Chronic	12.10	10.86	10.99		
Alcohol – Episodic	13.99*	12.09	8.61		
<u>Continuous Paired Associate Learning</u>					
<i>Speed (log duration)</i>					
Healthy Controls	5.36	5.32	5.32	ns	ns
Alcohol – Chronic	5.43	5.37	5.36		
Alcohol – Episodic	5.41	5.37	5.38		
<i>Total Errors</i>					
Healthy Controls	44.77	44.48	45.83	.06	ns
Alcohol – Chronic	59.40	50.45	65.38		
Alcohol – Episodic	40.84	45.28	51.90		

Note. EM = estimated marginal means. ns = not significant

**p < 0.01. *p < 0.05. ^p = .06

Of those reassessed on their community, five (31%) had remained abstinent from further alcohol use while 11 (68%) had relapsed. Comparison of abstinent and relapsed users to healthy controls revealed no significant difference between the alcohol users (both abstinent and relapsed) and controls on any of the measures, indicating prior abnormalities had recovered by this time. There was no difference in baseline performance between those who were followed up after 11 months and those who were not.

10.4 DISCUSSION

Episodic alcohol users presented a comparable profile of cognitive deficit and subsequent recovery with abstinence compared to chronic alcohol users. Cognitive performance did not differ between the groups for any time point or task. Both chronic and episodic alcohol use impacted visual motor, learning, memory and executive functions. With the exception of visual motor problems, these deficits had improved to normal levels within four weeks for both groups. Persistent visual motor impairments had recovered within 11 months. The majority of alcohol related cognitive impairments may therefore arise from residual biochemical effects that ameliorate following detoxification. These results reflect previous research suggesting that heavy episodic alcohol use may have similar effects to chronic use and these profiles of impairment and recovery may be comparable across cultures (Cairney, et al., 2007; Kokavec & Crowe, 1999).

Many studies have observed considerable recovery within the first few weeks after cessation of drinking, which may reflect resolution of the acute neurotoxic effects of

alcohol (M. E. Bates, et al., 2005; Brandt, et al., 1983; Eckardt, et al., 1995; Fein, et al., 1990; Goldman, et al., 1983; Mann, et al., 1999; Moriyama, et al., 2006; Schafer et al., 1991). However, a subacute alcohol related organic mental disorder, that resolves gradually after a year or more sobriety has also been suggested (Brandt, et al., 1983; Fein, et al., 2006; Grant, et al., 1984; Rosenbloom, et al., 2004; Ryan, et al., 1980). The positive recovery reported here may relate to reduced severity or duration of abuse compared to studies observing long term CNS changes and/or to the specific cluster of cognitive functions tested. Many studies reporting residual impairments after many years of abstinence have examined chronic users of more than 10 years duration (Brandt, et al., 1983; Fein, et al., 2006; Rosenbloom, et al., 2004; Ryan, et al., 1980). But another examining a group who had abused alcohol for an average of nine years reported normalisation of impairments within six months of abstinence (Pitel, et al., 2009). While our study group had an average total duration of alcohol use of 15-16 years, they did not explicitly report any periods of reduced use, so it is possible that such periods occurred preventing more severe deterioration of CNS functions. However, Kokavec and Crowe (1999) reported comparable abnormalities among episodic and chronic alcohol users with 19-20 years of abuse on tests of visual motor speed, visuo-spatial processing, learning and memory and suggested that duration or frequency of abuse may be less important than the quantity of abuse.

Persistent cognitive deficits reported in other studies after one month of abstinence have involved visual motor speed as well as other faculties not assessed here such as verbal short term memory, visuo-spatial processing, and fluid intelligence involving problem solving and abstracting abilities (Fein, et al., 2006; Grant, et al., 1984;

Mann, et al., 1999; Ryan, et al., 1980). In addition, Kokavec and Crowe (1999) did observe differences between chronic and episodic users on tasks that required semantic organisational abilities. These language based assessments were not included in the current study as participants represented a diverse range of Aboriginal language groups where English is a second or third language, and it is therefore difficult if not impossible to use tests based on language in this context if they have not been specifically developed for use with interpreters (Dingwall & Cairney, 2010b).

In a separate study in the same population, individuals who presented for treatment with paired associate learning deficits were more likely to relapse and, cognitive improvements were observed amongst those who reduced their alcohol intake after treatment (Dingwall, Maruff, & Cairney, 2010, see Chapter 11). Due to the insidious nature of cognitive impairment and the implications for treatment, it is therefore important to assess and monitor cognitive function during treatment using culturally validated assessments (M. E. Bates, et al., 2002; Fals-Stewart, et al., 1994).

Assessing cognition for Aboriginal Australians is extremely challenging due to language and other cultural differences and the assessment used here (CogState) is one of very few with proven validity for detecting substance abuse related changes within this population (Cairney, et al., 2007; Dingwall & Cairney, 2010b; Dingwall, et al., 2009; Dingwall, Lewis, et al., 2010; Lewis, et al., 2010). Considering the reported impacts of cognitive impairments on treatment outcomes and the improvements observed here, future research should investigate whether tailoring specific treatment programs to accommodate identified impairments leads to improved treatment outcomes for this population (Teichner, et al., 2002).

