Understanding the Relationship between Impulsivity and Cognitive Biases in the Treatment of Substance Misuse

by

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I am the author of the thesis entitled

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Abstract

Background: Impulsivity has been long-considered fundamental to the understanding of the development and maintenance of substance misuse. The factor of rash impulsivity in particular has been related to more severe and riskier substance misuse presentations and poorer treatment outcomes and retention rates. In this thesis it is argued that this may be due to the executive functioning deficits associated with heightened rash impulsivity. Thus, implicit cognitive biases may be particularly useful as treatment targets for these individuals. Based on a theoretical and empirical foundation, in this thesis it is argued that impulsivity and cognitive biases may be interactive variables affecting substance misuse behaviour. This thesis consists of two components. The first presents the findings of an original systematic review and meta-analysis of the relationship between impulsivity and substance-related cognitive biases which is published in the journal Drug and Alcohol Dependence. The second component presents the findings of the potential moderating role of impulsivity in an RCT of cognitive bias modification (CBM) for alcohol use disorder.

Method: 1) A systematic review and meta-analysis was conducted for existing literature examining a quantitative relationship between impulsivity and substance-related cognitive biases. A total of 19 studies (comprising 41 effect sizes) were identified and included in the analyses. Two-factor conceptualisation of impulsivity (reward sensitivity and rash impulsivity) and measurement type (trait and behavioural) were analysed as categorical moderators. Gender and age moderators were examined utilising meta-regression. 2) A second study utilising a randomised controlled trial (RCT)
design was conducted examining the efficacy of a CBM intervention for alcohol use disorder and the role of reward sensitivity and rash impulsivity in this intervention. Eighty-seven participants with alcohol use disorder received four sessions of CBM or sham training while undergoing inpatient detoxification. Hierarchical logistic regression and 2x3 mixed between-within ANOVA analyses were conducted.

Results: Results from the meta-analysis identified a significant weak positive relationship between impulsivity and cognitive biases. This relationship was found to be consistent across the two-factor conceptualisation of impulsivity, impulsivity measurement type, gender, and age. The review highlighted a dearth of research examining multiple cognitive biases simultaneously, however results overall support previous notions of interaction between impulsivity and cognitive biases in substance misuse. The RCT revealed that reward sensitivity and rash impulsivity did not act as moderators of CBM training efficacy, suggesting potential utility of CBM as an adjunct intervention for clinical presentations related to these factors when heightened. CBM was not found to reduce rash impulsivity levels, however rash impulsivity was interestingly found to significantly decrease following inpatient detoxification, suggesting viability of rash impulsivity as a malleable treatment target.

Conclusion: Combined, results from the studies conducted provide support for the notion that impulsivity and cognitive biases may be interactive variables that affect each other in the progression towards the development and maintenance of substance misuse behaviour. These findings are consistent with models of addiction such as incentive sensitisation theory.
and warrant further research. Clinically, findings from this thesis implicate heightened potential for improved treatment outcomes when integrating CBM-related interventions for the highly reward sensitive or rash impulsive substance misuser, particularly if conducted early in detoxification.
Introduction and Overview

Substance misuse represents a significant issue of concern in Australia and internationally. Data collected by the Australian Institute of Health and Welfare (AIHW, 2011) suggest that approximately 15% of Australians are daily tobacco smokers, 7% are daily users of alcohol, and 15% report recent illicit substance use. Additionally, increases in the use of recreational pharmaceuticals, cannabis, cocaine, and hallucinogens were noted between 2007 and 2010 (AIHW, 2011) and epidemiological studies suggest that Australians display higher rates of illicit substance dependence than comparable Westernised countries such as the United States (McBride et al., 2009). Across 2004/05, these issues have been estimated to cost Australians $55 billion (Collins & Lapsley, 2008). As a consequence, understanding substance misuse behaviour has garnered substantial interest in both research and clinical settings.

The construct of impulsivity is considered important in the development and maintenance of substance misuse (de Wit, 2009) and has been conceptualised in a number of theoretical models (e.g., Barratt, 1959, 1985; Cloninger, 1987; Eysenck & Eysenck, 1978; Gray, 1970; Zuckerman, 1978). Among them, a two-factor model of impulsivity, consisting of reward sensitivity and rash impulsivity has been posited to align closely with neurobiological models of addiction (Gullo, Loxton, & Dawe, 2014). It is argued in this thesis that the factor of rash impulsivity may be considered more pertinent to dependence and risky substance misuse behaviour such as polysubstance use. Further, rash impulsivity also negatively affects treatment outcomes and retention rates. It is proposed that this may be due...
to executive functioning deficits associated with heightened rash impulsivity, suggesting that complex, explicit interventions may be less effective in the rash impulsive individual. Thus, there is clear clinical utility in exploring interventions that may be beneficial for these individuals.

Following, a consideration of implicit processes – referred to in this thesis as cognitive biases – represent attractive treatment targets for those with heightened rash impulsivity. Cognitive biases are believed to occur automatically and outside conscious awareness, requiring limited cognitive resources (Stacy & Wiers, 2010). Indeed, the emerging branch of interventions termed Cognitive Bias Modification (CBM) have shown promising results in reducing substance misuse behaviour and improving treatment outcomes (e.g., Eberl et al., 2013; Schoenmakers et al., 2010). At present, the literature has not investigated the relationship between rash impulsivity and cognitive biases in the context of substance misuse. Examining this relationship may have implications for understanding how CBM acts to reduce substance misuse, and aid in characterising clinical presentations that may be best suited to benefit most from CBM.

Chapter One of this thesis begins by exploring the various models of impulsivity proposed in the literature, converging evidence for a two-factor model, and relationship with substance misuse. In Chapter Two, the role of each impulsivity factor in current substance misuse treatments is examined. Cognitive biases and CBM will then be discussed in Chapter Three, and limitations in understanding how these constructs relate to impulsivity are highlighted. Chapter Four presents the overarching aims, hypotheses, and rationale of the thesis and the studies conducted herein. Chapter Five
presents a systematic review and meta-analysis of previous literature examining the association between impulsivity and substance-related cognitive biases. In Chapter Six, an empirical investigation of the role of impulsivity is provided, specifically exploring the potential for rash impulsivity and reward sensitivity to moderate the efficacy of a cognitive bias modification intervention for alcohol use in an RCT design. Finally, findings from the above two studies are integrated in a general discussion in Chapter Seven. This chapter discusses how the present thesis contributes significantly to the literature and understanding of impulsivity and cognitive biases in substance misuse, as well as the clinical and research implications following from the results presented. Limitations and future research directions are also considered before concluding remarks are provided.
Chapter One

Impulsivity: Conceptualisation, Measurement, and Role in Substance Misuse

The psychological construct of impulsivity has been considered fundamental to understanding substance misuse (see Fillmore, 2003 for review). In basic terms, the *a priori* association suggests that individuals who are impulsive appear more likely to use substances and become dependent (Perry & Carroll, 2008). With increased attention and research however, this relationship has been revealed to be more complex. This chapter will begin by briefly reviewing impulsivity in terms of its definition and conceptualisation among various theoretical models. Following, evidence for a neurobiologically-based two-factor conceptualisation of impulsivity, as well as the measurement of these factors, will be discussed. These factors will then be considered in relation to their role in alcohol and other substance misuse. It will be argued that there is important clinical utility in examining interventions that are beneficial for the rash impulsive substance misuser.

1.1. Definition

Broadly, impulsivity may be defined as the tendency to rapidly engage in behaviours without forethought to the consequences of these actions (Evenden, 1999; Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). This definition is encompassing of a multitude of more specific characteristics such as poor preconception, rapid action, and decreased sensitivity to negative consequences (Evenden, 1999; Moeller et al., 2001). Though impulsivity has been argued to serve an adaptive purpose (e.g., Dickman, 1990; Gullo & Dawe, 2008), it is generally considered maladaptive, serving
dysfunctional or inappropriate behaviours such as aggression, violence, criminality, and self-harm (Dougherty et al., 2009; Gvion & Apter, 2011; Perroud, Baud, Mouthon, Cortet, & Malfosse, 2011; Zimmerman, 2010).

In psychopathology, the maladaptive nature of impulsivity is reflected in its position within many clinical disorders. In the DSM-5 (American Psychiatric Association [APA], 2013), impulsivity is noted as a diagnostic feature of attention deficit-hyperactivity disorder (ADHD), borderline and antisocial personality disorders, bipolar disorder, and binge-eating disorder. Additionally, as would be anticipated from the umbrella term “impulse-control disorders” used in the DSM-5, impulsivity constitutes a key criterion for these conditions, encompassing oppositional defiant disorder (ODD), intermittent explosive disorder, pyromania, and kleptomania (APA, 2013).

1.2. Models of Impulsivity

It is generally agreed that impulsivity constitutes a multifaceted construct (Gullo et al., 2014). The complexity of this conceptualisation is reflected among the various personality models in which aspects of impulsivity have been associated with. A complete historical commentary of these models is beyond the scope and focus of this thesis (see Evenden, 1999 for review). A selection of these models are briefly discussed here to elucidate the variety of conceptualisations of impulsivity that have been previously proposed.

Eysenck and Eysenck’s (1978) Psychoticism-Extraversion-Neuroticism (P-E-N) model of personality included impulsivity as a second-order factor of Extraversion. Later revisions of this model shifted impulsivity as a factor of Psychoticism (Eysenck, 1992) though importantly, within this
paradigm, impulsivity is considered a unitary construct reflecting rash action and inadequate preconception (Dawe & Loxton, 2004; Eysenck & Eysenck, 1978). This conceptualisation has given way to the development of Eysenck’s Impulsiveness Scale (Eysenck, Pearson, Easting, & Allsopp, 1985), currently used widely in the empirical literature (Reynolds, Ortengren, Richards, & de Wit, 2006).

In contrast to a unitary conceptualisation, Cloninger’s (1987) biosocial model of personality encompasses impulsivity characteristics across three domains: novelty seeking, harm avoidance, and reward dependence. Notably, characteristics of novelty seeking in particular, which include acting on whims and difficulty delaying gratification, share many conceptual similarities with Eysenck’s model of impulsivity. The assessment of Cloninger’s dimensions has been measured by the Tridimensional Personality Questionnaire (TPQ; Cloninger, Przybeck, & Svrakic, 1991) and more recently, by the Temperament and Character Inventory (TPI; Cloninger, Svrakic, & Przybeck, 1993).

Further conceptual similarities of impulsivity are observed in models proposed by Zuckerman (1978) and Barratt (1959). Zuckerman proposed an alternative five-factor model of personality guided in the assumption that personality traits are biologically-based (Zuckerman, 1991). In this model, the factor of sensation seeking, now measured by the Sensation Seeking Scale (SSS; Zuckerman, Eysenck, & Eysenck, 1978), was suggestive of an individual who is rash in their actions without considered forethought and seeks novel and exciting stimuli irrespective of risk (Zuckerman et al., 1978). Barratt (1959, 1985) instead characterised impulsivity across three sub-trait:
cognitive impulsiveness, involving rapid decision-making, motor impulsiveness, involving acting rashly, and non-planning impulsiveness, involving inadequate forethought (Stanford et al., 2009). Currently the Barratt Impulsivity Scale (BIS-11; Patton, Stanford, & Barratt, 1995) assesses impulsivity across these dimensions and is widely used in the empirical literature (Stanford et al., 2009).

Divergent to these conceptualisations, Gray’s (1970) Reinforcement Sensitivity Theory (RST) proposed two components to personality: impulsivity and anxiety. In this model, impulsivity was characterised by an individual’s sensitivity to rewarding environmental stimuli; anxiety, in contrast, regarded an individual’s sensitivity to punishment (Dawe & Loxton, 2004; Gray, 1970). Two neurobiological pathways were proposed to underlie these facets: the Behavioural Activation System (BAS) and the Behavioural Inhibition System (BIS) respectively (Gray, 1970). In this model, impulsivity’s neural pathway (BAS) is believed to involve the mesolimbic dopaminergic pathways – brain regions involved in ascribing rewarding properties to stimuli and behaviour (Dawe & Loxton, 2004). This framework has provided the basis for the BIS/BAS scales (Carver & White, 1994) and the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia, Avila, Molto, & Caseras, 2001).

The UPPS-P model of impulsivity (Cyders et al., 2007; Whiteside & Lynam, 2001) proposes a five-factor structure of impulsivity. These comprise: negative urgency, positive urgency, (lack of) premeditation, (lack of) perseverance, and sensation-seeking. While negative and positive urgency relate to impulsive tendencies in response to heightened negative
and positive emotion respectively, perseverance refers to the ability to stay focused on an activity that is repetitive or uninteresting. Premeditation concerns an individual’s capacity to consider the consequences of behaviour and sensation-seeking indexes an individual’s motivation to seek novel and rewarding experiences.

1.3. Impulsivity as a Two-Factor Construct and Measurement

Despite varied theoretical models of impulsivity, in the study of substance misuse, a two-factor model of impulsivity has been suggested to closely align with neurobiological models of addiction (see Gullo et al., 2014 for review) and provide a more parsimonious model of impulsivity in substance misuse research (Stautz, Dinc, & Cooper, 2017). As reviewed by Dawe and Loxton (2004), factor analytic studies have provided consistent evidence to indicate that various measures of impulsivity load primarily on two related, but distinct factors (see Table 1.1. for an overview of these analyses).
Table 1.1.  
Overview of Factor Analytic Study Findings Loading on Two Factors of Impulsivity and Examples of Related Behavioural Measures

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<th>Factor</th>
<th>Self-report measures</th>
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<td><strong>Reward sensitivity</strong></td>
<td>BAS-Drive scale&lt;sup&gt;a,b,c,d,e&lt;/sup&gt; (Carver &amp; White, 1994)</td>
<td>Delay Discounting Task (DDT; Kirby, Petry, &amp; Bickel, 1999)</td>
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<td></td>
<td>BAS-Reward Responsiveness scale&lt;sup&gt;a,b,c,d,e&lt;/sup&gt; (Carver &amp; White, 1994)</td>
<td>Experiential Discounting Task (EDT; Reynolds &amp; Schifbauer, 2004)</td>
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<tr>
<td></td>
<td>Sensitivity to Reward scale&lt;sup&gt;b,d,e&lt;/sup&gt; (SR; Torrubia et al., 2001)</td>
<td>CARROT (Powell, Al-Adawi, Morgan, &amp; Greenwood, 1996)</td>
</tr>
<tr>
<td><strong>Rash impulsivity</strong></td>
<td>I&lt;sub&gt;7&lt;/sub&gt;&lt;sup&gt;a,b,c,e&lt;/sup&gt; (Eysenck et al., 1985)</td>
<td>Go/No-go task</td>
</tr>
<tr>
<td></td>
<td>Novelty Seeking scale&lt;sup&gt;a,b,e&lt;/sup&gt; (NS; Cloninger et al., 1993)</td>
<td>Stop Signal Task (SST; Logan, Schachar, &amp; Tannock, 1997)</td>
</tr>
<tr>
<td></td>
<td>Sensation Seeking Scale&lt;sup&gt;d&lt;/sup&gt; (SSS; Zuckerman et al., 1978)</td>
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<tr>
<td></td>
<td>BIS-11&lt;sup&gt;c,d&lt;/sup&gt; (Patton et al., 1985)</td>
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<sup>a</sup> Zelenski & Larsen, 1999  
<sup>b</sup> Caseras, Avila, & Torrubia, 2003  
<sup>c</sup> Miller, Joseph, & Tudway, 2004  
<sup>d</sup> Quilty & Oakman, 2004  
<sup>e</sup> Franken & Muris, 2006a

Dawe and Loxton (2004) report that scales such as the BAS-Drive, BAS-Reward Responsiveness, and the SR scale of the SPSRQ appear to load on a single domain. When inspecting items on these scales, it is apparent that
they appear to tap aspects of an individual’s responsiveness to rewarding stimuli. For example, in these measures, individuals are asked to respond to items such as “If I see a chance to get something I want, I move on it right away” as on the BAS-Drive scale, and “Are you interested in money to the point of being able to do risky jobs?” as on the SR scale. Common across these items, there is a consideration of an individual’s propensity to be sensitive to, and motivated by, rewarding stimuli.

This domain has been termed by Dawe and Loxton (2004) as reward sensitivity and is believed to be conceptually similar to the BAS system proposed in Gray’s RST model of personality (Dawe & Loxton, 2004; Gullo & Dawe, 2008). As such, reward sensitivity is believed to be related to the same neurobiological motivation system as the BAS, particularly in the functioning of the mesolimbic dopaminergic system and areas such as the ventral tegmental area and the nucleus accumbens (Gullo & Dawe, 2008). Indeed, these areas have been shown to play important roles in incentive motivation (Koob & Volkow, 2010; Robinson & Berridge, 2008) and the learning processes involved in attributing salience to rewarding stimuli (Hyman, 2005). In support of this relationship, measures of reward sensitivity such as the SR have been associated with increased activation among these pathways (e.g., Costumero et al., 2013; Hahn et al., 2009).

In contrast to reward sensitivity, impulsivity as conceptualised by Eysenck’s I7 scale, Cloninger’s Novelty Seeking scale (NS), and Zuckerman’s Sensation Seeking Scale (SSS) appear to load on a separate factor (Dawe & Loxton, 2004). As described earlier, these approaches to impulsivity have common thematic elements related to approach-oriented, risk-taking
behaviour and an inadequate consideration of consequences (Gullo, Ward, Dawe, Powell, & Jackson, 2011a). Among these measures, individuals are asked to respond to items such as “I do things without thinking” (I-7), “I often act on hunches, momentary whims, or by intuition without making a detailed analysis of facts” (NS), and “I would like to take off on a trip with no preplanned or definite routes, or timetable” (SSS). The domain to which these measures have loaded has been termed rash impulsivity (Dawe & Loxton, 2004), which refers to the inability to inhibit prepotent approach tendencies, and to act rashly without forethought to negative consequences.

Consistent with this definition, rash impulsivity is believed to be involved in areas associated with the prefrontal cortex (Gullo, Dawe, & McHugh, 2011b). These areas are believed to mediate inhibitory control (see Bechara, 2005 for review). Supportive of this association, a number of studies have shown a relationship between measures of rash impulsivity and functioning in areas such as the orbitofrontal (Lyvers, Duff, Basch, & Edwards, 2012) and dorsolateral prefrontal cortices (DLPFC; Boy et al., 2011; Lyvers et al., 2012). Structural abnormalities in these areas have also been implicated in individuals with higher levels of rash impulsive tendencies (e.g., Boes et al., 2009; Matsuo et al., 2009), particularly in those who engage in substance misuse even when compared to biological siblings (Ersche, Turton, Pradhan, Bullmore, & Robbins, 2010).

Notably, behavioural measures of impulsivity – which typically use computerised neurocognitive tasks in contrast to self-report questionnaires – have further been delineated according to the two-factor model (see Table 1.1. for examples). For example, delay discounting paradigms such as the
Delay Discounting Task (DDT; Kirby et al., 1999) and the Experiential Discounting Task (EDT; Reynolds & Schiffbauer, 2004) index an individual’s preference for smaller, immediate rewards (e.g., $50 now) relative to larger, delayed rewards (e.g., $100 in 2 months). When delayed rewards are devalued steeply relative to immediate rewards, the individual may be considered more sensitive to the incentive properties of rewarding stimuli (i.e., heightened reward sensitivity; Stephens et al., 2010). Similarly, the Card Arranging Reward Responsiveness Objective Test (CARROT; Powell et al., 1996) assesses increases in performance on a simple card-sorting task when financially rewarded. Greater gains in performance suggest an increased sensitivity to the motivational properties of rewards and, consistent with this, has been found to correlate significantly with self-reported reward sensitivity (Kambouropoulos & Staiger, 2004).

Behavioural disinhibition measures such as the Go/No-go task and Stop Signal task (SST; Logan et al., 1997) have been suggested to tap rash impulsive tendencies (Gullo & Dawe, 2008). In these tasks, individuals are required to make quick, accurate responses to visually presented “Go”-signals and inhibit responses to occasional presentations of “Stop”-signals. Reliable presentation of Go-signals produces a prepotent response pattern which must be inhibited in order to accurately withhold responses to Stop-signals. As such, these measures are believed to reflect an individual’s inhibitory capacities – a distinct feature of rash impulsivity (Dawe et al., 2007).
1.4. Reward Sensitivity and Substance Misuse

There is strong and consistent evidence that has linked reward sensitivity with substance misuse. Cross-sectional studies have shown heightened reward sensitivity scores across alcohol- (Franken, Muris, & Georgieva, 2006), ecstasy- (Egan, Kamboroupoulos, & Staiger, 2010), cocaine- (Franken et al., 2006), and heroin-users (Dissabandara et al., 2014; Franken et al., 2006). Further, a number of studies have shown that reward sensitivity is predictive of hazardous drinking across age groups (e.g., Franken & Muris, 2006b; Gullo, Jackson, & Dawe, 2010; O’Connor & Colder, 2005). These findings have also been observed using behavioural measures of reward sensitivity. For example, in MacKillop et al.’s (2011) meta-analysis of 46 studies (total N = 56,013), greater delay discounting rates were consistently observed in substance misusing individuals and was particularly greater in clinical samples meeting criteria for a substance use disorder.

Notably, there is emerging evidence that in substance misuse, reward sensitivity plays a key role in early experimentation and initiation. This notion was purported by Dawe and Loxton (2004) based in part on the neurobiological “reward pathways” that reward sensitivity is presumed to be related. It is suggested that the appeal of substance use experimentation is heightened in individuals with strong reward sensitivity traits. This is due to an amplified receptiveness to the positive reinforcement provided by substances of abuse (Dawe, Gullo, & Loxton, 2004). Once the substance is administered, the reward sensitive individual is posited to also experience a heightened responsivity to the reinforcing properties of these substances, increasing incentive salience towards these cues (Robinson & Berridge,
The transition from initiation to dependence is suggested to be moderated by the ability to inhibit behaviour once an approach response is initiated (i.e., rash impulsivity; Gullo & Dawe, 2008) and this will be discussed in the next section.

In support of these ideas, Dissabandara et al. (2014) examined reward sensitivity and rash impulsivity among 93 heroin-dependent individuals and 232 controls. Earlier age of onset, suggesting heightened motivation towards substance use experimentation, was found to be related to reward sensitivity but not with rash impulsivity. These results are consistent with previous reports by Pardo, Aguilar, Molneuvo, and Torrubia (2007) and Lyvers, Czerczyk, Follent, and Lodge (2009). In these studies, higher levels of reward sensitivity were related to earlier age of alcohol consumption. Related, Kambouropoulos and Staiger (2004) found that reward sensitivity was positively correlated with alcohol cue-elicited urges to drink, suggesting that early initiation of substance misuse is related to heightened incentive motivation.

1.5. Rash Impulsivity and Substance Misuse

Like reward sensitivity, there is consistent evidence suggesting rash impulsivity is important in substance misuse. Rash impulsivity has been found to be heightened in adolescents and adults with increased alcohol consumption or alcohol problems on measures such as the I7 (MacKillop, Matson, MacKillop, Castelda, & Donovick, 2007) and BIS-11 (Lawrence, Luty, Bogdan, Sahakian, & Clark, 2009; von Diemen, Bassani, Fuchs, Szobot, & Pechansky, 2008). Behavioural measures of rash impulsivity have also been found to be heightened in substance-using populations. For example, a
number of studies have shown that alcohol, cocaine, opiate, and nicotine use is associated with increased errors on the Go/No-go tasks (Ahmadi et al., 2013; Forman et al., 2004; Kamarajan et al., 2005; Pike, Stoops, Fillmore, & Rush, 2013) and Stop Signal tasks (Billieux et al., 2010; Li, Luo, Yan, Bergquist, & Sinha, 2009) suggesting impaired inhibitory capacities within these individuals.

In comparison to reward sensitivity, there is emerging evidence to indicate that rash impulsivity may be more critical in dependence and risky substance misuse behaviour. As described by Dawe et al. (2004), it is proposed that once reward sensitivity mechanisms mediate initiation of substance use, persistence of use is facilitated by heightened rash impulsiveness due to an inability to inhibit approach behaviour. In other words, rash impulsivity is believed to be linked to more severe and risky substance misuse problems, and specifically, to the transition to dependence.

A number of animal studies have provided preliminary evidence of this (see Dalley, Everitt, & Robbins, 2011 for review). In one example conducted by Belin, Mar, Dalley, Robbins, and Everitt (2008), rats identified to be high or low in rash impulsivity were compared to rats identified to be high or low in reward sensitivity. As expected, heightened reward sensitivity was related to an increased propensity to acquire cocaine self-administration – an indicator to the role reward sensitivity plays in initiation. Heightened rash impulsivity, however, was found to predict the transition to compulsive cocaine administration.

Indeed, Gullo, Ward, Powell, and Jackson (2011a) employed structural equation modelling to compare the utility of one- or two-factor
conceptualisations of impulsivity in the prediction of problematic substance use. As anticipated, a two-factor model was found to provide the best predictive fit of alcohol and drug use. Importantly however, rash impulsivity was found to be a more robust predictor of problematic substance misuse than reward sensitivity. These results are supported by Loxton et al. (2008) who examined “club drug” use (e.g., ketamine, ecstasy, and cannabis) among a Hong Kong-Chinese sample. Rash impulsivity was significantly associated with more risky and problematic substance misuse such as polysubstance use. Similarly, in heroin dependent individuals, Dissabandara et al. (2014) found that rash impulsivity was related to higher daily consumption of heroin, lower treatment-seeking behaviour, hazardous drinking, and intravenous route of administration. Such findings parallel that reported by Goodwin, Browne, Rockloff, and Loxton (2016), who found that rash impulsivity was predictive of activities and substances noted to be intensely rewarding and potentially illicit or restricted (e.g., alcohol, drugs, gambling) when compared to reward sensitivity.

Supporting this notion, rash impulsivity has been linked to the severity of substance misuse problems. For example, rash impulsivity as measured by the BIS-11, has been positively related to the Alcohol Use Disorders Identification Test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001), a measure indicative of problematic alcohol use (Marshall-Berenz, Vujanovic, & MacPherson, 2011). Additionally, Dom, Hulstijn, and Sabbe (2006) reported significantly higher rash impulsivity scores as indexed by the BIS-11 and SSS in early-onset alcoholics than late-onset alcoholics. Importantly, early-onset alcoholics were described to have more
severe problems across health, legal, social, and psychiatric domains suggesting a link between rash impulsivity and more problematic substance misuse.

Measures of rash impulsivity have also been shown to be particularly heightened among polysubstance users. Martinotti et al. (2009) assessed 752 individuals with substance dependence and compared polysubstance users with monosubstance users. They found that polysubstance users displayed significantly higher rash impulsivity scores, measured by the BIS-11, than monosubstance users. Similar results have been reported by Conway et al. (2003) and Lackner, Unterrainer, and Neubauer (2013) who reported heightened rash impulsivity (measured by the NS scale and SSS respectively) among individuals with two or more substances of dependence than those with one substance of dependence.

As Staiger, Kambouropoulos, and Dawe (2007) suggest, taken in sum these findings point towards the utility in examining interventions that are matched towards impulsivity-related dimensions in order to increase the potential benefits of these treatment programs. With regard to rash impulsivity, this may have important clinical benefits for more severe substance dependent individuals and riskier substance misuse behavior presentations. As will be discussed in the following chapter, rash impulsivity additionally negatively impacts upon treatment outcome and retention rates. Thus, examining interventions that may benefit these individuals has important clinical implications.
1.6. Summary

Impulsivity has been conceptualised in a number of theoretical models. Previous research has indicated that conceiving impulsivity as a two-factor construct aligns closely with neurobiological models of addiction (Gullo et al., 2014). Factor analytic and principal component studies of impulsivity measures have provided consistent evidence to show that various impulsivity measures load either on a dimension related to the drive and sensitivity to rewarding stimuli – *reward sensitivity* – or the inability to inhibit responses and tendency to act without deliberation – *rash impulsivity* (Dawe & Loxton, 2004). This chapter has argued that while both factors have provided unique insights into substance misuse behaviour, rash impulsivity may be regarded as more pertinent to problematic substance misuse and ongoing dependence. Thus, interventions that are particularly beneficial among rash impulsive substance misusers has important clinical utility and may be particularly useful in riskier substance misuse presentations. The following chapter will examine the role of reward sensitivity and rash impulsivity in substance misuse treatments and highlight the possible reason for this association.
Chapter Two

The Role of Impulsivity in Substance Misuse Treatment

In the previous chapter, it was argued that rash impulsivity relates to more severe substance misuse presentations, polysubstance use, and riskier forms of substance misuse behaviour, whilst reward sensitivity is associated with earlier experimentation and initiation of substance misuse. This chapter reviews the literature which reports on how individuals who are high in rash impulsivity and reward sensitivity respond to substance misuse treatments. It will be argued that while both factors have been implicated as important variables predictive of treatment response, a more developed evidence base exists to suggest that rash impulsivity is associated with poorer treatment outcomes and retention rates. This chapter will then explore the potential neurobiological pathways associated with rash impulsivity, inclusive of the orbitofrontal and dorsolateral prefrontal cortices (Boy et al., 2011; Ersche et al., 2010; Lyvers et al., 2012). Potential deficits in executive functioning processes related to these areas are then explored as a potential explanatory mechanism for rash impulsivity’s negative impact on substance misuse treatment response, suggesting that complex, explicit interventions may be inadequate for these individuals.

2.1. Reward Sensitivity in Substance Misuse Treatment

As previously outlined, reward sensitivity concerns an individual’s tendency to be sensitive to, and motivated by, rewarding stimuli (Dawe & Loxton, 2004; Gullo & Dawe, 2008). Though preliminary, there is some evidence to indicate that elevated reward sensitivity may negatively impact upon substance misuse treatment outcomes. Jia et al. (2011) examined the
neural responses of 20 cocaine dependent patients and 20 healthy controls while completing a monetary incentive delay task (see Andrews et al., 2011 for protocol description). Their findings indicated that decreased activity in reward sensitivity-related neural pathways (e.g., ventral striatum and thalamus) was associated with increased rates of abstinence during treatment. Conversely, increased activations among these pathways were negatively associated with percent cocaine-negative urine toxicology results. In other words, greater activation among reward sensitivity-pathways were associated with poorer treatment outcomes; decreased activation among reward sensitivity-pathways were associated with better treatment outcomes. Consistent with these findings, Stanger et al. (2012) examined the role of a delay discounting task for 165 adolescents enrolled for cannabis misuse treatment. Their results indicated that greater delay discounting rates (i.e., greater reward sensitivity) was predictive of negative treatment outcomes. Similar results have been reported for cigarette smokers (Yoon et al., 2007) and cocaine users (Washio et al., 2011). Taken in sum, these research findings point towards a negative impact of heightened reward sensitivity in substance misuse treatments, though due to the relatively few studies that have examined this association, further research is still required to more comprehensively understand this relationship.

2.2. Rash Impulsivity in Substance Misuse Treatment

Relative to reward sensitivity, a more extensive number of research studies have indicated rash impulsivity as an important variable affecting substance misuse treatment outcomes and retention rates (Staiger, Dawe, Richardson, Hall, & Kambouropoulos, 2014). In three separate studies, rash
impulsivity was found to predict treatment attrition among substance dependent patients (Helmus, Downey, Arfken, Hederson, & Schuster, 2001; Kravitz, Fawcett, McGuire, Kravitz, & Whitney, 1999; Roll, Saules, Chudzynski, & Sodano, 2004). Similarly, among cocaine users, the BIS-11 and the SSS has been shown to be associated with significantly shorter stays in treatment (Moeller et al., 2001; Patkar et al., 2004) and increased relapse (Patkar et al., 2004). Consistent findings were recently reported by Staiger et al. (2014) with regard to the I7 among illicit substance-dependent inpatients. These studies were summarised by Loree, Lundahl, and Ledgerwood (2014) who concluded, in their systematic review, that impulsivity is a key predictor of poorer substance misuse treatment outcomes.

Rash impulsivity also appear to negatively impact upon response to traditional psychosocial treatments for substance misuse. For example, Cognitive Behaviour Therapy (CBT) techniques are designed to teach strategies to manage substance misuse behaviour and to identify and challenge maladaptive thinking patterns (McHugh, Hearon, & Otto, 2010). There is strong and clear evidence that CBT is beneficial in treating alcohol and substance misuse (see Magill & Ray, 2009 for meta-analysis). Indeed, as CBT typically involves recognising and avoiding triggers of substance misuse utilising approaches to control cravings and more general problem solving skills, these strategies have been argued to translate to increased self-control (Enticott & Ogloff, 2006; Leeman et al., 2014; Sofuoglu, DeVito, Waters, & Carroll, 2013).

While few studies have examined the role of rash impulsivity in a CBT-based substance misuse intervention directly, indirectly there are
several lines of evidence to suggest that CBT may be less effective for individuals who are rash impulsive. For instance, Bell and Newns (2002) examined the efficacy of CBT for “multi-impulsive bulimic patients” in comparison to non-multi-impulsive bulimic patients. Importantly, multi-impulsive bulimia is defined by behaviours such as hazardous alcohol misuse, illicit drug use, history of overdose, risky sexual behaviour, and shoplifting – risky, disinhibited behaviours characteristic of rash impulsive tendencies. Notably, multi-impulsive bulimia is also associated with higher drop-out rates and poorer treatment outcomes (Myers et al., 2006), again signposting rash impulsivity’s relevance in this clinical population. More specifically, the authors noted that while supervised self-help CBT significantly reduced non-impulsive patient bulimic symptoms, the multi-impulsive group remained moderately to severely symptomatic.

Mindfulness strategies are also often employed in the treatment of substance misuse (e.g., Mindfulness-based relapse prevention; Witkiewitz, Marlatt, & Walker, 2005). In this approach, mindfulness techniques help an individual to develop a decentered, non-judgmental relationship with thoughts and emotions in order to deescalate automatic patterns of thinking that may trigger substance misuse and relapse (Bowen et al., 2009). Combined with increased awareness and emotional tolerance towards these thoughts and emotions, mindfulness approaches may also help in minimising negative thinking patterns (e.g., self-blame) that may increase risk for substance misuse episodes (Bowen et al., 2009; Witkiewitz & Bowen, 2010).

Despite growing evidence to support the effectiveness of mindfulness-based interventions for substance misuse (see Chiesa & Serretti, 2014 for
systematic review), there is evidence to indicate that individuals with heightened rash impulsivity may find these treatments less effective. Vinci et al. (2016) compared the relationships between rash impulsivity and negative affect, positive affect, and urge to drink across three interventions (mindfulness, relaxation, and control) for college student drinkers. Their results indicated that relative to participants who completed a relaxation intervention and controls, among those who completed a mindfulness intervention, baseline rash impulsivity (indexed by positive and negative urgency) was related to increased negative affect, increased urge to drink, and decreased positive affect. Similarly, Staiger et al. (2014) examined the association between a mindfulness-related intervention and self-reported rash impulsivity (as measured by the I7) among 144 illicit substance-dependent inpatients. It was reported that while increases in mindfulness skills were associated with decreased drug severity at three-month follow up, rash impulsivity continued to have a negative relationship with treatment outcome. Overall, these findings are suggestive of a negative effect of heightened levels of rash impulsivity on substance misuse treatment outcomes. Therefore, highly rash impulsive substance misusers not only characterise a subset of the clinical population at greater risk for greater substance misuse problems, but also for poorer treatment response and retention, signposting distinct utility in examining interventions that may be particularly effective for these individuals.
2.2.1. Interventions for the Rash Impulsive Substance Misuser: An Issue of Complexity?

As discussed, an individual’s response to typical treatment approaches for substance misuse is negatively affected by heightened rash impulsivity. One possible explanation for this relationship regards the relative complexity of approaches such as CBT and mindfulness/acceptance approaches. As Sofuoglu et al. (2013, p.458) notes, interventions such as CBT require “learning, practicing, and implementation of new cognitive skills [that are] complex” and necessitates that patients are “able to attend to and understand therapist instructions, then remember and execute these new skills in difficult situations”.

Complex interventions requiring sustained attention may not be the most effective approach for an individual high in impulsive tendencies (Tomko, Bountress, & Gray, 2016). As discussed in the previous chapter, rash impulsivity is believed to be related to the functioning of areas in the prefrontal cortex (Gullo et al., 2011b). Specifically, the orbitofrontal and dorsolateral prefrontal cortices have been implicated (e.g., Boy et al., 2011; Brevet-Aeby, Brunelin, Iceta, Padovan, & Poulet, 2016; Ersche et al., 2010; Lyvers et al., 2012). Importantly however, these areas are not only believed to mediate inhibitory control, they are also believed to be heavily involved in extended areas of executive functioning. For example, the DLPFC has been noted as an integral structure related to working memory operations (Daskalakis et al., 2008), attention (Katskuki & Constantinidis, 2012), and planning (Kaller, Rahm, Spreer, Weiller, & Unterrainer, 2011). Similarly, the orbitofrontal cortex is believed to have an important role in adaptive
learning – the ability to shift behaviour according to new contingencies (Schoenbaum, Roesch, & Stalnaker, 2006; Schoenbaum, Roesch, Stalnaker, & Takahashi, 2009). Arguably, adaptive learning may be a critical component to the successful implementation of new cognitive thinking strategies, as would be demanded by mindfulness/acceptance and CBT interventions.

Indeed, there is evidence to support these assertions. Activity in the DLPFC has been shown to be predictive of responsiveness to CBT in patients with schizophrenia (Kumari et al., 2009). Similarly, poorer executive functioning has been associated with poor responsiveness to CBT treatment in adults with anxiety (Mohlman & Gorman, 2005) and depression (Julian & Mohr, 2006). A recent study conducted by Kiluk, Nich, and Carroll (2010) found that the acquisition of coping skills (i.e., strategies to minimise possibility of substance misuse in identified risky situations) in a computerised CBT program for substance misuse was negatively related to components of rash impulsivity (measured by the BIS-11).

It is argued that these findings suggest that traditional interventions for substance misuse may be excessively reliant on cognitive processes which may be poorer in the rash impulsive individual. Thus, there is a strong precedent to examine processes which are less dependent on explicit cognitive operations and sustained attention.

The emerging literature in implicit cognitive interventions for substance misuse that target cognitive motivational processes that are automatic, effortless, and occur outside conscious awareness (Wiers et al., 2007) may have important clinical utility. Due to their automatism, implicit processes and the interventions used to modify them, require limited
cognitive resources (De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009; Gawronsky, Hofmann, & Wilbur, 2006). Therefore, in the rash impulsive individual, these processes may serve as more suitable targets of intervention. At present however, research examining the relationship between rash impulsivity and these interventions, particularly in the context of substance misuse, remain in their infancy.

2.3. Summary

Preliminary evidence suggests that reward sensitivity is associated with poorer substance misuse treatment outcomes, however further research in this area is required. In contrast, there is strong and consistent evidence to indicate that heightened rash impulsivity also relates to poorer outcomes and retention rates. This chapter has argued that this may be due to the executive functioning deficits associated with rash impulsivity, suggesting that complex, explicit interventions may be limited in their efficacy for the rash impulsive individual. As such, a consideration of implicit processes, which do not require extensive cognitive resources, have potential to be important areas of treatment for these individuals. The next chapter will review the emerging literature concerning implicit processes in substance misuse (termed cognitive biases), related interventions (i.e., Cognitive Bias Modification), and highlight current limitations in understanding how these processes relate to impulsivity.
Chapter Three

Cognitive Biases and Relationship with Impulsivity

In substance misuse research, increasing attention has been paid to the area of implicit cognitive processes (e.g., Peeters et al., 2013; Thush & Wiers, 2007; Wiers et al., 2007). These processes are believed to be revealed on tests that do not require conscious deliberation and instead operate automatically and spontaneously (Stacy & Wiers, 2010). Consistent with emerging interventions aimed at modifying these processes that have been termed Cognitive Bias Modification (CBM; MacLeod, 2012), this thesis will refer to implicit cognitive processes as cognitive biases. This chapter will begin by discussing the definition of cognitive biases in substance misuse and their measurement. Following, CBM interventions that have been applied to substance misuse will be examined. Lastly, cognitive biases’ relationship with impulsivity will be discussed. In this chapter it will be argued that there is a strong theoretical foundation and preliminary evidence to indicate that impulsivity and cognitive biases are interrelated processes. Current limitations in the present understanding of this relationship will be highlighted, and clinical implications of this interaction are discussed.

3.1. Definition and Measurement

At present, a widely agreed-upon operationalised definition of cognitive biases has evaded the literature. Despite this, cognitive biases are generally considered to operate automatically, and without need for conscious reflection, deliberation, or awareness (Stacy & Wiers, 2010). Further characteristics may include independence from goal-direction and intentionality, and observation even under substantive time constraints or
cognitive load (De Houwer et al., 2009). Cognitive biases, therefore, may be characteristic of any or all these components (Stacy & Wiers, 2010).