Despite several challenges, this study is one of the first to describe comparable patterns of cognitive impairment and subsequent recovery for chronic and episodic alcohol users within an Aboriginal Australian population. Although limited by incomplete data sets and small sample size at the community follow up, this study had many strengths. By assessing individuals upon entry to treatment, and again after four and eight weeks of abstinence, as well as 11 months later, we could differentiate resolution of the acute withdrawal syndrome from longer term recovery (Grant, et al., 1984). In addition, by employing the use of a control group at these same test intervals, any impact of practice effects that might be associated with repeated assessments was controlled (Grant, et al., 1984). Although only 31% were reassessed after 11 months, the baseline scores of those who were or who were not followed up did not differ for any task, suggesting those followed up were representative of the entire sample. The results support findings from other populations demonstrating rapid recovery within the first few weeks of abstinence, reflecting resolution of the acute neurotoxic effects of alcohol, with persistence of a subacute organic brain syndrome that recovers with more prolonged (11 months) abstinence (Goldman, et al., 1983; Grant, et al., 1984; Mann, et al., 1999; Pitel, et al., 2009). However, no definite conclusions can be drawn from such a small sample size at follow up. The importance of monitoring cognition throughout treatment for both chronic and episodic users was highlighted and may provide important information for tailoring treatment to meet the specific needs of the individual, or motivation for maintaining abstinence.

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Chapter 11

Cognitive and Psychological Problems Underlie Continued Alcohol Misuse after Treatment for Aboriginal Australians

Preface

Findings submitted for publication as a 'Letter to the Editor' [see Appendix A]

Chapter 10 found that significant cognitive impairments were likely to result from both heavy chronic and heavy episodic alcohol use and that these impairments could improve with abstinence both during and after treatment. The current chapter therefore seeks to investigate the impact of these cognitive impairments, along with other environmental and psychosocial factors on continued alcohol use following treatment. Chapter 9 found no impact of cognitive impairment on treatment outcomes for petrol sniffers, but petrol availability, peer pressure, psychological symptoms, and substance use severity were identified as potential risk factors for relapse. Among the alcohol users examined, only five of those followed up had abstained from further alcohol use upon their return to the community. However, another three had reported reducing their alcohol use after treatment. This chapter therefore compares users who reduced their alcohol intake (including those who abstained) to users who continued using alcohol at the same level (i.e. relapsed) on pre and post-treatment neuropsychosocial factors. Although group sizes are small in this study, a similar analysis has not been conducted and its inclusion was therefore considered important and may serve as a pilot study that warrants subsequent investigation.

**Cognitive and psychological problems underlie continued alcohol misuse after
treatment for Aboriginal Australians**

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ABSTRACT

Introduction and Aims: Significant morbidity and mortality is associated with excessive alcohol use, which generally occurs within a context of social and economic disadvantage for Aboriginal Australians. This study aimed to identify neuropsychosocial factors impacting alcohol use patterns among Aboriginal Australians following treatment. **Method:** On admission to two months residential alcohol treatment, 37 individuals completed baseline interviews and cognitive and psychological assessments. Community follow-up assessments were conducted an average of 11 months post-treatment ($SD = 4.4$) whereby 62% ($n=23$) had continued drinking at the same level, 24% ($n = 9$) had improved outcomes (i.e. 6 had stopped using and 3 had reduced their alcohol intake), and change in use was unknown for five users. Those who abstained or reduced their use (improved users; $n = 9$) were compared to those who continued heavy alcohol use (relapsed users; $n = 23$) on cognitive, psychological, and demographic factors. **Results and Discussion:** Compared with improved users, relapsed users showed poorer cognitive performance on a paired associate learning task at treatment admission and poorer performance on tasks of visual attention, executive function, learning and memory and paired associate learning at follow up. Relapsed users were more likely to experience the psychological symptom of 'worry' and were less likely to return to remote communities with restricted alcohol availability. **Conclusions:** Neuropsychological problems and alcohol availability appear to underlie ongoing alcohol misuse among Aboriginal Australians.

Keywords: Alcohol, Aboriginal Australian, relapse, cognition

11.1 INTRODUCTION

While many Aboriginal Australians abstain from alcohol use, those that do drink are more likely to do so at hazardous levels compared to other Australians, with increased rates of morbidity and mortality for this population (Australian Bureau of Statistics, 2006a; National Drug Research Institute, 2007). For Aboriginal Australians, hazardous drinking occurs in a context of social, political and economic inequality and may reflect or exacerbate psychological and other social problems (Burdekin, 1993; Siggers & Gray, 1998). The aim of this exploratory study was to identify neuropsychosocial factors that may influence changes in alcohol use after treatment for Aboriginal Australians.

11.2 METHODS

11.2.1 Participants

Participants were 22 male and 15 female (M age = 32 years; SD = 8.1) Aboriginal Australians attending urban based residential treatment for alcohol use during 2007-2009. The mean number of years using alcohol was 13.5 (SD = 8.0). Over half (58%) reported drinking everyday or most days and the majority (82%) reported drinking greater than 10 standard drinks per occasion.

11.2.2 Procedure

At baseline, an average of 16 days from treatment entry ($SD = 10$), participants completed demographic (e.g. age, education) and substance use history (i.e. frequency, amount, first and last use of alcohol and other drugs) questionnaires along with a psychological screening tool (based on Strong Souls) and a computerised cognitive assessment (CogState) (Dingwall & Cairney, 2010a; Dingwall, Lewis, et al., 2010). These assessments have proven suitable for use with Aboriginal Australians and measure psychological symptoms along with visual attention, working memory, psychomotor function, executive function, visual learning and recall, and paired associate learning (Dingwall & Cairney, 2010a; Dingwall, et al., 2009; Dingwall, Lewis, et al., 2010; Dingwall, et al., In Press; Lewis, et al., 2010; Thomas, et al., 2010).

Researchers also visited participant's communities an average of 11 months later ($SD = 4.4$) to reinterview participants and key informants ($n = 21$) and examine clinic notes for information regarding the participant's continued use of alcohol and/or other drugs (Clough, Bailie, et al., 2002; Clough, Cairney, et al., 2004; Dingwall, et al., In Press). Consent was given to this process at baseline. Those interviewed in person ($n = 16$) also completed the cognitive and psychological assessments again. For those unable to be located, information from key informants and clinic notes enabled classification regarding continued alcohol use post-treatment. The joint Human Research Ethics Committee (including the Aboriginal Ethics Sub Committee) for the Department of Health and Community Services and Menzies

School of Health Research granted ethical approval. All participants gave written informed consent prior to participation.

11.2.3 Data Analysis

To examine any relationships between cognitive, psychological and demographic factors with reductions in alcohol use following treatment, simple comparisons between individuals who had ceased or reduced their alcohol use (improved users) and those who had not (relapsed users) were conducted. Mann-Whitney tests were used to examine cognitive measures (due to the small sample size) and computer familiarity was controlled where appropriate (Dingwall, Lewis, et al., 2010).

Psychological and demographic variables were described in percentages with relative risk ratios (RR) and Fisher's exact tests of significance calculated.

Table 1. Comparison of Relapsed and Improved Users on Continuous Variables

	Relapsed Users n = 23 (Median)	Improved Users n = 9 (Median)	Z statistic	Sig.
Age (years)	31.30	29.04	-0.15	ns
No. years drinking (baseline)	13	11.64	-0.59	ns
Visual Attention				
<i>Speed (log transformed)</i>				
▪ Baseline	2.81	2.76	-1.67	ns
▪ Follow up	2.79	2.71	-2.10	0.04
Working Memory				
<i>Accuracy (arcsine transformed)</i>				
▪ Baseline	0.70	0.70	-0.19	ns
▪ Follow up	0.80	0.74	-0.53	ns
Psychomotor speed				
<i>moves per second</i>				
▪ Baseline	0.77	0.95	-.35	ns
▪ Follow up	1.17	1.37	-0.75	ns
Learning and Executive function				
<i>Moves Per Second</i>				
▪ Baseline	0.44	0.47	-0.39	ns
▪ Follow up	0.58	0.76	-2.32	0.02
Visual Learning & Recall				
<i>Moves Per Second</i>				
▪ Baseline	0.48	0.46	-0.21	ns
▪ Follow up	0.73	0.84	-2.20	0.03
Paired Associate Learning				
<i>Duration (seconds)</i>				
▪ Baseline	307.81	214.11	-2.52	0.01
▪ Follow up	286.51	168.48	-2.67	0.008

Sig. = Significance level. ns = not significant ($p > .07$).

11.3 RESULTS AND DISCUSSION

After treatment, 31 (84%) alcohol users had continued using alcohol and six (16%) had abstained from further alcohol use. For those who continued using, three (8%) had reportedly reduced their alcohol intake and 23 (62%) continued using at the same level as before they entered treatment (change in use was unknown for five individuals). Improved users (i.e., individuals who abstained or reduced their use; $n = 9$) were compared to relapsed users (i.e. individuals who continued heavy use; $n = 23$) to determine the factors associated with reducing alcohol use following treatment.

Poorer cognitive performance appeared to be a risk factor for continuing heavy alcohol use following treatment. Relapsed users performed significantly worse on baseline tests of paired associate learning compared to improved users (see Table 1). Furthermore, relapsed users exhibited poorer cognitive performance in even more cognitive domains at follow up, with significantly slower performance on tests of visual attention, executive function, visual learning and memory and paired associate learning compared to improved users. This suggests that reducing alcohol use is associated with some degree of cognitive improvement and continued alcohol use leads to further cognitive decline.

Living in remote communities and the restricted availability of alcohol appeared to be associated with reductions in alcohol use following treatment, with improved users more likely to have returned to a remote community, and a community where alcohol was not available compared to relapsed users (Fishers Exact Test $p = 0.006$

& 0.002 respectively). This finding also suggests however, that those wanting to continue drinking will remain in an environment where alcohol is easily accessible such as urban centres. Nevertheless, this finding does lend some support to the effectiveness of alcohol restrictions for reducing alcohol use in remote communities and highlights the importance of encouraging individuals from remote communities with restricted access to alcohol to return there following treatment.

Although most users (85%) reported positive feelings associated with drinking alcohol, individuals who relapsed were significantly more likely to experience psychological symptoms including worry (67%; $n = 4$; Fisher's Exact Test $p = 0.03$) after treatment compared to abstaining users (0%). This implies that alcohol use may be a form of self-medication or may mask underlying psychological problems. Interestingly, a greater proportion of relapsed users (62.5%) were using cannabis at follow up compared to abstainers (11%). Cannabis use has independently been associated with symptoms of depression, anxiety and psychoticism in other Australian studies (Clough, et al., 2005; Dingwall & Cairney, 2010a). These findings support the need to concurrently treat psychological problems to reduce the impact of alcohol abuse for this group.