Measurement tools used to assess cognitive biases share the key feature of indirect assessment. In other words, these measures do not ask participants to directly report on the cognitive bias of interest; instead, cognitive biases are inferred from indirect indexes such as reaction time, memory performance, among others (De Houwer et al., 2009; Stacy & Wiers, 2010).

In psychopathology, a number of a cognitive biases have been proposed to be relevant depending on the disorder of interest. For example, attentional and threat-related interpretation biases have been suggested in anxiety (e.g., Cisler & Koster, 2010; Salemink & Wiers, 2011) and similar cognitive biases have been proposed in depression (e.g., Everaert, Koster, & Derakshan, 2012). In substance misuse however, three cognitive biases have been proposed to be most relevant in the development (e.g., Wiers et al., 2007) and maintenance (e.g., Stacy & Wiers, 2010) of substance misuse behaviour: memory bias, attentional bias, and approach bias.

### 3.1.1. Memory Bias

Memory bias in substance misuse (often referred to as implicit memory associations) refers to implicit associations between the substance of abuse and positive affective attribution (Houben & Wiers, 2008; Stacy & Wiers, 2010). Expressed more simply, positive memory associations with substance-related cues. The Implicit Association Task (IAT; Greenwald, McGhee, & Schwartz, 1998) is the most commonly used measure to assess memory bias. The IAT infers memory bias upon reaction time (RT) between
presentations of substance-related and control stimuli (e.g., alcohol and soft drinks) and two attribute categories (e.g., positive and negative). Participants are asked to rapidly categorise the stimulus categories with attribute categories, and performance differences between combinations of categories are assumed to reflect the strength of the implicit memory association (e.g., alcohol + positive vs. soft drinks + negative).

### 3.1.2. Attentional Bias

Attentional bias refers to the extent an individual is reactive to substance-related cues such that they capture or direct attention (Field & Cox, 2008). In substance misuse research, attentional bias is commonly measured using the addiction-Stroop task and visual probe tasks (Cox, Fadardi, Intrilligator, & Klinger, 2014). The addiction-Stroop infers attentional bias as a function of RT to name the colour of words related to the substance of abuse. As an example, if an individual with alcohol issues displays increased RT to name the colour of alcohol-related words compared to neutral words, it is assumed that the interference is indicative of automatic processing of semantic meaning, suggesting attentional bias for alcohol (Cox et al., 2014; Cox, Fadardi, & Pothos, 2006). In visual probe tasks, typically a substance-related and matched control cue are simultaneously presented. When these cues disappear, a visual probe presents in the location of one of the cues. Individuals must then react to the location of the visual probe. Attentional bias is inferred from reduced RT for probes replacing substance-related cues, as participants are generally faster to respond to visual probes that appear in regions already directed by attention (Cox et al., 2014; Field & Cox, 2008).
3.1.3 Approach Bias

Approach bias (also referred to as automatic action tendencies) refers to the tendency for substance misusers to automatically approach, rather than avoid, substance-related cues (Wiers, Rinck, Kordts, Houben, & Strack, 2010b; Wiers et al., 2013a). Early studies of approach bias employed a modified version of the IAT in which positive and negative attribute categories were replaced with approach and avoid attributes (e.g., Ostafin & Palfai, 2006; Palfai & Ostafin, 2003). Similarly, Stimulus Response Compatibility (SRC) tasks have been developed in which participants are asked to move a mannequin toward and away from pictures of substance-related and control stimuli (Field, Kiernan, Eastwood, & Child, 2008). Based on related principles, the Approach-Avoidance Task (AAT; Rinck & Becker, 2007) has been developed that involves pushing and pulling a joystick. When pulled towards, the stimulus picture increases in size simulating an approach action; when the joystick is pushed away, the stimulus picture decreases in size, simulating an avoid action.

3.2. Cognitive Biases and Substance Misuse

An exhaustive review of cognitive biases’ relationship with substance use is beyond the scope of this thesis (see Stacy & Wiers, 2010 for review). In summary, memory, attentional, and approach biases have all been shown to have important roles in substance misuse behaviour. For example, the IAT has been used to demonstrate that heavier drinkers have a positive memory bias for alcohol, and no evidence for negative associations (Houben & Wiers, 2007). Further, positive memory associations have been shown to be uniquely predictive of drinking and smoking behaviour beyond the variance.
explained by explicit measures of alcohol- and tobacco-related cognitions (Houben & Wiers, 2008; McCarthy & Thompsen, 2006; Thush & Wiers, 2007).

Similarly, researchers have reported consistent findings of heightened substance-related attentional bias among substance-using populations (see Field, Marhe, & Franken, 2014 for review). For example, users of alcohol (Field et al., 2011; Miller & Fillmore, 2010), tobacco (Field, Rush, Cole, & Goudie, 2007; Lochbuehler, Voogd, Scholte, & Engels, 2010), opiates (Constantinou et al., 2010), cannabis (Cane, Sharma, Albery, 2009; Cousijn et al., 2013), and cocaine (Kennedy, Gross, Ely, Drexler, & Kilts, 2014) have demonstrated attentional biases for their respective substances. Attentional bias has also been associated with motivations for use, increased relapse, and poorer treatment outcomes (Carpenter, Schreiber, Church, & McDowell, 2006; Garland, Franken, & Howard, 2012; Marrisen, et al., 2006; Waters, Marhe, & Franken, 2012).

Evidence also suggest that individuals show an approach bias for their substance of abuse (Stacy & Wiers, 2010). Heavy drinkers have reported stronger approach tendencies toward alcohol compared to light drinkers in both adolescents and adults, and this approach bias has been related to craving (Field, Kiernan, Eastwood, & Child, 2008; Field, Mogg, Bradley, 2005; Palfai & Ostafin, 2003; Peeters et al., 2012). Like memory and attentional biases, approach bias has been reported for other substances such as cigarettes (e.g., Mogg Bradley, Field, & De Houwer, 2003) and marijuana (e.g., Cousijn, Goudriaan, & Wiers, 2011). Further, approach bias has been found to be predictive of hazardous drinking in adults (Christiansen, Cole, Goudie,
Field, 2012), future drinking behaviour of young adolescents (Peeters et al., 2013), and increased cannabis use at 6 month follow up (Cousijn et al., 2011), suggesting a key role of approach bias in substance misuse behaviour.

3.3. Cognitive Bias Modification (CBM)

Due to an increasing recognition of cognitive biases’ role in substance misuse behaviour, a number of interventions have been developed specifically targeting these processes. Broadly, these interventions have been termed Cognitive Bias Modification (CBM) procedures (MacLeod, 2012) and have generally been developed as adaptations of existing cognitive bias measures. This section will briefly review some of the key findings in this new area of research (for further commentary, see Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013).

Schoenmakers et al. (2010) developed an attentional bias retraining intervention for alcohol use among 43 alcohol-dependent adults undergoing conventional treatment. The intervention was a variation of the visual probe task; instead of probes replacing both alcohol-related and control cues, all probes replaced control cues, thus manipulating attentional bias away from alcohol. After five sessions, participants’ attentional bias toward alcohol was found to significantly decrease. Furthermore, participants who underwent training took significantly longer to relapse post-intervention. Similar results were reported by Fadardi and Cox (2009) who adapted the addiction-Stroop task to alter attentional bias. The intervention was found to be successful in reducing attentional bias toward alcohol and, importantly, harmful drinkers showed post-intervention reductions in alcohol consumption that were maintained at three months. Summarising the encouraging findings reported
in relation to attentional bias retraining interventions for substance misuse, Cox et al. (2014, p.222) suggest that these CBM interventions should be “given more weight in intervention programs for addiction disorders”, highlighting the potential clinical utility of these interventions.

Recently, researchers have examined the clinical utility of altering approach bias towards alcohol. Research conducted by Wiers et al. (2010b) employed a modified version of the AAT to retrain approach bias in hazardous drinkers. Unlike the original assessment AAT, participants in the training condition were tasked to push away almost all (90%) alcohol pictures (i.e., avoid action) and pull towards almost all (90%) non-alcoholic pictures (i.e., approach action). Importantly, participants are not explicitly told to produce these responses according to the presentation of alcoholic or non-alcoholic pictures; instead, participants are instructed to respond to the picture orientation (landscape or portrait) which is associated with the stimuli response that is being trained (e.g., 90% of landscape pictures are alcoholic requiring a ‘push away’ response; 90% of portrait pictures are non-alcoholic requiring a ‘pull towards’ response). In so doing, it is suggested that the training of approach bias occurs indirectly at an implicit level (Wiers et al., 2010b). Using the modified AAT, after only a single session of training participants demonstrated a reduction in approach bias as well as reduced drinking behaviour in a bogus taste test. This CBM intervention was also implemented in a clinical sample of 214 alcohol-dependent inpatients (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011). In this study, following four training sessions, participants in the training group showed significantly reduced relapse rates at one-year follow up compared to controls. More
recently Eberl et al. (2013) replicated these clinical effects in a large-scale study of 509 alcohol-dependent patients. Consistent with previous research, those who received training showed significantly reduced relapse rates at one-year follow up, and importantly, changes in approach bias were found to mediate this effect.

Notably, the modified AAT differs in a critical respect when compared to other CBM-related interventions: the combined motor movement and approach/avoid sensation (due to increasing/decreasing size of picture) produced by the joystick response. Indeed, as compared to approach bias training that utilises symbolic movements towards and away from substance-related stimuli (e.g., Spruyt et al., 2013), studies that have examined the AAT appear to show more positive findings for reducing alcohol use and improving treatment outcomes (e.g., Eberl et al., 2013; Wiers et al., 2009, 2010). Thus, the unique motor response required by the AAT may be a potentially crucial component of CBM in the treatment of substance misuse (Wiers et al., 2010b). Following a systematic review of studies assessing the AAT, Kakoshke, Kemps, and Tiggemann (2017) noted that all but one of the studies identified (18 in total), the modified AAT produced generally positive improvements in consumption behaviour and reduced approach bias towards appetitive stimuli.

Overall, these findings highlight the clinical utility of CBM in the treatment of substance misuse. At present however, the exact mechanisms of action CBM involves remain debated (Verdejo-Garcia, 2016; Wiers et al., 2013b). Indeed, partly due to the research area’s infancy, current understanding is limited by a lack of integration with other intermediary
variables. For example, at present, only Eberl et al. (2013) found that effects of CBM were mediated by changes in approach bias. This finding however, remains insular to the broader processes involved. As Wiers et al. (2013) suggests, CBM may act by allowing a consideration of alternative responses once substance-related stimuli produce an appetitive response; in other words, a “longer time window for decision making” (p. 201) before engaging in substance misuse. This interpretation implicates a varied array of psychological, neurocognitive, and even genetic (see Pieters et al., 2011; Wiers, Rinck, Dictus, & van den Wildenberg, 2009) factors not captured in Eberl et al.'s mediation finding. Indeed, the potential clinical utility for CBM rests heavily on a considered integration with these factors to not only optimise the benefits of these interventions, but understand who they may work for best and how this may occur.

3.4. Impulsivity as an Interacting Variable and Implications for CBM

It is argued here that rash impulsivity may be an interacting variable with cognitive biases in substance misuse, and related, an important construct in CBM interventions. This proposition has previously been suggested indirectly by Robinson and Berridge's (2008) incentive sensitisation theory of addiction. In this theory, reward sensitivity-related neurobiological pathways are sensitised due to repeated exposure to addictive substances. As a result, hypersensitive pathways develop, causing heightened incentive salience attribution toward substance-related stimuli. It is argued that cognitive biases are then developed leading to addiction (Robinson & Berridge, 2008; Stacy & Wiers, 2010). Importantly, Robinson and Berridge note that this process may only culminate in to the core
symptoms of addiction in combination with “impaired executive control over
behaviour” (p. 3137), thus implicating rash impulsive characteristics in this
progression. Indeed, as Verdejo-Garcia (2016) notes, previous research has
indicated significant overlap between executive mechanisms related to
impulsivity (e.g., response inhibition) and implicit cognitive biases to the
extent that the weakening of one of these systems can result in cognitive
resources being recruited by the other. Similarly, Stacy and Weirs (2010)
suggest that other neurobiological theories of addiction such as learning,
habit, and opponent process theories are all suggestive of a modulating role
of impulsivity-related processes. As a consequence, these theoretical models
implicate an interactive process between cognitive biases and impulsivity
that has yet to be definitively examined.

3.4.1. Correlational Studies

In order to understand the potential interactive process between
impulsivity and cognitive biases, it remains important to establish a baseline
relationship between the two constructs. To date, one systematic review has
examined this relationship in substance misuse. Coskunpinar and Cyders
(2013) examined 13 studies that assessed a measure of impulsivity and
correlation to attentional bias. Of note, food-related attentional bias was
included in this review. Their meta-analysis indicated an overall significant
positive relationship between the two constructs ($r = 0.20$). Further,
behavioural measures of impulsivity were found to have a stronger
relationship with attentional bias than self-report measures. The authors
concluded that while no definitive conclusions can be drawn, the positive
relationship observed may be due to the role of impulsivity to either bias
classical conditioning processes or affecting dopaminergic responses to substance-related stimuli. This interpretation aligns with that proposed by Field, Christiansen, Cole, and Goudie (2007) who suggested a synergistic relationship between impulsivity and attentional bias is apt – impulsive individuals may be more susceptible to the attention-grabbing properties of substance-related cues. In sum however, Coskunpinar and Cyders’ (2013) results indicate that impulsivity is consistently associated with attentional bias in substance misuse, providing preliminary evidence for the interactive nature of these constructs.

The review is limited, however, by assessing impulsivity components as a function of methodology (i.e., self-report vs. behavioural tasks). In doing so, it remains unknown how a two-factor model of impulsivity (i.e., reward sensitivity and rash impulsivity) may differentially relate to attentional bias. Additionally, whether a similar relationship may be observed for memory and approach biases remains yet to be examined. If differential relationships are found, this may have important implications to guide the usage of CBM to target particular population groups. For example, the clinical decision to use a memory, attentional, or approach-based CBM intervention for reward sensitivity-related presentations (e.g., high-risk adolescents) or rash impulsivity-related presentations (e.g., polysubstance users) may be informed by such findings.

3.4.2. Moderation Studies

A small number of studies have found rash impulsivity to moderate cognitive biases’ relationship with substance misuse. For example, Burton, Pederson, and McCarthy (2012) reported that positive and negative urgency
– facets related to rash impulsive tendencies in the presence of positive or negative mood (see Cyders & Smith, 2008 for further discussion of conceptual similarities) – were found to moderate the predictive relationship of alcohol memory bias and drinking behaviour. In other words, when rash impulsivity was heightened, cognitive biases were more likely to predict substance misuse.

In line with these results, Friese and Hofmann (2009) conducted two studies of alcohol memory bias’ relationship with alcohol consumption and the moderating effects of rash impulsivity as measured by the I7. In the first study, an alcohol-IAT was used while in the second study, a non-RT reliant measure of memory bias known as the Affect Misattribution Procedure (AMP; Payne et al., 2005) was employed. Both studies showed partial support for rash impulsivity as a moderating variable with results trending close to significance ($p = .056$ and $p = .068$ respectively). Importantly however, Friese and Hofmann’s participant samples were heavily female skewed (71.8% and 72.9% respectively). As described by Coskunpinar and Cyders (2013), cognitive biases’ relationship with impulsivity appears to be stronger in male participants. As such, Friese and Hofmann’s studies may have produced larger effects if their participant samples were more evenly gender distributed. Regardless, considering the trend of these results align with previous research, these findings suggest that rash impulsivity and cognitive biases should be considered interrelated variables in substance misuse.

Supporting these findings, an increasing number of studies have found measures of executive functioning – processes implicated in the same
neurobiological areas as rash impulsivity (Bickel, Jarmolowicz, Mueller, Gatchalian, & McClure, 2012) – to be moderators of cognitive biases’ association with substance misuse (see Wiers et al., 2010 for review). General findings from these studies suggest that when executive functioning indexes such as working memory capacity (Grenard et al., 2008; Sharbanee et al., 2013; Thush et al., 2008) and executive inhibitory control (Houben & Wiers, 2009; Peeters et al., 2012) are low, cognitive biases more strongly predict substance misuse behaviour. In contrast, when these indexes were high, a weaker relationship between cognitive biases and substance misuse behaviour is observed. Reviewing these results in sum, the evidence suggests that heightened rash impulsivity interacts with cognitive biases to inform substance misuse behaviour.

3.4.3. Implications for CBM

The way in which rash impulsivity and cognitive biases interrelate has a number of implications for CBM in substance misuse. First, if CBM interventions are believed to act upon cognitive biases, impulsivity-related processes may also be affected, providing preliminary indication as to how CBM might act to treat substance misuse. This notion has been proposed previously (e.g., Leeman et al., 2014), however at present, the effects of CBM on impulsivity dimensions have not yet been examined.

Secondly, CBM may have particular clinical utility for individuals with heightened rash impulsivity. As Staiger et al. (2007) argues, there is considerable value in matching individual differences, such as rash impulsivity, to suited interventions. Thus, supported by the moderation studies discussed previously, an individual with heightened rash impulsive
characteristics may benefit most from CBM, while those low in rash impulsivity may not be as suited to CBM interventions. This is consistent with previous findings that suggest that those with stronger pre-intervention cognitive biases show greatest changes in bias after CBM (e.g., Amir, Taylor, & Donohue, 2011; Eberl et al., 2013).

Lastly, as described earlier, heightened rash impulsivity has been associated with more risky and problematic substance use behaviour. Thus, these clinical presentations may be well-matched to CBM. In particular, as there is strong evidence to suggest a role of rash impulsivity in polysubstance use (e.g., Conway et al., 2003; Lackner et al., 2013; Martinotti et al., 2009), CBM may be useful in reducing substance misuse among these individuals. Indeed, the clinical effects to which substance-specific CBM generalises to other substance use behaviour has yet to be examined. An investigation of this question may suggest whether CBM promotes reduced substance misuse behaviour in specific contexts, or through more global processes such as rash impulsivity.

3.5. Summary

Cognitive biases have been shown to be important in various areas of substance misuse. Importantly, cognitive biases appear to be amenable to change through CBM interventions and early findings are suggestive of reduced substance misuse behaviour as a result. Currently, the exact mechanisms to which CBM act are unknown. This chapter has argued that there is a theoretical and evidence-based foundation to suggest that rash impulsivity may be an interrelated variable with cognitive biases, and when heightened, may be indicative of individuals who may benefit most from CBM
interventions. At present however, the role of rash impulsivity has not been examined in CBM research. Despite this, one meta-analysis showing a positive relationship between impulsivity and attentional bias provide preliminary support for this notion, though other cognitive biases have yet to be examined. Studies have also shown rash impulsivity to act as a moderating factor between cognitive biases and substance misuse outcomes, further supporting an interaction among these variables. Thus, CBM may have important utility in the treatment of rash impulsivity-related clinical presentations, such as polysubstance users. This is an area of further research first dependent on a considered integration of rash impulsivity and cognitive biases and the application of this understanding in the treatment of substance misuse.
Chapter Four

Rationale, Aims, and Hypotheses

4.1. Rationale

Cognitive Bias Modification may be particularly beneficial for individuals with heightened rash impulsive tendencies. The nature of impulsivity’s relationship with cognitive biases in the context of substance misuse, however, has yet to be conclusively determined. To date, only one systematic review has assessed impulsivity’s relationship with attentional bias. It remains unknown, however, how impulsivity associates with memory and approach biases, and how a two-factor conceptualisation of impulsivity may impact these associations.

Further, no study has yet examined the role of rash impulsivity in CBM interventions for substance misuse. And related, it is currently unknown whether CBM may be used to target and reduce rash impulsivity. Thus, it is hoped that the findings of the proposed studies will inform the literature by examining how impulsivity and cognitive biases interrelate, such that the application of CBM in the treatment of substance misuse may be better informed and targeted to those who may benefit most.

4.2. Aims of the Thesis

The overall aim of this thesis is to understand the relationship between impulsivity and cognitive biases as they relate to substance misuse and to apply a two-factor model of impulsivity in this investigation. To address this overarching aim, the research presented in this thesis has three objectives:
1. To systematically review and meta-analyse previous literature that has investigated the relationship between impulsivity and substance-related cognitive biases.

2. To investigate the role of impulsivity in the efficacy of CBM training directed towards reducing substance misuse in a clinical population.