While this study suggests that alcohol abuse is more likely to continue after treatment for those with cognitive and psychological problems, and when alcohol continues to be available, such as in urban centres, the findings were based on a relatively small group of users and because of the number of comparisons the risk of Type 1 error may be high. Therefore further research is needed in a larger sample to confirm and

explore these apparent associations, which may also help to inform improvements in policy and practice.

Chapter 12

General Discussion

12.1 SUMMARY OF RESEARCH FINDINGS

The cognitive and psychological impacts of petrol and alcohol abuse among Indigenous Australians can be profound. The research presented in this thesis measured these impacts objectively using tests of cognitive and psychological function developed for use with Indigenous Australians. The results demonstrated pervasive impairments in psychomotor, attention, learning, memory and executive functions, among both petrol and alcohol abusers, that recovered either partially or fully during the two months of abstinence while in treatment. The abnormalities related to petrol abuse appeared somewhat more persistent than those associated with alcohol abuse. Petrol related impairments in visuomotor, memory and executive function speed persisted even after 12 months of abstinence, while alcohol related impairments in all domains tested had resolved within 11 months. Furthermore, significant relationships between petrol, alcohol, and cannabis use with psychological symptoms of anxiety and depression were observed and these symptoms appeared to negatively impact on treatment outcomes.

While assessing cognitive and psychological function among Indigenous Australians can be a difficult task, it is also an important one. Undiagnosed cognitive problems are likely to be prevalent among Indigenous populations due to widespread exposure to known risk factors such as, violence, head trauma, malnutrition, chronic illness, foetal alcohol syndrome and of course, substance abuse (Dingwall & Cairney, 2009). Difficulty with the appropriate measurement of cognitive and psychological functions can lead to further disadvantage for this group as any problems may remain undetected, undiagnosed and untreated. The availability of scientifically validated

tools for assessing cognitive and psychological function among Indigenous people can improve service provision and promote better health outcomes. For example, this research showed that cognitive and psychological problems are prevalent among substance users seeking treatment. Early detection of these abnormalities will enable early intervention, prevent progression to more severe or irreversible neurological damage, and lead to improved treatment quality and better health outcomes. The establishment of culturally appropriate, validated assessment procedures facilitates accurate and systematic collection of epidemiological data that can improve knowledge regarding the aetiology, presentation, and treatment of psychological and substance use problems for Indigenous people.

Monitoring cognition and psychological function using culturally appropriate assessment tools, as presented in this thesis, has been used to better understand the nature of impairment and the timeline for cognitive recovery associated with petrol and alcohol abuse. In addition, the impact of these factors on longer term treatment outcomes were described, providing important insight for the development of more appropriate treatment programs that can rely on cognitive skills to progress. For both petrol and alcohol abusers, many cognitive deficits resolved within eight weeks of treatment. However, residual impairments in visuomotor, memory and executive function speed were identified among petrol abusers that persisted after one year of abstinence. While the focus of this research was petrol and alcohol abuse, cannabis use was also identified as an important predictor of specific psychological symptomatology including depression and anxiety, and is therefore important to consider in the context of polysubstance abuse for this population.

This research demonstrated that the assessment processes used were appropriate and practical for assessing cognitive and psychological functioning in a treatment setting and could prove to be invaluable tools to inform the treatment process. Chapters 9 and 11 showed that cognitive and psychological factors do have the potential to impact on treatment outcomes. In addition, environmental and substance use factors including the availability of substances, poly substance abuse and primary substance use severity, may also be important risk factors for relapse post-treatment. However, further research in a larger sample is required to confirm and explore these findings. Nevertheless, monitoring cognitive and psychological function during treatment is an important practice that may help to identify comorbidities, customise treatment programs by responding to the individual needs of the client, and to educate clients about the impact of their behaviour leading to reduced substance use following treatment.

12.2 IMPORTANCE OF FINDINGS, LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

12.2.1 Measuring Cognitive and Psychological Function Following Substance Abuse

Associations between substance abuse, mental illness, and cognitive impairment are well established for most substances, and suggest underlying CNS involvement (Yucel, et al., 2007). However, these conditions are often difficult to objectively detect and manage for Indigenous Australians. In order to accurately assess the success of treatment or other interventions, adequate techniques for monitoring

health improvements with abstinence are required. Some individuals have developed their own crude techniques for measuring recovery from petrol abuse. For example, one community elder would periodically call out to a recently abstinent petrol sniffer who was walking away and then count the number of steps taken before the ex-sniffer turned around or reacted (B. Abbott, personal communication, 7 January 2008). He recalled that some would initially take 36 steps before turning, but once they reacted straight away, he 'knew' they had returned to normal. While useful as a crude measure among severely impaired individuals, more sensitive measures may be required to detect the more subtle cognitive changes that are often associated with substance abuse. Among Western cultures, standardised psychological assessments have become important tools for diagnosing and understanding mental illness and cognitive functioning. They can provide objective measures of the CNS impacts of substance abuse and provide a scientific basis for treatment programs designed to minimise the impact of substance abuse. However, as Chapter 2 illustrated, despite the disproportionate levels of mental health problems for Indigenous Australians, there remained a scarcity of culturally appropriate assessments for measuring psychological and cognitive function in this population.