3. To investigate the potential for CBM to target and reduce rash impulsivity.

With relation to the first aim, Chapter Five presents a systematic review and meta-analysis of the relationship between impulsivity and substance-related attentional, memory, and approach biases. In addition to examining these relationships, this meta-analysis further examines whether these associations may differ according to impulsivity measurement type (trait and behavioural), two-factor conceptualisation of impulsivity (rash impulsivity and reward sensitivity), and demographic variables of gender and age. Consistent with the findings of the reviewed literature herein, this meta-analysis tests the hypotheses:

1. Impulsivity will display a significant positive relationship with substance-related cognitive biases.

2. The relationship between impulsivity and substance-related cognitive biases will be significantly stronger for behavioural measures of impulsivity as compared to trait measures.

3. Rash impulsivity’s relationship with substance-related cognitive biases will be significantly stronger than reward sensitivity.
With relation to the second and third aims, Chapter Six presents an investigation of the role of rash impulsivity and reward sensitivity in a randomised controlled trial of CBM for alcohol use. Participants are 87 adults with diagnosed alcohol use disorder, recruited while undergoing alcohol detoxification in a residential detoxification facility in Melbourne, Australia. Pre-intervention, post-intervention, and follow-up measures of rash impulsivity and reward sensitivity are collected along with relevant substance use intake. Utilising hierarchical logistic regression analyses and mixed between-within model ANOVA, this study tests the hypotheses:

1. Rash impulsivity will be a significant moderator of the efficacy of CBM training, with those more highly rash impulsive displaying lower relapse rates.

2. Participants who complete CBM training will show significantly reduced rash impulsivity levels compared to participants who complete sham training.

Following these chapters, Chapter Seven summarises the main findings presented in the study investigations, and integrates these results in a larger discussion of the research and clinical implications of the thesis. Limitations and future research directions are then explored, before final conclusions are presented.
Chapter Five

Meta-analysis of the Relationship between Impulsivity and Substance-related Cognitive Biases

Note: This chapter presents an expanded version of a meta-analysis published in the journal Drug and Alcohol Dependence (2017) due to copyright reasons. A pdf copy of the published article has been appended for your consideration (Appendix A).

5.1. Introduction

In recent years, research has suggested that substance misuse is associated with cognitive biases (e.g., Peeters et al., 2013; Rooke, Hine, & Thorsteinsson, 2008; Thush & Wiers, 2007; Wiers et al., 2007). Cognitive biases refer to a selectivity in cognitive processing believed to be associative in nature that operates automatically with little conscious input or introspection (Stacy & Wiers, 2010). In the context of substance misuse, Stacy and Wiers (2010) propose that three classes of cognitive biases are relevant to the development and maintenance of substance misuse: attentional bias, memory bias, and approach bias. For example, evidence indicates that an automatic approach tendency (i.e., approach bias) towards cigarettes, as measured by the Approach Avoidance Task (AAT; Rinck & Becker, 2007), is present in heavy smokers, and that this bias decreases in strength following long-term abstinence (Wiers et al., 2013a). Similarly, substance misusers typically show an attentional bias towards substance-related cues (Field & Cox, 2008; Field et al., 2014). This attentional bias has been associated closely with subjective craving and subsequent relapse (Field et al., 2014; Marhe, Franken, & Luijten, 2013). Such findings support
the view that cognitive biases may play an integral function in maintaining substance misuse. Importantly, substance-related cognitive biases may in part help to understand why individuals continue to consume substances despite considerable negative consequences (e.g., Hofmann, Friese, & Wiers, 2008; Stacy & Wiers, 2010; Wiers et al., 2007).

There has been a growing interest in examining the factors and conditions that influence how cognitive biases translate into substance misuse (e.g., Farris, Ostafin, & Palfai, 2010; Friese & Hofmann, 2009; Wiers et al., 2007, 2010a). A variety of factors have been implicated in this link including motivation (Wiers et al., 2007), ego depletion (Christiansen et al., 2012a), acute substance effects (Korucuoglu, Gladwin, & Wiers, 2014), and positive and negative expectancies (Pieters et al., 2014). Prominently however, the construct of impulsivity, defined broadly as the tendency to rapidly engage in behaviours without forethought to the consequences of these actions (Evenden 1999; Moeller et al., 2001) is considered to be a key component. Impulsivity affects an individual’s capacity to withhold from acting in accordance with automatic cognitive processing (i.e., cognitive biases towards substances). For example, automatic attentional bias towards substances in the environment may be difficult to ‘resist’ in individuals who have a tendency to act impulsively. A number of moderation studies have supported this notion (e.g., Burton et al., 2012; Lindgren et al., 2014; Wiers et al., 2010a) with general findings indicating that cognitive biases more strongly predict substance misuse among those with heightened impulsive tendencies. However, as yet, the magnitude of the associations between impulsivity and cognitive biases is unknown. Therefore, the aim of the
present study is to conduct a meta-analytical review examining the strength of the associations between impulsivity and substance-related memory, attentional, and approach biases.

5.1.1. Impulsivity and Cognitive Biases

The construct of impulsivity is generally agreed to consist of a number of related, but distinct components (de Wit, 2009; Whiteside & Lynam, 2001). Generally, either a two-component model comprising rash impulsivity and reward sensitivity (Dawe et al., 2004) or a five factor model comprising urgency, (lack of) premeditation, (lack of) perseverance, sensation seeking, and positive urgency (UPPS-P; Lynam, Smith, Whiteside, & Cyders, 2006; Whiteside & Lynam, 2001) are proposed. Between the two, the two-component model has been posited to more closely align with neurobiological models of addiction as an imbalance between enhanced incentive salience and poor inhibitory control (see Gullo, et al., 2014 for recent review) and to provide the more parsimonious model of impulsivity in relation to substance misuse (Stautz et al., 2017). Within this framework, rash impulsivity – encompassing the inability to inhibit prepotent approach tendencies – and reward sensitivity – defined by an individual’s propensity to be sensitive to, and motivated by, rewarding stimuli have been differentially related to substance misuse behaviours and presentations (Gullo et al., 2014). Specifically, reward sensitivity has been posited to associate with an amplified receptiveness to the positive reinforcement of substance misuse, contributing to earlier experimentation behaviour (Dawe & Loxton, 2004). There is evidence to support this association suggesting earlier initiation of substance misuse in individuals with elevated reward
sensitivity traits (Dissabandara et al., 2014; Lyvers et al., 2009; Pardo et al., 2007). In contrast, rash impulsivity has been implicated in more severe and risky forms of substance misuse and the transition to dependence (Dawe et al., 2004). Supporting this, rash impulsivity has been found to be a more robust predictor of problematic substance misuse than reward sensitivity (Gullo et al., 2011a) and riskier forms of substance misuse such as intravenous administration and escalating patterns of use (Dissabandara et al., 2014) as well as poly-substance misuse (Conway et al., 2003; Lackner et al., 2013; Loxton et al., 2008; Martinotti et al., 2009).

Our increasing recognition of the role of impulsivity to influence substance misuse has substantially contributed to better understanding of individual differences in the development and maintenance of substance misuse. However, critical questions remain regarding the interaction between impulsivity and substance-related cognitive biases. In particular, how this relationship fuels substance misuse continues to be of significant interest. Burton and colleagues (2012) reported that rash impulsivity (as measured by positive and negative urgency – see Cyders & Smith, 2008 for further discussion of conceptual similarities) moderated the predictive relationship between alcohol memory bias and drinking behaviour. That is, individuals high in rash impulsivity reported acting more in line with their alcohol memory bias as indicated by higher levels of drinking. These findings are consistent with previous research indicating that response inhibition moderates the relationship between alcohol memory bias and drinking behaviour in adults (Houben & Wiers, 2009) and alcohol approach bias and drinking behaviour in adolescents (Peeters et al., 2012). These findings
suggest that when an individual’s levels of impulsivity are high, substance-related cognitive biases more strongly predict substance misuse, possibly due to an increased governance of automatic cognitive processes in these individuals (Burton et al., 2012). Hence there is a growing interest in examining the relationship between substance-related cognitive biases and general inhibitory processes that fall within the rubric of impulsivity (Wiers et al., 2010a, 2013b).

A number of prominent theories of addiction suggest that impulsivity may influence how cognitive biases first develop and then maintain substance misuse. For example, in their incentive sensitisation theory of addiction, Robinson and Berridge (2008) propose that repeated substance misuse sensitises the neurobiological pathways associated with attributing incentive salience to rewarding stimuli. They propose that these sensitised pathways, reflected by heightened attentional bias towards substance-related cues, culminate in the core symptoms of addiction in combination with “impaired executive control over behavior” (Robinson & Berridge, 2008, p.3137), implicating impulsive characteristics in this development. Similarly, Field and Cox (2008) suggest that highly impulsive substance misusers may be more susceptible to an attentional bias towards substance-related stimuli, or that heightened attentional bias may influence an individual’s impulsive tendencies. The potentially bidirectional nature of this relationship is also reflected in dual-process models of addiction. In these models, substance misuse is proposed to be informed by the relative influence of associative and reflective classes of cognitive processes (Stacy & Wiers, 2010; Wiers et al., 2007, 2010). In this context, the associative system refers to the
automatic, appetitive processes that are reflected by substance-related cognitive biases while the reflective system encompasses executive control capacities and an individual’s ability to regulate impulses (Stacy & Wiers, 2010; Wiers et al., 2007, 2010). When these systems are imbalanced, strong associative processes bypass the regulatory capabilities of the reflective system, and thus promote substance misuse (Stacy & Wiers, 2010; Wiers et al., 2007, 2010). Thus, the interplay between substance-related cognitive biases and an individual’s impulsive tendencies and capacity for self-regulation form the foundation of these dual-process models of addiction. Thus far, these models have largely focused on the relationship between impulsivity and attentional bias, and a recent meta-analysis of 13 studies (inclusive of 5 food-related studies) reported a small, positive relationship ($r = .20$) between these two constructs, providing preliminary evidence to support these models (Coskunpinar & Cyders, 2013). Coskunpinar and Cyders (2013) examined the moderating role of impulsivity measurement type where behavioural impulsivity was more strongly related to attentional bias ($r = .22$) than trait impulsivity ($r = .10$) across both substance and food studies. They also found that gender played a moderating role; that is, males reported a stronger relationship between attentional bias and impulsivity. However, their review did not include related and important cognitive biases which are part of the dual process understanding of addiction (see Stacy & Wiers, 2010). That is, evidence indicates that substance-related memory bias (e.g., Burton et al., 2012; Friese & Hofmann, 2009; Houben & Wiers, 2009; Wiers et al., 2009) and approach bias (e.g., Fleming & Bartholow, 2014; Peeters et al., 2012) may relate to impulsive characteristics in similar ways to...
attentional bias, possibly suggesting a generalised role for cognitive biases in relation to impulsivity and, ultimately, substance misuse. Based on these findings, it is expected that impulsivity positively relates to memory and approach biases, however this has yet to be systematically reviewed.

5.1.2. Measures of Impulsivity in Substance Misuse

5.1.2.1. Rash Impulsivity. Trait measures of rash impulsivity share common thematic elements related to assessing approach-oriented, risk-taking behaviour and an inadequate consideration of consequences of action (Gullo et al., 2011a). Examples include the Eysenck I7 (Eysenck et al., 1985), Cloninger’s Novelty Seeking scale (NS; Cloninger et al., 1993), Barratt Impulsivity Scale (BIS-11; Patton et al., 1995), and Zuckerman’s Sensation Seeking Scale (SSS; Zuckerman et al., 1978). Among these measures, individuals are asked to respond to items such as “I do things without thinking” (I7), “I often act on hunches, momentary whims, or by intuition without making a detailed analysis of facts” (NS), and “I would like to take off on a trip with no preplanned or definite routes, or timetable” (SSS).

Behavioural measures of rash impulsivity include response inhibition measures such as the Go/No-Go task (GNG) and Stop Signal Task (SST; Logan et al., 1997). In these tasks, individuals are required to make quick, accurate responses to visually presented “Go”-signals and inhibit responses to presentations of “Stop”-signals. Reliable presentation of “Go”-signals produces a prepotent response pattern, which must be inhibited in order to accurately withhold response to “Stop”-signals. Responses made in error to “Stop”-signals (i.e., commission error rate) are believed to reflect an
individual’s inhibitory capacities – a distinct feature of rash impulsivity (Dawe et al., 2007).

5.1.2.2. Reward Sensitivity. Trait measures of reward sensitivity are considered to tap into aspects of an individual’s responsiveness and motivation towards rewarding stimuli. Typical examples include the BAS-Drive scale (Carver & White, 1994) which has individuals respond to items such as “If I see a chance to get something I want, I move on it right away” and the Sensitivity to Reward scale (SR; Torrubia et al., 2001) that has items including “Are you interested in money to the point of being able to do risky jobs?”.

Behavioural measures of reward sensitivity include delay discounting paradigms such as the Delay Discounting Task (DDT; Kirby et al., 1999) and the Experiential Discounting Task (EDT; Reynolds & Schiffbauer, 2004). These tasks index an individual’s preference for smaller, immediate rewards (e.g., $50 now) relative to larger, delayed rewards (e.g., $100 in two months). When delayed rewards are devalued steeply relative to immediate rewards, the individual may be considered more sensitive to the incentive properties of rewarding stimuli (i.e., heightened reward sensitivity) (Stephens et al., 2010). Similarly, the Card Arranging Reward Responsiveness Objective Test (CARROT; Powell et al., 1996) assesses increases in performance on a simple card-sorting task when financially rewarded. Greater gains in performance suggest an increased sensitivity to the motivational properties of rewards, and this has been found to correlate significantly with self-reported reward sensitivity (Kambouropoulos & Staiger, 2004).
5.1.3. Measures of Cognitive Biases in Substance Misuse

As cognitive biases are implicit in nature and spontaneously activated (Stacy & Wiers, 2010), measurement tools used to assess these biases share the key feature of indirect assessment. That is, participants are not directly asked to report on the cognitive bias of interest; instead, they are inferred from indirect indexes such as reaction time performance (De Houwer et al., 2009; Stacy & Wiers, 2010).

5.1.3.1. Attentional Bias. In substance misuse research, attentional bias refers to an individual’s reactivity to substance-related cues such that they capture or direct attention (Field & Cox, 2008). Using assessment tools such as the addiction-Stroop task and variants of visual probe tasks (Cox et al., 2014), there is consistent evidence to indicate that users of alcohol (Field et al., 2011; Miller & Fillmore, 2010), tobacco (Field et al., 2007b; Lochbuehler et al., 2010), opiates (Constantinou et al., 2010), cannabis (Cane et al., 2009; Cousijn et al., 2013), and cocaine (Kennedy et al., 2014) demonstrate attentional bias towards their respective substances. Attentional bias has also been associated with motivations for use, increased relapse, and poorer treatment outcomes in substance-dependent outpatient adults (Carpenter et al., 2006; Garland et al., 2012; Marrisen et al., 2006; Waters et al., 2012).

5.1.3.2. Memory Bias. Memory bias (also referred to as implicit memory associations) refers to implicit associations held between substance-related cues and positive affective attribution (Houben & Wiers, 2008; Stacy & Wiers, 2010). Most commonly, memory bias is assessed using the Implicit Association Task (IAT; Greenwald et al., 1998). The IAT has been used to demonstrate that heavier drinkers have a positive memory bias for alcohol
(Houben & Wiers, 2007) and that these positive memory associations are uniquely predictive of drinking and smoking behaviour beyond the variance explained by explicit measures of alcohol- and tobacco-related cognitions (Houben & Wiers, 2008; McCarthy & Thompsen, 2006; Thush & Wiers, 2007).

5.1.3.3. Approach Bias. Approach bias (also referred to as automatic action tendencies) refers to the tendency to automatically approach, rather than avoid, substance-related cues (Wiers et al., 2013a, 2010b). While early studies of approach bias utilised modified versions of the IAT using approach and avoidance categories (e.g., Ostafin & Palfai, 2006; Palfai & Ostafin, 2003), more recent investigations have used Stimulus Response Compatibility (SRC) tasks (Field et al., 2008) and the Approach-Avoidance Task (AAT; Rinck & Becker, 2007). Using these tools, research indicates that heavy drinkers report stronger approach tendencies toward alcohol compared to light drinkers in both adolescent and adult populations, and this approach bias has been related to craving (Field et al., 2011, 2008, 2005a; Peeters et al., 2012). Like memory and attentional biases, heightened approach bias has been reported for other substances including cigarettes (e.g., Mogg et al., 2003) and marijuana (e.g., Cousijn et al., 2011). Further, approach bias has been shown to be predictive of hazardous drinking in adults (Christiansen et al., 2012b) and future drinking behaviour of young adolescents (Peeters et al., 2013).

In summary, there is clear evidence supporting the role of cognitive biases and impulsivity in the development and maintenance of substance misuse. What remains less clear is the relationship between these two
constructs. That is, firstly, is there a consistent significant relationship between impulsivity and substance-related cognitive biases, and if so, do the different components of impulsivity (rash impulsivity and reward sensitivity) and impulsivity measurement type (trait and behavioural) differentially influence this relationship? Given previous evidence to indicate impulsivity varies according to gender (Cross et al., 2011; Weafer & de Wit, 2014) and age (Steinberg et al., 2008), whether these factors also influence this relationship is also of interest.

5.1.4. Current Study

This review aims to summarise research to assess whether there is a relationship between impulsivity and substance-related cognitive biases, and examine how components of impulsivity across the measures discussed (rash impulsivity and reward sensitivity) might influence this relationship. Secondary aims were to examine how impulsivity measurement type (trait and behavioural) and demographics such as gender and age may affect impulsivity’s relationship with substance-related cognitive biases.

5.2. Method

5.2.1. Search Strategy and Selection Criteria

Articles were identified using the following electronic databases: MEDLINE (hosted by OvidSP), PsycINFO (hosted by EbscoHost), and PsycArticles (hosted by EbscoHost). The search strategy aimed to identify studies that provided a quantitative measurement of impulsivity and substance-related cognitive bias in clinical or non-clinical samples and were examined up to July 2016. Details of all keywords used in database searches are presented in Appendix C. Reference lists of relevant articles identified
were manually reviewed for any further potentially eligible studies. Lastly, authors were contacted for additional data if the published article did not provide the sufficient information.