Because of variation due to language and culture, assessment tools developed in one culture can rarely be applied successfully in another culture without modification and evaluation. The current research selected and evaluated a cognitive and psychological assessment protocol developed specifically for detecting substance abuse related impairments and monitoring cognitive changes over time amongst Indigenous Australians. The cognitive (i.e. CogState) and psychological (i.e. Strong Souls) assessments selected were integrated in a computerised form making them

suitable for use in a variety of primary care settings (i.e. treatment, remote areas). The cognitive test battery demonstrated acceptable reliability and limited practice effects among Indigenous adolescents assessed longitudinally over two months (Chapter 3). While timed measures exhibited some practice effects, primarily from the first to the second assessment, the accuracy measures were generally stable across time. Although this finding may reflect differing concepts of time among Indigenous Australians compared to non-Indigenous Australians, it may also be a reflection of reduced familiarity with computers. Chapter 4 demonstrated that while the test was able to detect impairments related to the abuse of petrol and other solvents, the impact of age and computer familiarity do need to be considered when interpreting results. Together, these findings suggest that a dual baseline or practice test prior to the initial assessment should be conducted in order to familiarise participants with the format of the test and eliminate any practice effects.

The utility of the psychological assessment for detecting symptoms of depression or anxiety among substance users was also demonstrated. Interestingly, Chapter 5 suggested that cannabis use was the best predictor of these psychological symptoms, with fewer symptoms found in association with petrol or alcohol use. Although not identified as the primary substance of concern, the prevalence of cannabis use was high amongst the study cohort. These results indicate that symptoms of depression or anxiety may be common for individuals seeking treatment for substance abuse and demonstrated a need to screen for these symptoms on admission in order to provide more responsive and holistic primary care services.

This research is an important step toward the development of a national protocol that has scientific, medical and cultural validity for assessing cognitive and psychological function among Indigenous people however, there is much more work to be done.

The use of a case control design in the studies included in Part B of this thesis controlled for the impact of age, computer familiarity and practice on performance outcomes. However, in order to improve the clinical utility of the assessment protocol, a procedure for interpreting test scores with respect to appropriate normative data still needs to be established and the ability of a dual baseline to reduce the impact of practice and computer familiarity should also be assessed. In addition, the relationship between test scores and current diagnostic measures along with the underlying neuroanatomical correlates of identified cognitive impairments and recovery remains to be examined. While interpretation of the test scores may be relevant and meaningful to predominantly non-Indigenous health care professionals, the meaning and relevance of undertaking the test and attaining subsequent performance scores to those Indigenous people assessed, still needs to be explored. In addition, future research is required to investigate the generalisability of the tests for measuring cognitive and psychological function among other Indigenous groups in different regions or within different clinical subpopulations.

High rates of domestic violence, assault, trauma, poor nutrition, otitis media, foetal alcohol syndrome, mental illness, dementia and other chronic diseases also have the potential to bring about high rates of cognitive impairment among Indigenous Australians (Australian Bureau of Statistics, 2006a, 2008; Pollitt, 1997; Smith, et al., 2008). While the potential for these factors to impair cognition has been recognised, they have not been adequately explored and their impact is therefore poorly

understood and not yet quantifiable. Identifying the impact of these problems on communities and defining appropriate inclusion and exclusion criteria for healthy Indigenous control groups therefore pose significant challenges for researchers and the community. With the availability of appropriate cognitive assessments, knowledge and understanding may be enhanced, research methodologies improved, and appropriate health services may be developed and funded.

12.2.2 Monitoring Cognitive Changes Associated with Petrol and Alcohol Abuse

Until recently the neurological dysfunction associated with petrol abuse was thought to be permanent. Recent evidence suggested however that recovery of brain function was possible within two years of abstinence (Cairney, et al., 2004b, 2005). The studies presented here have furthered this understanding by documenting the specific time course for cognitive recovery immediately following cessation of abuse. Petrol sniffers were monitored over a two month treatment period and reassessed after approximately one year. While the petrol sniffers assessed in previous studies had used predominately leaded petrol, recent restrictions on the sale of leaded petrol along with fuel replacement strategies (i.e. AVGAS, and Opal fuel) in petrol sniffing affected regions of Australia meant that those in the current studies had abused primarily unleaded petrol (with a few abusing other solvents including paint and glue). In previous studies, the severity of neurological impairment was correlated with blood lead levels, and those who suffered lead encephalopathy also exhibited greater neurological dysfunction indicating that the tetraethyl lead in leaded petrol was a major contributing factor in the neurological consequences of petrol sniffing

(Cairney, et al., 2004a, 2005; Maruff, et al., 1998). However, despite using predominantly unleaded petrol, those examined here also showed significant cognitive impairments in visual motor, attention, learning, memory and executive functions, with cognitive recovery evident throughout the study period (Chapter 8). The majority of cognitive impairments had recovered quickly, within the first two months of abstinence. However, impairments in visual motor, memory and executive function speed persisted after 12 months of abstinence. It is difficult to compare the results of this and previous research directly due to differences in methodologies and sample characteristics. Therefore, this research was unable to determine whether the abuse of unleaded petrol and other solvents is associated with fewer or less severe neurological impairments compared to leaded petrol sniffing, or to determine the relative contribution of lead versus hydrocarbons to the severity of impairments. Nevertheless, this research demonstrates that significant impairment occurs in relation to unleaded petrol and other solvent abuse and that although recovery of many functions occurs rapidly, residual impairments may persist following years of abstinence.

Heavy alcohol use was associated with impairments in similar cognitive domains as occurred with petrol abuse, regardless of the pattern or frequency of misuse (see Chapter 10). Chronic and episodic alcohol users both exhibited impaired visual motor functions, learning, memory and executive functions that improved with abstinence. Only impairments in visual motor speed persisted post-treatment, and even these had recovered within one year. In contrast to the persistent cognitive deficits observed as a result of petrol abuse, the impairments observed among chronic and episodic alcohol users appeared to resolve more rapidly, with the

majority of recovery occurring within four weeks of treatment. Importantly, there was no difference between chronic and episodic users on any task at any time point, suggesting that heavy episodic alcohol use may be as damaging as chronic use.

The similarity in pharmacological and behavioural effects of using volatile solvents and other CNS depressants including alcohol, as shown here, has also been observed previously (E. B. Evans & Balster, 1991; Yucel, et al., 2007). The established profile of acute CNS depressant use, including biphasic effects on motor performance, anticonvulsant effects, disruption of operant behaviour, anti-anxiety effects, the production of tolerance and dependence, reinforcing and discriminative stimulus effects, and the ability to enhance the effects of concurrently administered depressant drugs, are common to both alcohol and solvents (E. B. Evans & Balster, 1991). However, the cellular bases for the pharmacological actions of solvents, including petrol, are not yet well understood.

A solvent induced cerebellar disease has been described that consists of an acute intoxication phase which resolves within weeks of abstinence and a chronic phase which may be more persistent (Lolin, 1989). Similarly, the literature suggests that rapid recovery from alcohol related cognitive impairments reflects resolution of the acute neurotoxic effects of alcohol, with persistence of a subacute organic brain syndrome that recovers more gradually (Grant, et al., 1984). While similar processes may underlie the recovery profiles for alcohol and petrol abusers, differences in the rates of metabolism and elimination of alcohol and petrol, or their lipid solubility, may account for the observed differences in the time course for cognitive recovery. For example, upon inhalation the hydrocarbon toluene binds to lipid rich tissues and

is slowly released back into the bloodstream (King, et al., 1981). The slow elimination of stored hydrocarbons from the CNS has been proposed to account for the gradual resolution of acute toxicity and absence of withdrawal symptoms among solvent abusers (Hormes, et al., 1986). Interestingly, Unger and colleagues hypothesised that the toluene partitioned into brain lipids may account for white matter abnormalities observed on magnetic resonance (MR) images from solvent abusers (Unger, et al., 1994). If this is the case, it seems plausible that progressive elimination of stored toluene following abstinence may correlate with the functional recovery observed among solvent abusers, and specific abnormalities on MR images may therefore also return to normal following detoxification. Determining such a relationship was beyond the scope of this research however, but certainly warrants future investigation.

The neuroanatomical correlates of cognitive dysfunction and recovery following petrol abuse have yet to be determined empirically. Cognitive assessments measure behaviours that are accepted surrogate markers of brain function. However, the most sophisticated, direct and precise measurements of brain function are obtained using brain imaging techniques (Cairney & Maruff, 2007a). The use of neuroimaging techniques to access specific neuroanatomical information may therefore strengthen the current research and improve understanding regarding the brain-behavioural relationships associated with petrol or alcohol abuse and recovery. By examining neuroimaging data alongside neuropsychological assessments, brain structural changes may be interpreted with respect to measured cognitive impairments. In addition, repeated assessments or cross sectional comparisons between current and

recovered users would provide an indication of the permanence of any neuroanatomical changes.

12.2.3 Factors Impacting on Treatment Outcomes

The studies presented in this thesis demonstrated that significant proportions of petrol and alcohol users attending treatment revert to using, or ‘relapse’, upon their release back into the community. Nevertheless, a small proportion of users were observed to change their substance use patterns post-treatment (i.e. to abstain or reduce their use). It was therefore pertinent to examine the specific factors contributing to post-treatment substance use patterns for this population. Zinberg (1984) argued that it is not possible to understand substance use, its effects and outcomes, without considering the interrelationships between the substance, the user, and the physical and social environments of use. Few studies have examined the impact of neuropsychosocial factors on continued substance use in this population (Coleman, et al., 2001). The few evaluations conducted on the success of alcohol treatment programs for Indigenous Australians have either been inconclusive or suggested only modest gains (Gray, Saggars, Sputore, & Bourbon, 2000). There have been a few reports on the successes of various outstation programs at combating petrol sniffing (MacLean & d'Abbs, 2002; Preuss & Brown, 2006), but the efficacy of more traditional urban based residential treatment programs have not been formally evaluated in the literature.