5.2.2. Study Inclusion and Exclusion Criteria

Inclusion criteria were: (1) publication in peer-reviewed journal, (2) written in English, and (3) provided quantitative measurement of an impulsivity measure and a substance-related attentional, memory, or approach cognitive bias. Studies were excluded from the review if (1) the necessary data were unobtainable through author contact, (2) if data were reported following experimental manipulation, (3) the study assessed food-related cognitive biases, or (4) measures were reported from a third-party source (see also Appendix D). Figure 5.1. summarises flowchart of articles retrieved, included in the meta-analysis, and excluded following QUOROM guidelines (Moher et al., 1999).
Articles identified through database search (n = 485)

Articles identified through reference list search (n = 5)

Articles after duplicates removed (n = 297)

Articles excluded (n = 237) for not meeting eligibility criteria:
- No quantitative measurement of either impulsivity or substance-related cognitive bias (n = 207)
- Article was review, book chapter, or commentary article (n = 29)
- Article was non-published study (n = 1)

Articles screened (n = 297)

Articles included in quantitative synthesis (n = 19)

Articles excluded (n = 41) for not meeting eligibility criteria:
- No quantitative measurement of either impulsivity or substance-related cognitive bias (n = 31)
- Article was review, book chapter, or commentary article (n = 1)
- Impulsivity measure was parent-report (n = 1)
- Data reported following experimental manipulation (n = 3)
- Article did not provide sufficient data and could not be obtained through author contact (n = 5)

Full-text articles assessed for eligibility (n = 60)

5.2.3. Study Selection

After duplicates were removed, two reviewers (DL and PS) independently screened all retrieved articles based upon title and abstract. Inconsistencies between reviewers were resolved via discussion and
consensus decision. DL and PS then independently examined full-text copies of each article according to outlined inclusion criteria. Inter-rater reliability was high. For 58 of the 60 articles (Cohen’s kappa = .931), the reviewers independently agreed upon the suitability of inclusion of each article in the meta-analysis. In total, 19 published studies were included in the meta-analysis. A summary of each study’s design, impulsivity measure, cognitive-bias measure, gender ratio, mean age, and effect size are presented in Table 5.1.
<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>% Male</th>
<th>Clinical sample/Non-Clinical sample</th>
<th>Mean Age (SD age)</th>
<th>Substance</th>
<th>Impulsivity Measure</th>
<th>Cognitive Bias Measure</th>
<th>Relationship</th>
<th>Reported Pearson’s r</th>
<th>Fisher’s z score</th>
<th>Averaged Pearson’s r study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ames et al. (2007)</td>
<td>121</td>
<td>64</td>
<td>Non-Clinical</td>
<td>16.07 (0.74)</td>
<td>Marijuana</td>
<td>SSS</td>
<td>Unipolar IAT (Neutral vs Relaxation) SSS</td>
<td>tra – mem</td>
<td>.120</td>
<td>.120</td>
<td>.057</td>
</tr>
<tr>
<td>Andrews et al. (2010)</td>
<td>766</td>
<td>50</td>
<td>Non-Clinical</td>
<td>Not reported</td>
<td>Tobacco</td>
<td>SSS (Short Form)</td>
<td>Unipolar IAT (Neutral vs Excitement) SRC</td>
<td>tra – mem</td>
<td>.006</td>
<td>.006</td>
<td></td>
</tr>
<tr>
<td>Christiansen et al. (2012a)</td>
<td>80</td>
<td>42</td>
<td>Non-Clinical</td>
<td>22.08 (4.53)</td>
<td>Alcohol</td>
<td>BIS-11 (Total)</td>
<td>Bipolar IAT (Good vs Bad) VPT (Gaze) SRC</td>
<td>tra – app</td>
<td>.079</td>
<td>.079</td>
<td>.079</td>
</tr>
<tr>
<td>Christiansen et al. (2012b)</td>
<td>97</td>
<td>33</td>
<td>Non-Clinical</td>
<td>28.95 (11.57)</td>
<td>Alcohol</td>
<td>BIS-11 (Total)</td>
<td>BIS-11 (Total) BIS-11 (Attention) VPT (RT) SRC</td>
<td>tra – app</td>
<td>.012</td>
<td>.012</td>
<td>.039</td>
</tr>
<tr>
<td>Coskunpinar et al. (2013)</td>
<td>38</td>
<td>24</td>
<td>Non-Clinical</td>
<td>Not reported</td>
<td>Alcohol</td>
<td>UPPS-P (NU)</td>
<td>SRC</td>
<td>tra – att</td>
<td>.275</td>
<td>.282</td>
<td>.275</td>
</tr>
<tr>
<td>Field et al. (2007a)</td>
<td>90</td>
<td>92</td>
<td>Non-Clinical</td>
<td>16.83 (0.40)</td>
<td>Alcohol</td>
<td>DDT (Money)</td>
<td>Stroop</td>
<td>beh – att</td>
<td>.280</td>
<td>.288</td>
<td>.280</td>
</tr>
<tr>
<td>Field et al. (2007b)</td>
<td>30</td>
<td>50</td>
<td>Non-Clinical</td>
<td>27.23 (7.65)</td>
<td>Tobacco</td>
<td>DDT (Money)</td>
<td>Stroop</td>
<td>beh – att</td>
<td>-.339</td>
<td>-.353</td>
<td>-.087</td>
</tr>
<tr>
<td>Fleming and Bartholow (2014)</td>
<td>85</td>
<td>46</td>
<td>Non-Clinical (Not reported)</td>
<td>19.5 (Not reported)</td>
<td>Alcohol</td>
<td>UPPS (NU)</td>
<td>AAT</td>
<td>tra – att</td>
<td>.177</td>
<td>.179</td>
<td>.250</td>
</tr>
<tr>
<td>Friese and Hofmann (2009a)</td>
<td>156</td>
<td>28</td>
<td>Non-Clinical</td>
<td>24.63 (5.23)</td>
<td>Alcohol</td>
<td>I7</td>
<td>Bipolar IAT (Pleasant vs Unpleasant) DDT</td>
<td>tra – mem</td>
<td>.160</td>
<td>.161</td>
<td>.160</td>
</tr>
<tr>
<td>Friese and Hofmann (2009b)</td>
<td>129</td>
<td>27</td>
<td>Non-Clinical</td>
<td>23.07 (3.20)</td>
<td>Alcohol</td>
<td>I7</td>
<td>Bipolar AMP (Pleasant vs Unpleasant) VPT</td>
<td>tra – mem</td>
<td>.040</td>
<td>.040</td>
<td>.040</td>
</tr>
<tr>
<td>Gibbons et al. (2016)</td>
<td>132</td>
<td>45</td>
<td>Non-Clinical</td>
<td>14.39 (.53)</td>
<td>Alcohol</td>
<td>Self-Control Rating Scale (Impulsivity Subscale) DDT</td>
<td>tra – att</td>
<td>.120</td>
<td>.121</td>
<td>.120</td>
<td></td>
</tr>
<tr>
<td>Janssen et al. (2015)</td>
<td>378</td>
<td>35</td>
<td>Non-Clinical</td>
<td>14.9 (1.28)</td>
<td>Alcohol</td>
<td>DDT</td>
<td>AAT</td>
<td>beh – att</td>
<td>.102</td>
<td>.102</td>
<td>.160</td>
</tr>
<tr>
<td>Study</td>
<td>Sample Size</td>
<td>Condition</td>
<td>Mean (SD)</td>
<td>Substance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liu et al. (2011)</td>
<td>37 53</td>
<td>Clinical</td>
<td>40.5 (7.6)</td>
<td>Cocaine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loeber et al. (2009)</td>
<td>30 60</td>
<td>Clinical</td>
<td>51.8 (8.1)</td>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luehring-Jones et al. (2016)</td>
<td>36 39</td>
<td>Non-Clinical</td>
<td>19.6 (1.9)</td>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Murphy and Garavan (2011)</td>
<td>84 45</td>
<td>Non-Clinical</td>
<td>20.8 (3.0)</td>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powell et al. (2010)</td>
<td>141 46</td>
<td>Clinical</td>
<td>33.2 (12.8)</td>
<td>Tobacco</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>van Hemel-Ruiter et al. (2015)</td>
<td>86 43</td>
<td>Non-Clinical</td>
<td>14.86 (1.37)</td>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willem et al. (2013)</td>
<td>94 52</td>
<td>Non-Clinical</td>
<td>18.0 (1.10)</td>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Impulsivity measure: ATQ = Adult Temperament Questionnaire; BIS-11 = Barratt Impulsivity Scale; CARROT = Card Arranging Reward Responsivity Objective Test; CPT = Continuous Performance Task; DDT = Delay Discounting Task; GNG = Go/No-Go Task; I7 = Eysenck Impulsivity Scale; NS = Novelty Seeking Scale; NU = Negative Urgency; SPSRQ (RS) = Sensitivity to Punishment and Sensitivity to Reward Scale (Reward Sensitivity subscale); SSS = Sensation Seeking Scale; SURPS = Substance Use Risk Profile Scale. Cognitiv bias measure: AAT = Approach-Avoidance Task; IAT = Implicit Association Task; pVPT = Pictorial Visual Probe Task; SRC = Stimulus Response Compatibility task; VPT = Visual Probe Task. Comparison: app = Approach bias; att = Attentional bias; beh = Behavioural impulsivity; mem = Memory bias; tra = Trait impulsivity.
5.2.4. Effect Size Calculations and Extraction Procedures

Effect sizes extracted from the studies were Pearson’s \( r \) coefficients and in one case Spearman’s \( \rho \) (Field et al., 2007a). Correlations were coded such that higher values indicated higher impulsivity and stronger cognitive bias. Where multiple effect sizes are reported from the same participant sample, effect sizes were averaged to reduce inflated estimates and to meet assumptions of independence for the relevant analyses. Where both subscale scores and total scores were provided for a measure (e.g., BIS-11), total scores were prioritised for use to calculate effect sizes. If total scores were not reported, subscale effect sizes were averaged. Two studies (Field et al., 2007a, 2007b) employed two forms of the DDT: one using monetary reward and one using substance incentive (alcohol reward and cigarette reward). For these studies, data from the monetary DDT were utilised to more closely approximate impulsive responding without influence of substance-related cues. Effect sizes based upon unipolar IAT using negative and neutral attribution categories (e.g., Ames et al., 2007; Burton et al., 2012) were excluded from analyses as inclusion may have confounded directionality of results and previous research suggests that positive/appetitive-based memory bias is more strongly related to addictive outcomes (Wiers et al., 2010a).

5.2.5. Meta-analytic Procedures

All statistical analyses were conducted using Comprehensive Meta-Analysis Software (Borenstein, Rothstein, & Cohen, 1999). A random effects model was used to average effect sizes (Borenstein, Hedges, Higgins, & Rothstein, 2009). Significance tests were computed using an alpha level
of .05. Categorical moderators (i.e., behavioural versus trait impulsivity, rash impulsivity versus reward sensitivity) were analysed using meta-analysis of variance. Gender and age moderators were assessed using meta-regression.

5.3. Results

5.3.1. Description of Data Set

A total of 24 articles were found to be eligible for inclusion the present meta-analysis. Of those 24 articles, 10 reported sufficient data to perform meta-analysis. Authors of the remaining 14 articles were contacted and of those, nine responded with the relevant data. A total of 41 effect sizes were extracted from 19 articles for the final quantitative synthesis. Sum sample size of the included studies was 2610, with a median sample size of 90. Mean age of participants was 23.91. Fourteen articles investigated alcohol as the primary substance, three investigated tobacco, one investigated marijuana, and one investigated cocaine. Publication bias was assessed using a funnel plot, presented in Figure 5.2. that plots study precision (as measured by standard error) against the effect sizes of individual studies (Egger, Smith, Schneider, & Minder, 1997). Egger’s regression intercept analysis was not significant, revealing no evidence of publication bias ($t = 0.61$, $df = 17$, $p = .552$).
5.3.2. Relationship between Impulsivity and Attentional Bias, Memory Bias, and Approach Bias

Meta-analyses were conducted for the overall relationship between impulsivity and substance-related cognitive biases (summarised in Figure 5.3.), as well as individually for attentional, memory, and approach biases. Results of these meta-analyses are displayed in Table 5.3. Overall, impulsivity (trait and behavioural measures) exhibited a small, positive relationship with substance-related cognitive biases ($r = .10$, $Q = 23.43$, $p < .001$). Calculation of $I^2$ statistic indicated that 23.17% of variability between effect sizes represents true heterogeneity. Fail-safe N analysis revealed that 87 missing studies would be required to make this effect non-
significant. Results of sensitivity analyses (N-1) for each study removed is provided in Table 5.2. Results also indicated a small, positive relationship between impulsivity and attentional bias ($r = .11, Q = 20.86, p = .011$), impulsivity and memory bias ($r = .08, Q = 1.26, p = .004$), and impulsivity and approach bias ($r = .07, Q = 3.16, p = .041$)

Table 5.2.
One study removed (N-1) analysis

<table>
<thead>
<tr>
<th>Model</th>
<th>Study</th>
<th>Correlation</th>
<th>Lower limit</th>
<th>Upper limit</th>
<th>Z-Value</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ames et al. (2007)</td>
<td>0.106</td>
<td>0.054</td>
<td>0.157</td>
<td>3.998</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Andrews et al. (2010)</td>
<td>0.108</td>
<td>0.052</td>
<td>0.164</td>
<td>3.741</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Christiansen et al. (2012a)</td>
<td>0.106</td>
<td>0.055</td>
<td>0.156</td>
<td>4.048</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Christiansen et al. (2012b)</td>
<td>0.106</td>
<td>0.055</td>
<td>0.157</td>
<td>4.054</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Coskunpinar et al. (2013)</td>
<td>0.099</td>
<td>0.050</td>
<td>0.147</td>
<td>3.932</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Field et al. (2007a)</td>
<td>0.092</td>
<td>0.046</td>
<td>0.138</td>
<td>3.883</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Field et al. (2007b)</td>
<td>0.106</td>
<td>0.056</td>
<td>0.154</td>
<td>4.182</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Fleming &amp; Bartholow (2014)</td>
<td>0.095</td>
<td>0.047</td>
<td>0.143</td>
<td>3.840</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Friese &amp; Hofmann (2009a)</td>
<td>0.099</td>
<td>0.047</td>
<td>0.150</td>
<td>3.736</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Friese &amp; Hofmann (2009b)</td>
<td>0.107</td>
<td>0.055</td>
<td>0.158</td>
<td>4.056</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Gibbons et al. (2016)</td>
<td>0.102</td>
<td>0.050</td>
<td>0.154</td>
<td>3.830</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Janssen et al. (2015)</td>
<td>0.113</td>
<td>0.061</td>
<td>0.164</td>
<td>4.234</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Liu et al. (2011)</td>
<td>0.097</td>
<td>0.049</td>
<td>0.144</td>
<td>3.973</td>
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<tr>
<td></td>
<td>Loeber et al. (2009)</td>
<td>0.102</td>
<td>0.061</td>
<td>0.142</td>
<td>4.922</td>
<td>0.000</td>
</tr>
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<td></td>
<td>Luehring-Jones et al. (2016)</td>
<td>0.105</td>
<td>0.055</td>
<td>0.155</td>
<td>4.071</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Murphy &amp; Garavan (2011)</td>
<td>0.091</td>
<td>0.046</td>
<td>0.136</td>
<td>3.951</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Powell et al. (2010)</td>
<td>0.101</td>
<td>0.049</td>
<td>0.153</td>
<td>3.796</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>van Hemel-Ruiter et al. (2015)</td>
<td>0.104</td>
<td>0.052</td>
<td>0.155</td>
<td>3.945</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Willem et al. (2013)</td>
<td>0.105</td>
<td>0.053</td>
<td>0.156</td>
<td>3.961</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Random</td>
<td>0.102</td>
<td>0.054</td>
<td>0.151</td>
<td>4.107</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Figure 5.3. Forest plot of effect sizes of relationship between impulsivity and cognitive biases for all studies.

Table 5.3.
Mean effect sizes utilising random effects model

<table>
<thead>
<tr>
<th>Relationship Assessed</th>
<th>K</th>
<th>S</th>
<th>N</th>
<th>r</th>
<th>95% CI</th>
<th>Z</th>
<th>Q</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall impulsivity – All cognitive biases</td>
<td>19</td>
<td>41</td>
<td>2,610</td>
<td>.10</td>
<td>[.05, .15]</td>
<td>4.11</td>
<td>23.43</td>
<td>&lt;.001**</td>
</tr>
<tr>
<td>Impulsivity – Attentional bias</td>
<td>12</td>
<td>23</td>
<td>1,220</td>
<td>.11</td>
<td>[.03, .20]</td>
<td>2.54</td>
<td>20.86</td>
<td>.011*</td>
</tr>
<tr>
<td>Impulsivity – Memory bias</td>
<td>4</td>
<td>5</td>
<td>1,172</td>
<td>.08</td>
<td>[.03, .14]</td>
<td>2.84</td>
<td>1.26</td>
<td>.004*</td>
</tr>
<tr>
<td>Impulsivity – Approach bias</td>
<td>6</td>
<td>13</td>
<td>770</td>
<td>.07</td>
<td>[.00, .15]</td>
<td>2.05</td>
<td>3.16</td>
<td>.041*</td>
</tr>
</tbody>
</table>

Note. *p < .05, **p < .001

5.3.3. Categorical Moderators: Rash Impulsivity vs. Reward Sensitivity and Behavioural vs. Trait Impulsivity

Categorical moderator analyses results are presented in Table 5.4. and Table 5.5. For these analyses, effect sizes produced from the same participant sample were included for comparative analyses to the increase number of effect sizes included. Analyses revealed that the two-component
conceptualisation of rash impulsivity and reward sensitivity did not significantly moderate the relationship between impulsivity and cognitive biases ($Q = .12, df = 1, p > .05$). Similarly, impulsivity measurement type (behavioural and trait impulsivity) was also not a significant moderator ($Q = .04, df = 1, p > .05$).

Table 5.4.
*Rash impulsivity/reward sensitivity moderator analysis utilising random effects model*

<table>
<thead>
<tr>
<th>Relationship assessed</th>
<th>$K$</th>
<th>$I^2$</th>
<th>$Q$-statistic</th>
<th>$r_{SI}$</th>
<th>SE</th>
<th>$r_{RS}$</th>
<th>SE</th>
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</thead>
<tbody>
<tr>
<td>Overall impulsivity</td>
<td>24</td>
<td>23.17</td>
<td>.122</td>
<td>16</td>
<td>.11</td>
<td>.004</td>
<td>.011</td>
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<tr>
<td>— All cognitive biases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.5.
*Behavioural/trait impulsivity moderator analysis utilising random effects model*

<table>
<thead>
<tr>
<th>Relationship assessed</th>
<th>$K$</th>
<th>$I^2$</th>
<th>$Q$-statistic</th>
<th>$r_{beh}$</th>
<th>SE</th>
<th>$r_{tra}$</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall impulsivity</td>
<td>23</td>
<td>23.17</td>
<td>.043</td>
<td>10</td>
<td>.10</td>
<td>.018</td>
<td>.003</td>
</tr>
<tr>
<td>— All cognitive biases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.3.4. Gender and Age

Inspection of scatterplot produced by meta-regression analyses revealed a general positive trend between proportion of male participants and weighted effect sizes, however this was not revealed to be a significant moderator of impulsivity’s relationship with substance-related cognitive biases ($Q = 0.71, df = 1, p > .05$). Visual inspection of scatterplot indicated a general negative trend between mean age and weighted effect sizes, however this was also not found to be significant ($Q = 0.72, df = 1, p > .05$).
5.4. Discussion

5.4.1 Summary of Findings

This meta-analytical review aimed to summarise the research literature to assess whether there is a significant relationship between impulsivity and substance-related cognitive biases, and whether components of rash impulsivity and reward sensitivity may affect this relationship. A systematic review of the relevant literature identified 24 eligible studies, 19 of which could be included in the meta-analysis. As expected, the analysis revealed a positive significant relationship between impulsivity and the three substance-related cognitive biases measured (attentional, memory, and approach). Although the overall effect size was small for all three biases, the findings provide support for the idea that these biases may interact with the tendency for impulsive responding and possibly contribute to influencing the development and maintenance of substance misuse (e.g., Field & Cox, 2008; Robinson & Berridge, 2008). Notably, this relationship was not found to be moderated by the two component model of impulsivity (rash impulsivity and reward sensitivity), impulsivity measurement type (behavioural and trait), gender, or age. That is, the associations were found to be highly uniform across a large number of studies despite differences in measurement type.

Interestingly, existing research has largely studied substance-related attentional, memory, and approach biases in isolation from each other. As an example, of the 19 articles included in the current meta-analysis, only three (Christiansen et al., 2012a; Janssen et al., 2015; Willem et al., 2013) assessed more than one bias within the same study, and none investigated all three...
simultaneously. In the context of evidence that suggests that each of the three cognitive biases make unique contributions to the prediction of substance misuse (Ames et al., 2007; Sharbanee et al., 2013) and respond differentially following drug intake (Field et al., 2005b; Schoenmakers, Wiers, & Field, 2008), this general limitation indicates a constrained understanding of the role of each cognitive bias in substance misuse relative to each other and in relation with an individual’s level of impulsivity. The current review is the first to provide evidence that attentional, memory, and approach biases positively associate with impulsivity in a consistent manner across alcohol and other substances. In addition, this positive relationship is of a relatively consistent strength across the three cognitive biases.

The overall small effect size ($r = .10$) between impulsivity and cognitive biases is consistent with results reported by Coskunpinar and Cyders (2013), though of smaller strength. Our findings more closely align with their results for the relationship between trait measures of impulsivity ($r = .10$) and attentional bias while a larger discrepancy is noted for their results of behavioural impulsivity ($r = .22$). Three potential explanations for our small effect size are considered. First, as our analyses were inclusive of three different cognitive biases and trait and behavioural measures of impulsivity, a wide variety of measures from each category were included in the meta-analyses. Thus, it is possible that this may diluted the overall effect size observed. Indeed, among cognitive bias measures themselves, internal reliability has been reportedly poor (e.g., Ataya et al., 2012) particularly for reaction time measures (Christiansen et al., 2015) which would suggest broad variability in reported bias scores across studies and reduced effect
size estimates. Secondly, the relationship between impulsivity and cognitive biases may be stronger in ecological settings as opposed to laboratory settings. This would be consistent with research suggesting modulation of reward response and impulsivity when addiction-related cues are present (Miedl et al., 2014). Lastly, it is of course possible that the relationship between impulsivity and cognitive biases is not as strong as theoretically predicted. It is possible that the link between biases and poor self-control is better explained by other characteristics such as compulsivity or the tendency to perseverate on behaviours that have been previously associated with reward (Ersche et al., 2010; Voon, 2015). We argue, however, that the former explanations need to be further investigated before any conclusions can be drawn. Despite the wide variability of measures included in the analyses, the consistency in which impulsivity appears to relate to cognitive biases, albeit modestly, provides some support for interactive models of these constructs.