While the studies presented in Chapters 9 and 11 did not specifically evaluate the treatment programs themselves, they did identify important factors that could be

considered in designing appropriate treatment programs in the future or determining intervention policy in relation to substance abuse. For example, psychological symptoms, cognitive deficits, substance availability and substance use severity were all related to substance use patterns at follow up. This data provided support for current interventions including fuel replacement strategies and alcohol restrictions. While limited by small sample sizes, the findings of Chapters 9 and 11 also suggested areas for future research. Although cognitive impairment was associated with poorer outcomes (i.e. relapse) among alcohol users, no such relationship was identified among petrol sniffers. Future research could therefore investigate the impact of adapting treatment programs to accommodate identified impairments throughout the rehabilitation process.

Furthermore, the literature suggests that recovery associated with alcohol abuse can be both time and/or experience dependent (Forsberg & Goldman, 1987). Among mainstream alcohol use groups, cognitive rehabilitation strategies have proven effective in enhancing and accelerating recovery of cognitive function with subsequently improved treatment outcomes (Forsberg & Goldman, 1985, 1987; Roehrich & Goldman, 1993). The efficacy of cognitive rehabilitation strategies for improving recovery and subsequent treatment outcomes could therefore be investigated in this population for both alcohol and petrol abusers. Psychological problems were identified as a potential risk factor for relapse (Chapters 9 & 11). Research suggests that individuals with comorbid mental and substance use disorders have worse treatment outcomes than for either disorder alone (Kessler, et al., 1996). Future research should therefore investigate the impact of treating psychological symptoms during substance use treatment programs, as well as the impact of

providing ongoing post-discharge community based counselling for improving substance use behaviours and social and emotional wellbeing. These findings support increasing recognition in addiction medicine that substance dependence is a chronic relapsing brain disorder and that rehabilitation is a long term process, usually requiring multiple enrolments in residential rehabilitation programs (Leshner, 1997; Yucel, et al., 2007).

12.3 CONCLUSIONS

This research aimed to monitor the nature of cognitive and psychological impairment and subsequent recovery from petrol and alcohol abuse among Indigenous Australians, using an assessment process that was culturally appropriate for this population. The seven empirical studies reported in this thesis demonstrated the suitability and utility of the selected cognitive and psychological assessment protocol for detecting and monitoring cognitive and psychological changes associated with substance abuse among Indigenous Australians. They also confirmed that the chronic abuse of petrol is associated with significantly impaired brain function that begins to improve within just weeks of abstinence. The majority of identified impairments in attention, memory and learning had recovered within two months however residual impairments in visual motor, memory and executive function speed persisted even after one year of abstinence. Impairments comparable to those associated with chronic petrol abuse are also associated with heavy alcohol use. However, the alcohol related CNS effects appear to recover slightly faster than those associated with petrol abuse. The majority of alcohol related impairments resolved within four weeks of abstinence and residual impairments in visual motor speed

recovered within 11 months. Interestingly, episodic alcohol use resulted in a similar pattern of impairment and abstinence-related recovery compared to chronic alcohol use. This finding indicates that significant brain related changes also occur for episodic alcohol users and that these impairments, in conjunction with other psychosocial factors, do in fact impact on continued substance use post-treatment. The findings from this research have added important information regarding the specific impacts and recovery timeline immediately following abstinence from petrol and alcohol abuse to the previously limited knowledge regarding the cognitive and psychological effects of solvent and alcohol abuse among Indigenous Australians. With some further work, the cognitive and psychological assessment process utilised in this thesis may become a useful resource for detecting and managing impairments among Indigenous Australians from the Northern Territory in an education or primary care setting. Importantly, the results from the studies reported in Chapters 4, 8 and 9 have been used to help inform the development of the National Health and Medical Research Council's Volatile Substance Use Clinical Practice Guidelines.

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Appendix A

**A Summary of the Current Status of Each Article Followed By Published
Articles, Journal Acceptance Letters and Acknowledgement of Receipt Letters**

A Summary of the Current Status of Each Article

Chapter/ Article	Title	Authors	Status	Journal
2/1	Psychological and cognitive assessment of Indigenous Australians	Dingwall, KM Cairney, S	Published	Australian and New Zealand Journal of Psychiatry, 2010, 44(1), 20-30
3/2	Reliability of repeated cognitive assessment in healthy Indigenous Australian adolescents	Dingwall, KM Lewis, M Maruff, P Cairney, S	Published	Australian Psychologist, 2009, 44(1), 224-234
4/3	Assessing cognition following petrol sniffing for Indigenous Australians	Dingwall, KM Lewis, M Maruff, P Cairney, S	Published	Australian and New Zealand Journal of Psychiatry, 2010, 44(7), 631-639
5/4	Detecting psychological symptoms related to substance misuse among Indigenous Australians	Dingwall, KM Cairney, S.	Published	Drug and Alcohol Review, 2011, 30(1), 33-39.
6/5	Social, psychological, and physical impacts of petrol (gasoline) sniffing and other inhalant abuse for remote Indigenous communities.	Dingwall, KM Cairney, S.	Submitted	Australian Psychologist
6/6	The mysterious practice of petrol sniffing in isolated Indigenous groups.	Cairney, S Dingwall, KM	Published	Journal of Paediatrics and Child Health, 2010, 46(9): 510-515.
7/7	Recovery from central nervous system (CNS) changes following volatile solvent use (VSU)	Dingwall, KM Cairney, S	In Press	Substance Use and Misuse
8/8	Cognitive recovery during and after treatment for volatile solvent abuse.	Dingwall, KM Fredrickson, A Maruff, P Cairney, S	Submitted	Drug and Alcohol Dependence

9/9	Factors associated with continued solvent use in Indigenous petrol sniffers following treatment.	Dingwall, KM Maruff, P Clough, A Cairney, S	Published online ahead of print	Drug and Alcohol Review, available from: http://online.library.wiley.com/doi/10.1111/j.1465-3362.2010.00279.x/abstract
10/10	Similar profile of cognitive impairment and recovery for Aboriginal Australians in treatment for episodic or chronic alcohol use	Dingwall, KM Maruff, P Cairney, S	In Press	Addiction
11/11	Neuropsychological problems and alcohol availability key factors in continued heavy alcohol use for Aboriginal Australians	Dingwall, KM Maruff, P Cairney, S	Published	Medical Journal of Australia (Letter to the Editor), 2011, 194(1): 50-51.
1&12/12	The importance and challenges of assessing cognition in Indigenous Australians	Dingwall, KM Cairney, S.	Published	Australasian Psychiatry, 2009, 17(S1), S47-S50.

Appendix B

Follow Up Interview Questionnaire

Interview Schedule

Please answer the following questions about your substance use **since last test** (be as specific/detailed as possible):

Substance	Used since last test?	How often? e.g. Specific - 3 times a week or Only once or twice Few times each month? Few times each week? Everyday or most days?	When last used? (Date or no. of days ago)	How much usually? e.g. Specific -3cans/day or Little bit, not much, Fair bit big mob/heavy use
 Sniffing	Yes No			
 Alcohol (Grog)	Yes No			
 Cannabis (Gunja)	Yes No			
 Cigarettes	Yes No			
Kava	Yes No			
Other (list)	Yes No			
Other (list)	Yes No			

If you had been sniffing (RSV) (or drinking – RSA) can you tell me:

- Why did you sniff/drink?

- Bored
 Sad/to make me feel better
 Friend/family were doing it
 To forget
 ran out of other drug (grog, gunja etc)
 Other reason (specify) _____

- Did you sniff/drink with others or alone? others alone
- How did it feel? Good Bad other _____
- Any injuries/sickness from sniffing/drinking? no yes

If yes, can you tell us what it was? _____

- What did you think about sniffing/drinking before rehab and what do you think about sniffing/drinking now?

Before

- Like it/Still want to do it
 No good
 Other _____

Now

- Like it/Still want to do it
 No good
 Other _____

If you stopped for a period of time (e.g. went to CAAPS), can you tell me:

- When did you stop? _____

- Why did you stop?

- My own decision
- Family wanted me to
- Friends were stopping/wanted me to stop
- Health reasons
- Learnt more about what it does to me
- Community pressure
- For work/school
- Started using another drug instead
- Other: _____

- What was happening when you stopped?

- Health problems
- Child born
- Got married
- Community problems
- Intervention (e.g. Opal, treatment, alcohol restrictions etc)
- Trouble with law/police
- Other

- Did you stop with others or did you do it alone? Others Alone

- What do you think would have made it easier for you to stop? _____

- Do you have strong family to help you? Yes No

- Was it hard or easy to stop? Hard Easy

Why (what helped/didn't help you stop)? _____

- If you went to CAAPS, did you finish the program? Yes No

If not why not? _____

- When you were sniffing/drinking any problems with:
(i.e., did you have them and did they get better when you stopped?)

	Problems	better when stopped?
Thinking	<input type="checkbox"/>	<input type="checkbox"/>
Memory?	<input type="checkbox"/>	<input type="checkbox"/>
Walking?	<input type="checkbox"/>	<input type="checkbox"/>
Talking?	<input type="checkbox"/>	<input type="checkbox"/>
Working?	<input type="checkbox"/>	<input type="checkbox"/>
Playing sport?	<input type="checkbox"/>	<input type="checkbox"/>
Family?	<input type="checkbox"/>	<input type="checkbox"/>
Hunting?	<input type="checkbox"/>	<input type="checkbox"/>
Ceremony?	<input type="checkbox"/>	<input type="checkbox"/>

Can you tell me about your home life (*prompt storyline*):

- Who do you live with?

- Mum and Dad
- Partner/Husband/Wife
- Other family
- Friends
- Foster family

- How many people in the house with you? _____

- Do your family:

- Talk to you, tell you not to sniff/drink
- Help you eat good food
- Take you to CAAPS/DASA, clinic etc to stay healthy
- Take you hunting/fishing
- Take you to ceremony
- Sniff or drink or smoke too
- Pressure you to drink/sniff/smoke
- Help you stay healthy other ways? (specify) _____

- Married? Yes No

- Children? Yes No

If yes, How many? _____

- Where do you spend most of your time now? Town Community

- Have you spent long periods of time in town?

- Yes No

If yes, what for (school, work, family etc) _____

How long? _____

- Do you know lots about your culture?

- Lots Fair bit Little bit Not much

- Do you know much about whitefella ways?

- Lots Fair bit Little bit Not much

Tell me about what's been happening in your life since you were in rehab?

- Health? Good Some little problems Big problems

- Working/school? Yes, work Yes, school No, neither

- Home life? Good always Good sometimes

- Bad sometimes Bad always