The significant association between cognitive biases and impulsivity may be interpreted in a number of ways. First, it has been previously argued that substance-related cognitive biases may be heightened or exacerbated in the context of heightened impulsivity (Dawe et al., 2004; Field & Cox, 2008). That is, among individuals who exhibit heightened impulsive tendencies, these same individuals may have difficulty inhibiting their responses towards the incentive-motivational properties of substance-related stimuli (Field & Cox, 2008). Dawe et al. (2004, p.1397) suggest that this relationship may be “synergistic” in nature – impulsivity may reduce an individual’s ability to inhibit their response towards substance-related stimuli, but may
also prime an individual’s responsivity to the rewarding value of these stimuli. From this perspective, researchers have largely emphasised the role of attentional bias in this relationship (e.g., Field & Cox, 2008; Robinson & Berridge, 2008), suggesting that impulsivity may make an individual more “sensitive to the attention-grabbing properties of substance-related stimuli than others” (Field & Cox, 2008, p.11). This notion was recently supported by the meta-analytical review by Coskunpinar and Cyders (2013). Secondly, a related interpretation of these relationships is provided by the incentive sensitisation theory of addiction. From this perspective, Robinson and Berridge (2008) propose that following substance misuse and neuroadaptation of incentive salience attribution pathways towards substance-related stimuli, associative learning mechanisms modulate an individual’s “focus” (p.3137) towards these stimuli. That is, they suggest that the classical conditioning processes that underlie cognitive bias development serve to direct and specify the stimuli in the environment that is desirable. This process is proposed to interact with incentive salience mechanisms when substances are taken that sensitise reward and motivational brain pathways, culminating in pathological levels of motivation towards substance-related stimuli. As Robinson and Berridge (2008, p.3138) note, associative learning processes “might be viewed as a layered onto basic sensitization processes in a top-down fashion, similar to how learning regulates the expression of such non-associative motivation processes as a stress and pain”. In line with our results, this may suggest that this interactive process occurs similarly across attentional, memory, and approach biases in relation to impulsivity. It is important to acknowledge,
however, that the directionality of this relationship requires further examination and may also be influenced by concurrent (non-mechanistically related) elevations or other unknown mediating variables.

Notably, recent studies have examined areas of neurocognitive activation in relation to impulsive responding and substance-related cognitive biases (Boy et al., 2011; Cousijn et al., 2012; Sripada, Gonzalez Phan, & Liberzon, 2011; Wiers et al., 2015). Consistent with our findings, results have suggested overlap in impulsivity-related and cognitive bias-related areas of activation. For example, in line with incentive sensitisation theories, dopamine reactivity has been implicated in the modulation of attentional bias towards substance-related cues (see Luijten et al., 2014 for review). Related, dopamine receptor activity is also considered to play critical role in a variety of impulse control behaviours and disorders (O’Sullivan et al., 2011; Voon et al., 2010). Generally, the dopaminergic reward system inclusive of the left orbitofrontal cortex, left insula, and right ventral striatum has been linked to reward sensitivity traits (Costumero et al., 2013). Activations in the dorsolateral prefrontal cortex (Cousijn et al., 2012), medial prefrontal cortex (Wiers et al., 2015a), and amygdala (Wiers et al., 2015b) have been observed in relation to approach bias. These same areas have been linked with rash impulsivity (Boy et al., 2011) and reward sensitivity (Sripada et al., 2011). For example, greater activity in the right inferior frontal gyrus has been noted for heavy users of marijuana during memory bias assessment (Ames et al., 2013) and this may be due to a greater need for these individuals to apply top-down influence to inhibit responses towards substance-related cues (Jentsch et al., 2014).
5.4.2. Clinical Implications

The findings of the current meta-analytical review have a number of clinical implications. Within addiction treatment settings, impulsive tendencies have largely been addressed by actively targeting explicit thoughts, attitudes, and beliefs (e.g., Krishnan-Sarin et al., 2006; Staiger et al., 2014). As an example, mindfulness-based approaches (e.g., Urge surfing; Bowen et al., 2009; Bowen & Marlatt, 2009) typically encourage the engagement of reflective awareness of the present moment to counteract automatic responding. Research has suggested that interventions such as mindfulness may serve to decouple the relation between implicit cognitive biases and substance misuse, but do not directly reduce the cognitive bias itself (Ostafin et al., 2013). As Rooke et al. (2008) suggest, even if interventions are effective in changing explicit thoughts and attitudes around substance misuse, this may not impact subtle cognitive processes that operate largely outside an individual’s awareness. Supporting this, a meta-analysis by Reich et al. (2012) found that implicit cognitive biases provided unique predictive power of alcohol use beyond that of explicit measures alone. Further, they found that implicit measures and explicit measures correlated only to a small, but significant, degree. This suggests that the presence of cognitive biases may not be strongly linked to changes in explicit processes (e.g., expectancies), possibly accounting for poorer treatment outcomes and retention rates associated with heightened impulsivity (e.g., Helmus et al., 2001; Roll et al., 2004; Staiger et al., 2014; Stevens et al., 2014). From this perspective, there is clear potential in examining interventions that target implicit cognitive biases as an adjunctive
to traditional therapeutic interventions for substance misuse – a notion that is consistent with a multi-faceted approach targeting transdiagnostic treatment targets in substance misuse (e.g., Sofuoglu, DeVito, Waters, & Carroll, 2016). Interestingly, a growing body of literature is emerging which shows that substance misuse outcomes are improved if these implicit cognitive biases are modified using a family of novel interventions known as Cognitive Bias Modification (CBM; see Eberl et al., 2013; Manning et al., 2016; Wiers et al. 2011, 2013). Indeed, in line with this interpretation, researchers are currently examining the additive benefits of integrating CBM with traditional psychosocial treatments of addiction (e.g., Boffo et al., 2015).

Interestingly, the relationship between impulsivity and cognitive biases was not moderated by the two-component conceptualisation of impulsivity (rash impulsivity and reward sensitivity), or any other factors. Rash impulsivity and reward sensitivity have each been related to differential substance misuse presentations (e.g., Dissabandara et al., 2014; Loxton et al., 2008; Lyvers et al., 2009; Pardo et al., 2007; Stautz & Cooper, 2013), with rash impulsivity in particular being associated with more riskier forms of substance misuse (Dissabandara et al., 2014; Loxton et al., 2008), more problematic substance misuse (Gullo et al., 2011a), and polysubstance misuse (Conway et al., 2003; Martinotti et al., 2009; Lackner et al., 2013; Pardo et al., 2007). In contrast, due to an amplified receptiveness to the positive reinforcement provided by substance misuse (Dawe et al., 2004), reward sensitivity has been associated with earlier initiation of substance misuse (Dissabandara et al., 2014; Lyvers et al., 2009; Pardo et al., 2007). Our findings suggest that despite these differing clinical presentations, both
rash impulsivity and reward sensitivity may relate to substance-related cognitive biases with a similar strength of association. This may indicate that CBM-related interventions could be appropriately applied across these presentations, however further research will be required to determine for whom CBM may be most appropriately targeted towards.

5.4.3. Limitations and Conclusion

The current review has several limitations that are typically experienced with meta-analyses. First, as described, due to the nature of the reported data included in the review, a number of key decisions were made with regard to the specific associations analysed. For example, the decision to use the general-domain version of the Delay Discounting Task over the specific-domain substance-related versions (e.g., alcohol, cigarettes). These decisions were made to ensure that the appropriate analyses could be conducted in order to best assess the relationship between impulsivity and substance-related cognitive biases. Though every effort was made to base these decisions on sound theory and evidence, it is possible that data yielding different results were not included in the sample. Second, it is recognised that the majority of the studies included in the sample were cross-sectional in design. This limits interpretations of our results and highlights the need for further research examining impulsivity and substance-related cognitive biases utilising longitudinal research designs. Additionally, it is acknowledged that data that could not be obtained from authors could have yielded different results than that reported. Third, our analysis of rash impulsivity was inclusive of negative urgency (e.g., Coskunpinar et al., 2013; Field et al., 2007b). Though there are conceptual
similarities between these constructs related to the disposition towards rash action, an emotional component of negative urgency (Cyders & Smith, 2008) is not captured by rash impulsivity. Thus the inclusion of urgency measures may have affected results. Lastly, it is recognised that while a general aim of the current meta-analysis was to examine the relationship between impulsivity and cognitive biases across a range of addictive substances, a majority (14) of the studies included examined alcohol. As such, the inclusion of five non-alcohol studies may have diluted the overall effect size. Thus, our findings provide preliminary evidence of a relationship between impulsivity and substance-related cognitive biases across substances, however there is a distinct need for further research to be conducted for non-alcohol substances.

In sum, the current meta-analytical review is the first to comprehensively investigate the relationship between impulsivity across attentional, memory, and approach biases, demonstrating a significant, albeit weak positive relationship between these constructs. Results indicate that this relationship is not moderated by a two-component conceptualisation of impulsivity, impulsivity measurement type, gender, or age. It is possible that impulsivity may interact with cognitive biases via heightened incentive salience attribution, possibly by increasing the propensity for these biases to develop following substance misuse. At this stage however, such conclusions remain tentative and future research is warranted.
Chapter Six

Impulsivity as a Moderator of Alcohol Cognitive Bias Modification Training during Inpatient Detoxification

Note: This chapter presents data collected as part of a larger RCT project published in the journal Alcoholism: Clinical and Experimental Research. A pdf copy of the published article has been appended for your consideration (Appendix B).

6.1. Introduction

Contemporary dual process theories of substance dependence (e.g., Stacy & Wiers, 2010, Wiers et al., 2007) propose that an interplay of two systems governs behavioural decisions for continued substance misuse. A fast, impulsive system that operates automatically through activation of associative networks and cognitive biases based on the motivational significance of stimuli, and a slower, reflective system that encompasses conscious deliberation, decision-making, and regulatory ability. Based on these theories, both systems are activated simultaneously in the presence of substance-related stimuli. Substance dependence is posited to occur however, when repeated substance misuse chemically enhances the impulsive system and compromises the reflective system, resulting in an imbalance between the two such that stronger impulsive processes drive continued substance misuse (Stacy & Wiers, 2010).

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1 The author of the present thesis (Daniel Leung) acted as lead HDR student and was involved in the conceptualisation, project management, data collection, design, and manuscript editing of the RCT. The author’s unique contribution involved examining the role of impulsivity in a CBM treatment for alcohol dependence.
In recent years, a number of computerised interventions have been developed that specifically target and manipulate the cognitive biases associated with the impulsive system. These interventions, broadly termed Cognitive Bias Modification (CBM; MacLeod, 2012) procedures, are designed to retrain cognitive biases away from substance-related cues (e.g., alcohol) to ultimately reduce substance misuse (e.g., drinking). Of note, promising findings in community and clinical settings have been reported following manipulation of alcohol approach bias – the automatic tendency to approach alcohol-related stimuli (Wiers et al., 2013a). In these studies, utilising a modified version of the alcohol Approach-Avoidance Task (A-AAT; Wiers et al., 2009), participants are asked to respond with a joystick to pictures of alcoholic and non-alcoholic beverages presented on a computer. Specifically, participants are tasked to push away almost all alcohol pictures (i.e., avoid action) and pull towards almost all non-alcoholic pictures (i.e., approach action). After a single session, participants demonstrated a reduction in approach bias and reduced drinking behaviour in a bogus taste test (Wiers et al., 2010b). Similar findings have been reported in a clinical sample of 214 alcohol-dependent inpatients (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011) where participants in the training group showed significantly reduced relapse rates at one-year follow up. These findings were replicated in a large-scale study of 509 alcohol-dependent patients (Eberl et al., 2013) where, additionally, changes in approach bias were found to mediate the clinical effect.
6.1.1. Moderators of CBM

Despite promising results, at present, there is limited research that has investigated variables that predict successful response to CBM interventions for substance misuse. Previous findings have suggested that relatively weak executive control ability (Houben & Wiers, 2009) and working memory (Thush et al., 2008) moderate the predictive power of implicit cognitive biases and alcohol use. Specifically, in those individuals with weaker executive control or lower levels of working memory capacity, substance-related cognitive biases are more strongly related to alcohol use. Based on these results, these variables have been theorised to moderate responsivity to CBM, however, to date only one study has examined this hypothesis and did not find support (Eberl et al., 2013). Hence, this hypothesis requires further investigation given the importance of understanding who might benefit most from CBM.

The most promising finding in this area indicates that those with strong approach bias at pre-test benefit most from CBM to reduce alcohol use (Eberl et al., 2013). The face value interpretation of this result makes intuitive sense: those who have an existing strong approach bias are likely to benefit from interventions designed to reduce it. However, the clinical application of this finding remains limited as the presence of strong approach bias has not been differentially associated with any particular substance misusing presentations. That is, without formally assessing and interpreting an approach bias measure conducted at the onset of treatment, matching CBM interventions for those with strong approach bias is likely difficult based on clinical presentation alone.
6.1.2. Impulsivity as a Moderator of CBM

Recently, the construct of impulsivity has been noted to be a potential variable that interacts with cognitive biases (e.g., Coskunpinar & Cyders, 2013, Field & Cox, 2008; Leung et al., 2017). The two-factor model of impulsivity comprising rash impulsivity – defined by the inability to inhibit prepotent behaviour – and reward sensitivity – defined by an individual’s propensity to be motivated by rewarding stimuli – has been posited to closely align with neurobiological models of substance dependence in the context of enhanced incentive salience and poor inhibitory control (see Gullo et al., 2014 for recent review). Importantly, these two factors have been differentially related to specific substance misuse behaviour and presentations with general findings suggesting rash impulsivity is related to high-risk behaviour such as problematic (Gullo et al., 2011a) and poly-substance use (Loxton et al., 2008), higher dose intake, and lower treatment-seeking (Dissabandara et al., 2014). Reward sensitivity, in contrast, has been linked to earlier experimentation and initiation behaviour (Dissabandara et al., 2014; Lyvers et al., 2009; Pardo et al., 2007). As such, if rash impulsivity or reward sensitivity traits interact with cognitive biases, there is clear benefit in being able to match these impulsivity-based presentations to appropriate CBM interventions.

At a theoretical level, impulsivity has been suggested to interact with and enhance the classical conditioning processes underlying the development of cognitive biases (Coskunpinar & Cyders, 2013) and affect dopaminergic reward responsivity associated with substance misuse (Robinson & Berridge, 2008). Indeed, research has indicated that rash
impulsivity positively relates to cognitive biases across substances (Coskunpinar & Cyders, 2013; Leung et al., 2017), moderates the relationship between cognitive biases and alcohol use (Burton et al., 2012), and is enhanced when exposed to alcohol-related cues where cognitive biases are activated (Noël et al., 2007). Additionally, interventions that have been designed to reduce impulsive responding to alcohol cues have been related to changes in implicit cognitive biases towards alcohol (Bowley et al., 2013; Houben, Nederkoorn, Wiers, & Jansen, 2011). For example, Houben et al. (2011) examined the effects of inhibitory control training on alcohol consumption. Participants were assigned to complete a modified Go/NoGo training task that either paired alcohol-related stimuli with a Go cue (Beer Go condition) or a NoGo cue (Beer NoGo condition). They reported that those who completed inhibitory control training (Beer NoGo condition) consumed significantly less weekly alcohol intake. Further, following training these participants also displayed significantly increased negative cognitive bias towards alcohol. Bowley et al. (2013) reported consistent results in their replication study. Additionally however, EEG asymmetry analyses also suggested decreased approach motivation towards alcohol stimuli following training. These findings parallel that of the food and obesity literature where the combination of heightened rash impulsivity and cognitive biases is predictive of increased food intake (Kakoschke, Kemps, & Tiggemann, 2015) and are significantly related among those who are obese (Bongers et al., 2015). These lines of evidence suggest that rash impulsivity may interact with the development and maintenance of substance-related cognitive biases. This then suggests that rash impulsivity may be a
moderating variable for CBM responsivity. The rationale being that those who are highly rash impulsive are likely to develop stronger approach bias, suggesting that these individuals will benefit from CBM most. Reward sensitivity may also play a similar role in this respect, particularly as cognitive biases are theorised to reflect an individual’s appetitive motivation towards substance-related cues (Stacy & Wiers, 2010). However, there is currently a lack of evidence to provide a strong directional hypothesis for reward sensitivity as a predictor of CBM responsivity.

6.1.3. Impulsivity as a Potential Treatment Target

The interaction between impulsivity and substance-related cognitive biases suggests potential clinical utility for CBM to target impulsivity itself. Despite decades of evidence to indicate impulsivity as a risk factor and consequence of substance misuse (de Wit, 2009; Dick et al., 2010; Grant & Chamberlain, 2014; Verdejo-Garcia, Lawrence, & Clark, 2008), limited research has been conducted examining the targeted effects of substance misuse interventions on trait impulsivity (Blonigen, Timko, Moos, & Moos, 2009; Staiger et al., 2014). This is possibly due to the view of trait impulsivity as a relatively stable and enduring construct throughout the lifespan. Despite this however, various lines of indirect evidence indicate that trait impulsivity is amenable to change and should be considered a dynamic construct. Impulsive traits have been shown to decline with older age (Steinberg et al., 2008) and when social or other contextual factors require increased self-control and responsibility (Roberts, Caspi, & Moffitt, 2003). In line with these findings, substance misuse interventions that promote self-efficacy and emotional regulation such as Alcoholics
Anonymous (AA; Blonigen et al., 2009, 2011), Cognitive Behavioural Therapy (CBT; Crane & Blud, 2012), and mindfulness approaches (Himelstein, 2011) have been related to post-intervention decreases in trait impulsivity. Indeed, the focus of these interventions to facilitate heightened self-control over an individual’s impulses appears to share a common overlap with decreased impulsive tendencies.

Cognitive bias modification may also act through similar mechanisms. As Wiers et al. (2013) suggest, CBM may allow an individual to override their approach bias towards alcohol by providing an increased “window for decision making” (p. 201). That is, the relevant stimulus-response associations trained by CBM not only directly enhance inhibition towards alcohol-related stimuli, but also provide the opportunity for regulatory skills to be recruited. In addition, CBM has been proposed to affect neural areas of the brain relevant to impulsive tendencies. For example, following CBM to retrain alcohol approach bias, Wiers et al. (2015) reported reductions in medial prefrontal cortex activation that was related to reductions in approach bias scores and alcohol craving. Further, there is also evidence to indicate alcohol approach bias is related to increased activity in the ACC (Ernst et al., 2014). This is consistent with previous suggestions that CBM may operate by enhancing the strength of prefrontal cortex and ACC areas related to impulsive responding (Ernst et al., 2014; Wiers & Wiers, 2017). Taken together, these lines of research are suggestive of CBM as a potential candidate intervention to reduce impulsivity. At present however, there has been no previous investigation of CBM’s effects on impulsivity. Such findings may provide an indication as to the mechanisms through which CBM acts to
reduce substance misuse, as well as guide CBM interventions towards individuals that will benefit most.

6.1.4. Current Study

Recently, our research group completed a randomised controlled trial of CBM training using the A-AAT to reduce relapse among alcohol-dependent individuals undergoing inpatient detoxification (Manning et al., 2016). We found that at two-week follow-up, participants who completed CBM training displayed significantly higher abstinence rates than controls. However, this paper did not examine differential responsivity to CBM training or changes in rash impulsivity following intervention. Therefore, the focus of this study is to test the hypotheses that rash impulsivity and reward sensitivity act as significant predictors of successful response to CBM training for alcohol use and, secondly, to examine whether rash impulsivity is significantly modified following CBM training.

6.2. Method

6.2.1. Participants

A total of 87 participants were recruited from two residential detoxification facilities in Melbourne, Australia. Participants were eligible for inclusion if they met the following criteria: (1) Aged 18 to 60 years; (2) English speaking; (3) At least weekly alcohol intake in the previous month; and (4) Meet DSM-5 criteria for alcohol use disorder (AUD). Participants were excluded if they had a history of neurological illness or traumatic brain injury involving loss of consciousness of 30 minutes or more. Demographic characteristics of the participant sample are provided in Table 6.1.
6.2.2. Measures

**Clinical interview.** At baseline, demographic information including date of birth, gender, highest education level achieved, relationship status, employment status, and housing information were collected. Clinical information was also obtained including age of onset of AUD, medication prescribed over the course of detoxification, and history of mental health diagnoses.

**Timeline Followback (TLFB).** The TLFB (Sobell & Sobell, 1992) is a well-established assessment tool used to assess alcohol use over the previous 30-day period. The TLFB has shown to have high temporal stability and convergent and discriminant validity with other substance use measures and information from third-party sources regarding an individual’s substance misuse (Fals-Stewart, O’Farrell, Freitas, McFarlin, & Rutigliano, 2000; Robinson, Sobell, Sobell, & Leo, 2014).

**Alcohol Craving Questionnaire – Short Form – Revised (ACQ-SF-R).** The ACQ-SF-R (Singleton, Tiffany, & Henningfield, 1994) is a 12-item measure of craving for alcohol in the present time (i.e., right now). It provides an overall craving index derived by summing all items and dividing by 12 (total ACQ score). It comprises four subscales: (1) Compulsivity – urges and desires in anticipation of loss of control over drinking; (2) Expectancy – urges and desires to drink in anticipation of the positive benefits of drinking; (3) Purposefulness – urges and desires to drink couple with intent and planning to drink; and (4) Emotionality – urges and desires to drink in anticipation of relief from withdrawal and/or negative affect.
Severity of Alcohol Dependence Questionnaire (SADQ). The SADQ (Stockwell, Sitharthan, McGrath, & Lang, 1994) is a 20-item screening tool designed to measure level of alcohol dependence. It comprises five subscales: (1) Physical withdrawal symptoms; (2) Affective withdrawal symptoms; (3) Craving and relief drinking; (4) Typical daily consumption; and (5) Reinstatement of dependence after a period of abstinence. Each item is scored on a four-point scale, providing a possible range of scores between 0 and 60. A score of >30 indicates severe alcohol dependence.

Impulsivity subscale of the I7 Impulsivity Questionnaire. Rash impulsivity was measured by the impulsivity subscale of the I7 (Eysenck, Pearson, Easting, & Allsop, 1985). The impulsivity subscale comprises 19 items requiring ‘yes’ or ‘no’ responses. The I7 has a reported Chronbach’s α of 0.84 indicating good internal consistency, and a one-year test-retest reliability of 0.76 (Eysenck et al., 1985).

Sensitivity to Reward (SR) subscale of the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ). The SR subscale of the SPSRQ (Torrubia et al., 2001) is a 24-item measure of reward sensitivity. The SR is reported to have acceptable internal consistency (α = .78 for males, α = .75 for females) and test-retest reliability, as well as acceptable construct, convergent, and divergent validity (Torrubia et al., 2001).

6.2.3. Intervention

The Alcohol Approach-Avoidance Task (Wiers et al., 2011) was used for the experimental group using E-Prime 2.0 software (Psychology Software Tools, 2012). In this program, participants were instructed to push away on a joystick (avoidance motion) when presented with a portrait-oriented
image on a laptop, and pull towards (approach motion) when presented with a landscape-oriented image. Pushing on the joystick decreased the size of the presented image simulating an avoidance sensation, while pulling on the joystick increased the size of the presented image simulating an approach sensation. A total of 50 alcohol and 50 non-alcoholic beverages commonly available in Australia were presented to participants in random order. All portrait-oriented images were alcoholic drinks (e.g., wine, beer) and all landscape-oriented images were non-alcoholic drinks (e.g., soft drink, juice), however this was not made known to participants.

Participants in the control condition completed sham training matched to the experimental condition. These participants were instructed to push away on the joystick in response to portrait images of kitchenware and pull towards on the joystick in response to landscape images of office stationery. In both experimental and control conditions, errors in joystick motions produced a red “X” on the screen. When this occurred, the participant was required to correct the error with the correct joystick response. For both conditions, a total of 120 trials were presented in each training session and took approximately 10 to 15 minutes to complete. Figure 6.1. presents examples of stimuli presented and response required.
Figure 6.1. Example stimuli and associated response required in CBM training condition.

6.2.4. Procedure

Suitable participants were recruited by researchers on day three or four of their inpatient detoxification admission. Following completion of informed consent documents, participants completed demographic and contact information forms, baseline measures of alcohol use across the previous 30-day period prior to admission (TLFB), alcohol craving (ACQ-SF-R), rash impulsivity (I7), and reward sensitivity (SR). Following, participants were randomly allocated to complete four sessions of CBM or sham training using a computerised random string generator developed by an independent researcher. Participants completed the first session following completion of baseline measures, with subsequent training sessions taking place over the following three days (one session per day). Following completion of the final (fourth) training session, participants were asked to complete post-intervention measures of alcohol craving (ACQ-SF-R) and rash impulsivity
(I₇). Follow up telephone interviews were conducted two weeks post-discharge from inpatient detoxification where alcohol use over the previous 14 days (TLFB), alcohol craving (ACQ-SF-R), and rash impulsivity (I₇) were again completed. Participants were reimbursed a $20 store voucher for completing the four training sessions during detoxification and a $10 store voucher for completing the follow up telephone interview. Figure 6.2. presents the flowchart of the trial design.

**Figure 6.2. Flowchart of trial design.**

### 6.2.5. Statistical analyses

All statistical analyses were conducted using SPSS 22.0 statistical software. Separate logistic regression analyses were used to assess whether
rash impulsivity and reward sensitivity moderated the effectiveness of CBM training (versus sham training condition) to reduce alcohol relapse rates. In these analyses, an interaction variable was created between group condition (CBM vs. sham training) and the moderating variable (rash impulsivity or reward sensitivity). The main outcome variable was the binary outcome of abstinence or relapse, defined as any alcohol consumption following detoxification.

A 2x3 mixed between-within subjects analysis of variance (ANOVA) was used to examine the effect of CBM training (compared to sham training) on rash impulsivity levels across three time periods (baseline, post-intervention, and two-week follow up). Preceding these analyses, relatedness of relevant variables were examined using Pearson r correlations.

6.3. Results

Table 6.1. displays the demographic characteristics of the participant sample, reproduced from the analysis provided in Manning et al. (2016) for convenience. As shown, no significant differences were observed between CBM training and sham training groups among these variables. Table 6.2. displays clinical participant variables, rash impulsivity, and reward sensitivity means for each group. Again, no significant differences were observed for these variables in the current sample. Correlations of relevant variables are provided in Table 6.3.
### Table 6.1.
**Demographic participant characteristics for CBM training and sham training conditions**

<table>
<thead>
<tr>
<th>Demographic characteristic</th>
<th>CBM training (n = 41)</th>
<th>Sham training (n = 42)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (n male/% male)</td>
<td>18/43.9</td>
<td>24/57.1</td>
<td>0.23</td>
</tr>
<tr>
<td>Age (years)</td>
<td>40.2</td>
<td>39.8</td>
<td>0.86</td>
</tr>
<tr>
<td>Age of onset of AUD</td>
<td>23.7</td>
<td>21.1</td>
<td>0.18</td>
</tr>
<tr>
<td>Born in Australia</td>
<td>33/80.5</td>
<td>34/81.0</td>
<td>0.96</td>
</tr>
<tr>
<td>Tertiary/further education</td>
<td>11/26.8</td>
<td>19/45.2</td>
<td>0.08</td>
</tr>
<tr>
<td>Unemployed</td>
<td>27/65.9</td>
<td>32/76.2</td>
<td>0.30</td>
</tr>
<tr>
<td>Relationship status (single)</td>
<td>24/58.5</td>
<td>31/73.8</td>
<td>0.14</td>
</tr>
<tr>
<td>Psychiatric comorbidity</td>
<td>36/87.8</td>
<td>40/95.2</td>
<td>0.22</td>
</tr>
<tr>
<td>Family history of AUD</td>
<td>26/63.4</td>
<td>28/66.7</td>
<td>0.76</td>
</tr>
</tbody>
</table>

*Note. Adapted from Manning et al. (2016). Continuous variables analysed with independent samples t-test (df=81); categorical variables analysed with chi-square test (df=1). All p-values are 2-tailed.*

### Table 6.2.
**Clinical participant characteristics, rash impulsivity, and reward sensitivity means for CBM training and sham training conditions**

<table>
<thead>
<tr>
<th>Clinical characteristic</th>
<th>CBM training (n = 41)</th>
<th>Sham training (n = 42)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total drinking days in the past two weeks (mean)</td>
<td>12.0/3.6</td>
<td>12.3/2.9</td>
<td>0.69</td>
</tr>
<tr>
<td>Total standard drinks in the past two weeks (mean)</td>
<td>167.9/126.4</td>
<td>218.0/190.9</td>
<td>0.16</td>
</tr>
<tr>
<td>Standard drinks per drinking day (mean)</td>
<td>17.9/8.2</td>
<td>22.0/14.3</td>
<td>0.06</td>
</tr>
<tr>
<td>Craving (ACQ-SF-R score)</td>
<td>3.9/1.3</td>
<td>4.1/1.2</td>
<td>0.31</td>
</tr>
<tr>
<td>Severity of alcohol dependence score (mean)</td>
<td>30.3/13.6</td>
<td>35.3/13.3</td>
<td>0.09</td>
</tr>
<tr>
<td>Rash impulsivity (I7 score)</td>
<td>10.6/4.2</td>
<td>11.3/4.8</td>
<td>0.53</td>
</tr>
<tr>
<td>Reward sensitivity (SR score)</td>
<td>12.5/5.3</td>
<td>12.2/5.3</td>
<td>0.77</td>
</tr>
</tbody>
</table>

*Note. Adapted from Manning et al. (2016). Continuous variables analysed with independent samples t-test (df=81). All p-values are 2-tailed.*
As reported in Manning et al. (2016), 68.6% of participants who completed CBM training reported abstinence at two-week follow up compared to 47.2% of participants who completed sham training. With an intention-to-treat (ITT) approach, this difference approached significance, $\chi^2(1, N = 71) = 3.32, p = .07$. However, for treatment completers (i.e., participants who completed all four sessions of CBM), this difference was significant, $\chi^2(1, N = 61) = 5.80, p = .02$. Thus, moderation analyses of rash impulsivity and reward sensitivity using logistic regression were conducted for treatment completers. The results of these analyses are presented in Table 6.4. and Table 6.5. respectively. Overall, the model with rash impulsivity as a predictor and moderator was nonsignificant, $\chi^2(5, N = 58) = 6.60, p = .25$. However, group remained a significant predictor (OR = 4.02, 95% CI = 1.24 - 12.99) indicating that participants who completed CBM training were four times more likely to report abstinence. Rash impulsivity did not emerge as a significant moderator in this model, $B = .02$, Wald = .02, $p$.
The model with reward sensitivity as a predictor and moderator was similarly nonsignificant overall in predicting outcome, \( \chi^2(5, N = 57) = 7.50, p = .19 \); however again, group remained a significant predictor of abstinence (OR = 4.29, 95% CI = 1.26 – 14.71). Like rash impulsivity, reward sensitivity did not emerge as a significant moderator in this model, \( B = .13, \text{Wald} = 1.28, p = .26 \).

### Table 6.4.
**Logistic regression with rash impulsivity as moderator**

<table>
<thead>
<tr>
<th>Block 1</th>
<th>B</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SADQ</td>
<td>-.02</td>
<td>.02</td>
<td>.61</td>
<td>1</td>
<td>.43</td>
<td>.98</td>
</tr>
<tr>
<td>Age</td>
<td>-.01</td>
<td>.04</td>
<td>.10</td>
<td>1</td>
<td>.75</td>
<td>.99</td>
</tr>
<tr>
<td>Block 2</td>
<td>Group</td>
<td>-1.39</td>
<td>.60</td>
<td>5.38</td>
<td>1</td>
<td>.02</td>
</tr>
<tr>
<td>I7 (baseline)</td>
<td>.03</td>
<td>.09</td>
<td>.10</td>
<td>1</td>
<td>.75</td>
<td>1.03</td>
</tr>
<tr>
<td>Block 3</td>
<td>Group x I7 (baseline)</td>
<td>.02</td>
<td>.14</td>
<td>.02</td>
<td>1</td>
<td>.90</td>
</tr>
</tbody>
</table>

*Note. All p-values two-tailed.*

### Table 6.5.
**Logistic regression reward sensitivity as moderator**

<table>
<thead>
<tr>
<th>Block 1</th>
<th>B</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SADQ</td>
<td>-.02</td>
<td>.02</td>
<td>.58</td>
<td>1</td>
<td>.45</td>
<td>.98</td>
</tr>
<tr>
<td>Age</td>
<td>&lt;.01</td>
<td>.04</td>
<td>&lt;.01</td>
<td>1</td>
<td>.99</td>
<td>1.00</td>
</tr>
<tr>
<td>Block 2</td>
<td>Group</td>
<td>-1.46</td>
<td>.63</td>
<td>5.42</td>
<td>1</td>
<td>.02</td>
</tr>
<tr>
<td>SR (baseline)</td>
<td>&lt;.01</td>
<td>.07</td>
<td>&lt;.01</td>
<td>1</td>
<td>.97</td>
<td>1.00</td>
</tr>
<tr>
<td>Block 3</td>
<td>Group x SR (baseline)</td>
<td>.13</td>
<td>.12</td>
<td>1.28</td>
<td>1</td>
<td>.26</td>
</tr>
</tbody>
</table>

*Note. All p-values two-tailed.*

A 2x3 mixed between-within subjects ANOVA revealed no significant interaction between group and time, Wilks’ Lambda = .99, \( F(2, 52) = .13, p > .05 \), partial eta squared = .01, suggesting that CBM training did not reduce rash impulsivity scores significantly differently to sham training. Results indicated a significant main effect of time, Wilks’ Lambda = .88, \( F(2,52) = 3.64, p < .05 \), partial eta squared = .12, with both group conditions showing decreases in rash impulsivity scores post-intervention and at two-week follow up with a moderate effect size (Cohen, 1988). Table 6.6. provides
mean rash impulsivity scores for CBM and sham training groups across the
three time periods (represented graphically in Figure 6.3). The main effect of
group was not significant, $F(1,53) = .89, p > .05$, partial eta squared = .02.

Table 6.6.
*Rash impulsivity (I7) scores for CBM training and Sham training groups across
time periods*

<table>
<thead>
<tr>
<th>Time period</th>
<th>CBM training</th>
<th></th>
<th></th>
<th>Sham training</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Baseline</td>
<td>28</td>
<td>10.79</td>
<td>3.76</td>
<td>27</td>
<td>11.81</td>
<td>4.82</td>
</tr>
<tr>
<td>Post-intervention</td>
<td>28</td>
<td>10.11</td>
<td>5.16</td>
<td>27</td>
<td>11.22</td>
<td>5.29</td>
</tr>
<tr>
<td>Two-week follow up</td>
<td>28</td>
<td>9.68</td>
<td>5.12</td>
<td>27</td>
<td>11.07</td>
<td>5.06</td>
</tr>
</tbody>
</table>

*Figure 6.3. Mean rash impulsivity scores for CBM training and sham training conditions*

6.4. Discussion

The primary aims of the present study were to investigate whether
rash impulsivity and reward sensitivity acted as significant moderators of
successful response (i.e., abstinence) to alcohol CBM training, and to
examine if levels of rash impulsivity significantly change following CBM training. Results indicated that rash impulsivity and reward sensitivity were not significant moderators of CBM training responsivity and, contrary to hypothesis, rash impulsivity did not change significantly compared to sham training.

Our finding that rash impulsivity was not a moderator of CBM training was unexpected, given previous research that has suggested rash impulsivity may act as an enhancer of the development and maintenance of substance-related cognitive biases (e.g., Coskunpinar & Cyders, 2013; Field & Cox, 2008; Leung et al., 2017; Robinson & Berridge, 2008). As the strength of cognitive bias pre-intervention has previously acted as a moderator to CBM responsivity (Eberl et al., 2014), this may suggest that the relationship between rash impulsivity and cognitive biases may not significantly impact upon potential treatment benefits from CBM-related interventions. Importantly however, our study utilised the Eysenck I7 as a measure of trait rash impulsivity. Though a widely-used measure of rash impulsive tendencies, previous meta-analytical findings have suggested a stronger relationship between impulsivity and cognitive biases when using behavioural measures of rash impulsivity (Coskunpinar & Cyders, 2013). Thus, behavioural measures may be better suited to capture differential responsivity to CBM training which itself is a behavioural-based task. To this end, there is a continued need for future research to utilise multi-modal forms of assessment rubrics when examining impulsivity’s role in substance misuse CBM interventions.
Though no moderating effect was found for rash impulsivity and reward sensitivity, these results are suggestive of the potential wide applicability of substance misuse CBM interventions across clinical presentations. That is, while there is strong evidence to indicate that components of rash impulsivity and reward sensitivity relate to poorer substance misuse treatment outcomes and retention rates (Charney, Zikos, & Gill, 2010; Evren, Durkaya, Evren, Dalbudak, & Cetin, 2012; Loree et al., 2014; Muller, Weijers, Boning, & Wiesbeck, 2008; Stevens et al., 2014), our results indicated that group condition (i.e., CBM training vs. sham training) continued to be a significant predictor of abstinence. This highlights the potential utility of CBM interventions to be used among the highly rash impulsive or reward sensitive substance user, who may otherwise respond poorly to treatment or terminate their treatment early. Furthermore, as these components of impulsivity have each been related to specific clinical presentations such as polysubstance and high-risk users (rash impulsivity; Dissabandara et al., 2014; Gullo et al., 2011a; Loxton et al., 2008) and earlier experimentation and initiation behaviour (reward sensitivity; Dissabandara et al., 2014; Lyvers et al., 2009; Pardo et al., 2007), our findings indicate that CBM may be an appropriate adjunct intervention for these at-risk clinical populations. Indeed, further research examining differential responsivity to CBM training will continue to aid in furthering understanding of the specific demographic and clinical characteristics that are associated with best outcomes following CBM interventions.

Our results did not support the hypothesis that CBM training would reduce rash impulsivity scores compared to sham training. One possible
explanation for this concerns the explicit nature of trait measurements of impulsivity such as the I7 used. That is, trait measures fundamentally rely on the explicit recall on personal characteristics and past behaviours that are more likely to generate responses related to long-term impulsive tendencies. Therefore, even if participants had reduced levels of approach bias towards alcohol following CBM training, this may have occurred at an implicit level but not an explicit level. Thus, when asked to respond to the I7 following CBM training and at follow-up, participants may have not been sensitive to the possible changes in rash impulsivity at a reflective level. As the current study relied on telephone follow ups, the use of self-report trait measures was necessitated, however further research may benefit from the use of impulsivity assessments that do not rely on explicit recall that may be conducted in face-to-face settings. This interpretation highlights the utility of using trait-based measurements of impulsivity in future research examining the additive benefits of combining implicit (e.g., CBM) and explicit (e.g., psychosocial interventions) substance misuse interventions, particularly as previous research has suggested changes in trait rash impulsivity following group therapeutic programs (e.g., Blonigen et al, 2009, 2011) and residential milieu therapy approaches (Bankston et al., 2009). Secondly, it is of note that results did not indicate a significant relationship between rash impulsivity and alcohol consumption levels. This is inconsistent with previous research that has indicated a link between levels of rash impulsivity and severity of substance dependence (Dom, Dhaene, Julstijn, & Sabbe, 2006; Marshall-Berenz et al., 2011) and gambling (Brevers et al., 2012). Therefore, it is possible that for the present study’s particular participant sample,
impulsivity may not have been a significant factor contributing to alcohol consumption. Thus, the effects of CBM training may not have been related to associated changes with rash impulsivity. It would be of high interest to see whether such results would be replicated in a sample congruent with a strong relationship between rash impulsivity and alcohol use.

Interestingly, the main effect of time observed in the present study suggests significant decreases in trait levels of rash impulsivity following inpatient residential detoxification. This is consistent with previous findings describing neurocognitive executive functioning improvements occur following alcohol detoxification (Manning et al., 2008; Manning, Teo, Guo, Wong, & Li, 2016) and that decreased impulsivity occurs among individuals following nine months in a therapeutic community (Bankston et al., 2009). To the authors’ knowledge however, our results are the first to indicate that trait impulsivity significantly reduces after short-term seven-day inpatient alcohol detoxification, indicating that even during this short period of time, supported alcohol abstinence can result in the self-reflection of increased control over impulsive responding. Therefore, despite the general view of trait constructs as temporally stable and enduring characteristics, our results add towards the growing understanding of trait impulsivity as a viable treatment target following intervention and highlight the need for further research to examine the benefits of current interventions on trait impulsivity.

6.4.1. Limitations and Conclusion

Several limitations should be noted when discussing the present study’s findings. First, the study did not include a specific measure of
approach bias and therefore changes in approach bias following CBM training were not able to be determined. As such, it was not possible to ascertain whether treatment outcomes were mediated by the change in approach bias (as previously reported in Eberl et al., 2013). Without this information, the present study’s findings cannot be definitively generalised across other CBM trials before examining these hypotheses among a sample where mediation of changes in approach bias is observed. Second, due to the constraints of conducting the RCT in an inpatient detoxification setting, we were unable to alter protocol to include behavioural measures of impulsivity which may be less affected by subjective reporting. We view this as an important area of further research in the CBM literature to continue determining characteristics and phenotypes that may be best matched to CBM interventions. Third, participants were followed up two-weeks post-discharge from detox. As the I7 (and various other trait measures) does not specify a time period when answering the questionnaire, participants may have responded to these questions with a more long-term general sensibility, rather than specifically on the time post-discharge. Though our results indicated a significant change in rash impulsivity following detox suggesting the I7 to be sensitive to change in this space of time, it is also possible that participants may have underreported reductions in impulsive tendencies leading to decreased sensitivity to changes in impulsivity and reducing overall power of our analyses.

Despite the limitations discussed, the present study provides evidence that CBM interventions may be appropriately utilised across rash impulsive and reward sensitive individuals that present for substance
misuse treatment. These specific presentations characterise a subset of the clinical population that may otherwise have poorer treatment outcomes or terminate treatment early (Charney et al., 2010; Evren et al., 2012; Loree et al., 2014; Muller et al., 2008; Stevens et al., 2014). Thus, the novel, low-cost, and efficient means through which CBM may be provided (see also Boendermaker, Prins, & Wiers, 2015) can be particularly beneficial for these individuals as an adjunct to traditional substance misuse treatment paradigms. Our results also indicate that trait rash impulsivity significantly decreases following short-term inpatient detoxification, further adding to the understanding of trait impulsivity as a potential treatment target amenable to change. Future research examining the role of impulsivity in CBM would benefit from the use of behavioural and trait measures of impulsivity to aid in determining the possible differences in affecting treatment outcomes.
Chapter Seven

General Discussion

The present thesis aimed to further understanding of the relationship between impulsivity and substance-related cognitive biases and to apply a two-factor conceptualisation of impulsivity in this investigation. It was argued that the factor of rash impulsivity is particularly associated with riskier forms of substance misuse behaviour such as polysubstance use. Further, rash impulsivity negatively impacts upon treatment outcomes and retention rates. It was proposed that this may be due to the executive functioning deficits associated with rash impulsive tendencies, suggesting traditionally complex, explicit interventions (e.g., CBT, mindfulness/acceptance approaches) may be less effective for the rash impulsive individual. As such, it was argued that implicit cognitive biases that do not rely on explicit cognitive processes may offer an attractive treatment target for those with heightened rash impulsivity.

Indeed, this thesis has proposed that impulsivity and cognitive biases may be interrelated constructs. Incentive sensitisation theories of addiction have previously proposed a dynamic interplay between impulsivity and cognitive biases such that the presence of heightened impulsivity contributes to an increased propensity for cognitive biases to develop and drive substance misuse behavior (Robinson & Berridge, 2008). This proposal is supported by correlational and moderation studies (Burton et al., 2012; Coskunpinar & Cyders, 2013; Friese & Hofmann, 2009). However, the empirical synthesis of previous findings of this relationship had not been
conducted, and none had previously examined the role of impulsivity in CBM-related clinical interventions for substance misuse.

The following sections of this chapter will review the primary aims, hypothesis, and findings of the two studies presented in this thesis. Following, a general discussion of these results is provided inclusive of the clinical and research implications. Finally, limitations and future directions for research are explored followed by concluding remarks.

7.1. Summary of Results

7.1.1. Meta-analysis of the Relationship between Impulsivity and Substance-related Cognitive Biases

This study aimed to summarise and synthesise previous research to examine whether there is a relationship between impulsivity and substance-related cognitive biases, and to examine how a two-factor conceptualisation of impulsivity (reward sensitivity and rash impulsivity) may influence this relationship. It was predicted that across the literature, impulsivity would display a significant positive relationship with cognitive biases and that rash impulsivity would be more strongly related to cognitive biases compared to reward sensitivity. Meta-analysis of 19 studies (41 effect sizes) indicated partial support of the hypotheses. Specifically, a small, significant positive relationship was observed between impulsivity and cognitive biases, and this relationship was consistent across attentional, memory, and approach biases. However, there was no significant difference in this relationship for rash impulsivity and reward sensitivity.

Second, this study further aimed to explore whether impulsivity measurement type (trait and behavioural) and demographic variables of
gender and age affected the relationship between impulsivity and cognitive biases. Notably, contrary to previous findings in the area (Coskunpinar & Cyders, 2013), impulsivity measurement type, gender, and age were not found to be significant moderators of the impulsivity-cognitive bias relationship.

Although one previous meta-analysis had been conducted for impulsivity and attentional bias (Coskunpinar & Cyders, 2013), this meta-analysis was limited by the inclusion of food-related studies and further did not examine memory and approach cognitive biases. Thus, the present meta-analysis was the first to demonstrate that a consistent association between impulsivity and cognitive biases is observed for traditional substances of dependence (excluding food studies), and that memory and approach bias also display a similar association.

7.1.2. Impulsivity as a Moderator of Alcohol Cognitive Bias Modification Training During Inpatient Detoxification

The primary aims of this study were to examine the role of impulsivity in the efficacy of a CBM training intervention to reduce alcohol use, and to investigate whether CBM may reduce rash impulsivity levels following intervention. It was hypothesised that rash impulsivity would moderate the efficacy of the CBM intervention such those higher in rash impulsivity would display lower relapse rates. Further, it was predicted that those who completed CBM training would show significantly reduced rash impulsivity levels compared to participants who completed sham training. Eighty-seven participants with alcohol use disorder were recruited from a residential detoxification facility and were randomised to complete either
four sessions of CBM alcohol approach bias training or sham training. Analyses were conducted with treatment completers (i.e., participants who completed all four sessions of CBM) as analysis indicated a significant difference in relapse rates between CBM and sham training for these participants.

Against expectations, moderation analyses indicated that rash impulsivity and reward sensitivity were not significant moderators of the efficacy of CBM alcohol approach bias training. In both models however, group (CBM training vs. sham training) remained a significant predictor of abstinence suggesting a robust effect of CBM training on abstinence even after inclusion of impulsivity variables.

Secondly, mixed between-within subjects ANOVA analyses revealed no significant interaction between group and time, suggesting that CBM training did not significantly reduce rash impulsivity scores compared to sham training. Notably, results did indicate that a significant main effect of time was present, suggesting that regardless of group allocation, rash impulsivity levels appeared to decrease post-intervention and at two-week follow up with a moderate effect size.

7.2. Implications of Present Thesis

7.2.1. Clinical Implications

For decades, the psychological construct of impulsivity has held a central role in the understanding of the initiation and maintenance of substance misuse behaviour (de Wit, 2009; Verdejo-Garcia et al., 2008). The findings of the present thesis extend upon this and suggest that impulsive tendencies may have an interactive relationship with cognitive biases
toward substance misuse. That is, results support the notion that impulsivity may exacerbate the development of cognitive biases, and may also contribute to ongoing dependence. This interpretation falls in line with previously proposed models of addiction and this will be discussed further in the following section. In relation to the impulsivity-cognitive bias relationship however, there may be clear clinical benefits towards the targeting of cognitive biases as an adjunct intervention for impulsive substance misusers. While results did not support the use of CBM to target impulsivity directly (specifically rash impulsivity), the use of CBM interventions have previously been shown to reduce the strength of substance-related cognitive biases (Eberl et al., 2013) and to generalise to cognitive biases outside that being directly targeted (Wiers et al., 2011). As such, CBM could potentially be used to partially mitigate the interactive effects between impulsive tendencies and cognitive biases. In particular, the combination of traditional psychotherapeutic interventions such as CBT and mindfulness/acceptance-based approaches that have been previously conceptualised as rubric approaches towards the management of impulsive responding and behaviour (Leeman et al., 2014; Tomko et al., 2016), in addition to CBM may offer a ‘best of both worlds’-approach to actively reducing substance misuse. That is, such multi-method approaches could be construed as reinforcing explicit, executive control capabilities while also reducing implicit processes in relation to substance misuse.

The concept of matching CBM-related interventions for impulsive substance misusers converges with previous proposals suggesting improved outcomes when personality characteristics are matched to appropriate
interventions (Staiger et al., 2007, 2014; Tomko et al., 2016). For example, Conrod, Castellanos-Ryan, and Mackie (2011) examined the outcomes of tailored, manualised therapeutic interventions based upon personality characteristics. Specifically, as part of the Preventure Trial, 2,530 adolescents completed the Substance Use Risk Profile Scale (SURPS; Woicik, Stewart, Pihl, & Conrod, 2009) which provides an indication of personality risk for substance misuse and psychopathology across four subscale dimensions: Hopelessness (H), Anxiety Sensitivity (AS), Impulsivity (IMP), and Sensation Seeking (SS). Notably the IMP and SS dimensions of the SURPS share conceptual similarities to rash impulsivity (i.e., assessing tendency toward rash, disinhibited behaviour and poor response inhibition) and reward sensitivity (i.e., assessing an individual's responsivity towards stimulating/arousing experience) respectively. Of these adolescents, those who scored above one standard deviation for these subscales were allocated to receive intervention (n = 364). Matched interventions incorporated psychoeducation and therapy techniques based upon CBT and motivational interviewing principles that were developed around specified personality trait dimensions. Their results indicated positive short-term and long-term outcomes of reduced drinking behaviour which has since been extended in additional randomised controlled trials for alcohol (e.g., Conrod et al., 2013; Newton et al., 2016; O’Leary-Barrett, Mackie, Castellanos-Ryan, Al-Khudhairy, & Conrod, 2010) and marijuana use (Mahu, Doucet, O’Leary-Barrett, & Conrod, 2015) when delivered in school contexts as a preventative measure.
Research conducted as part of this thesis supports the enhancement of clinician education regarding the utilisation of impulsivity profile assessment for clients, which may then be used to direct appropriate treatment pathways that may be most beneficial. In this context, as both rash impulsivity and reward sensitivity were found to be significantly related to all three cognitive biases across the literature, the use of brief, low-cost questionnaire assessments such as the I7 and the SPSRQ represent viable tools to meet these needs. As noted earlier, previous research suggests that clients who display heightened impulsivity levels characterise a subset of the clinical population at higher risk for poorer substance misuse treatment outcomes (Helmus et al., 2001; Kravitz et al., 1999; Loree et al., 2014; Patkar et al., 2004; Roll et al., 2004; Staiger et al., 2014) and retention rates (Moeller et al., 2001; Patkar et al., 2004). Such clients represent a clinical profile that could benefit highly from matched treatment interventions that are tailored towards their specific needs in order to maximise the opportunity for meaningful change to occur in relation to substance misuse patterns. Indeed, as strength of cognitive bias appears to also be relevant in the therapeutic benefit potential of CBM (Eberl et al., 2013), the combined assessment of impulsivity in addition to cognitive biases (using tools such as the AAT and IAT) could aid in directing appropriate clients to such interventions. The present thesis’ research results support the use of CBM for highly rash impulsive or reward sensitive substance misusers, and thus may have strong potential for use in this regard.

Though the use of comprehensive assessments of impulsivity and cognitive biases would be overall beneficial to the guidance of directed
intervention, in practice, even brief, additional assessment procedures may be unviable given possible limitations in a clinician’s time or available resources. However, a clear benefit of enhancing clinician understanding of impulsivity risk profiles is that rash impulsivity and reward sensitivity have each been repeatedly associated with particular clinical presentations. As discussed, rash impulsivity has been linked to risker substance misuse behaviours (Dissabandara et al., 2014), polysubstance use (Lackner et al., 2013; Loxton et al., 2008; Martinotti et al., 2009), and problematic use patterns (Gullo et al., 2011a). In contrast, reward sensitivity has been linked to earlier age of onset of substance misuse (Dissabandara et al., 2014; Pardo et al., 2007; Lyvers et al., 2009). Thus, even foregoing the use of formal assessment tools, these clinical presentations may be useful proxy markers of heightened rash impulsivity or reward sensitivity, and would therefore have potential to benefit from exposure to CBM interventions given a possible interrelated nature between these constructs. As CBM interventions themselves are generally low-cost and easily administered, a large spectrum of healthcare professionals may be suited to allocate particular client presentations towards these programs, making them more viably accessible in an array of treatment settings.

In addition to providing support for the utilisation of impulsivity profiles at assessment and CBM interventions, findings from this thesis also indicate that residential detoxification settings may offer a prime setting for such assessments and interventions to occur. Traditionally, residential withdrawal services provide medically supervised alcohol and drug withdrawal over a determined period of time. However, while some services
do provide some form of therapeutic intervention, such programs generally remain secondary – if provided at all – to the medical management of withdrawal itself. Results from this thesis’ study indicate that novel interventions such as CBM may be employed in such settings successfully for substance misusers who are highly rash impulsive or reward sensitive. As high levels of these impulsivity factors tend to associate with more severe symptoms of dependence (Dom et al., 2006; Marshall-Berenz et al., 2011), residential detoxification services could provide a critical opportunity to apply CBM interventions for these individuals, particularly as such withdrawal programs are often the first form of treatment service advocated for heavier substance misusers (Australian Government Department of Health and Ageing, 2009).

Indeed, neuroimaging studies have previously suggested that the early stages of abstinence is associated with levels of neurorecovery conducive to improved cognitive executive functioning. For example, while there is strong evidence to suggest chronic alcohol misuse is related with reduced volumes of gray and white matter in the brain (Chanraud et al., 2009; Demirakca et al., 2011), prolonged successful abstinence correlates with increased brain volume and recovery of various cognitive functioning deficits (Demiracka et al., 2011; Gazdzinski, Durazzo, Mon, Yeh, & Meyerhoff, 2010). In the short-term period of withdrawal such as that during detoxification, similar improvements in structural brain recovery and cognitive functioning are observed (van Eijk, Demiracka, Frischknecht, Hermann, Mann, & Ende, 2012; Manning et al., 2008). It is important to note however, that repeated withdrawal experiences can cause neurotoxic frontal
lobe damage, negatively affecting cognitive performance (de la Monte & Kril, 2014; Harper, 2007) and also impair neurocognitive functioning recovery (Loeber et al., 2010). In addition, repeated detoxification is linked with impairments in inhibitory control mechanisms that are central to the ability to resist future relapse (Duka & Stephens, 2014). Thus, in combination with the findings reported in this thesis, it appears that in order to capitalise best on the natural neuroplastic recovery observed during detoxification, neurocognitive interventions such as CBM may have peak utility during a client’s first and/or second episode of detoxification, particularly if these can be directed towards those high in rash impulsivity or reward sensitivity.

This thesis has also shown that undergoing detoxification itself is associated with reduced rash impulsivity levels. While these results require further replication, it does suggest that rash impulsivity is amenable to change over relatively short time periods. As such, from a dual-process perspective, early abstinence may also be a window of opportunity to capitalise on reduced impulsivity levels in order to decrease the strength of the approach-oriented cognitive biases via CBM intervention. That is, the targeting of cognitive biases could be optimal in the context of reduced impulsivity levels, where there may be less effect of impulsivity to exacerbate cognitive bias development and drive related behaviour.

7.2.2. Research Implications

Further to the clinical implications covered, the present thesis’ findings also inform a number of theoretical and research implications. Foremost, it is important to acknowledge that the studies conducted as part of this thesis are the first to examine a two-factor conceptualisation of
impulsivity in relation to substance-related cognitive biases. As such, findings reported herein expand upon previous research that has converged on two distinct factors of impulsivity (Gullo et al., 2014). As discussed in Chapter One and Chapter Two, rash impulsivity and reward sensitivity are constructs that are differentially predictive of specific aspects of substance misuse behaviour such as modality of substance ingestion (Dissabandara et al., 2014), presence of riskier or problematic forms of substance misuse behaviour (Gullo et al., 2011a; Loxton et al., 2008), and age of initiation of alcohol consumption (Dissabandara et al., 2014; Lyvers et al., 2009; Pardo et al., 2007). Despite these divergent associations, this thesis suggests, however, that in relation to substance-related cognitive biases, both rash impulsivity and reward sensitivity may play similar roles in affecting substance misuse. That is, both factors of impulsivity appear to be relatively equally relevant when considering how cognitive biases towards substance are initially developed and maintained when dependent. Thus, while some models of addiction have promoted rash impulsivity as a prime factor contributing to ongoing dependence (e.g., 2-CARS model; Gullo, Ward, Dawe, Powell, & Jackson, 2011), findings from the present thesis support the consideration of both rash impulsivity and reward sensitivity when examining impulsivity’s role in affecting implicit processes and related behaviour.

From this perspective, a consideration of rash impulsivity and reward sensitivity constructs has implications for theories of addiction that have previously posited an interrelated nature between impulsivity and cognitive biases. Specifically, incentive salience theories have proposed that impaired
inhibitory processes (i.e., rash impulsivity) act in combination with neurobiologically sensitised pathways that attribute incentive salience towards substance-related stimuli (Robinson & Berridge, 2008). These factors may affect each other to promote the progression towards substance dependence either through impulsivity’s role in potentially biasing classical conditioning processes that underlie cognitive biases or in affecting dopaminergic responsivity (Coskunpinar & Cyders, 2013). Though incentive sensitisation theories of addiction have typically emphasised the role of rash impulsivity in the progression of substance dependence (e.g., Robinson & Berridge, 2008), this thesis’ results suggest that an individual’s level of reward sensitivity may also be of similar importance. Indeed, neuroimaging studies have associated reward sensitivity with dopamine neurotransmission (Hahn et al., 2009, 2011; Laviolette, Lauzon, Bishop, Sun, & Tan, 2008) which is consistent with theoretical accounts of reward sensitivity that align with the Behavioural Approach System (BAS; Corr, 2004) of Gray’s Reinforcement Sensitivity Theory (RST; Gray, 1982).

Increased activation of dopamine neurotransmission in the brain is posited to underlie the sensitisation towards the incentive value of substances following repeated ingestion (Robinson & Berridge, 2008), suggesting an overlap of neurocognitive processes with reward sensitivity. ‘Synergistic’ interpretations of the impulsivity-cognitive bias relationship (e.g., Dawe et al., 2004; Field & Cox, 2008) have previously suggested that impulsive individuals may be more susceptible to the rewarding properties of substance-related stimuli in the environment. That is, substance-related stimuli may be more ‘attention-grabbing’ to the individual who is more
responsive to rewarding stimuli (i.e., reward sensitivity), particularly if incentive attribution has been chemically enhanced previously via substance ingestion. Further research is still required to delineate potentially differential roles of rash impulsivity and reward sensitivity's influence on cognitive biases in substance misuse.

A significant contribution of the present thesis' research investigation is the consideration of the all three prominent cognitive biases previously established in the substance misuse literature: attentional, memory, and approach bias. In so doing, this thesis’ results implicate the importance of these three biases in their relationship with impulsivity and substance misuse. Specifically, theories of addiction have typically emphasised a role for attentional bias in relation to impulsivity and subsequent substance misuse (e.g., Field & Cox, 2008; Robinson & Berridge, 2008); however, memory and approach biases similarly consistently relate to impulsivity, suggesting a level of equal influence from across these biases in relation to impulsivity and substance misuse. As suggested by the limited studies identified by the systematic review and meta-analysis that examined more than one cognitive bias at a time, the current state of the research literature is indicative of a constrained understanding of implicit cognitive biases as a set of processes influential in substance misuse. As a consequence, the findings reported herein are encouraging of future research endeavours in the area to consider the examination of a range of cognitive biases when investigating how these biases are informed by individual differences, phenotypical traits, and other constructs. A broader and more inclusive research paradigm in regards to substance-related cognitive biases will not
only allow comparative assessments of these processes to be made, but will also ultimately benefit overall understanding of these implicit processes and their role in informing substance misuse behaviour.

In addition, this thesis’ reported findings also provide preliminary indication for the viability of impulsivity facets to be active treatment targets. As argued in Chapter Two, while the study of impulsivity rests on over two decades of research suggesting it to be a central component to understanding substance misuse behaviour (de Wit, 2009; Fillmore, 2003; Perry & Carroll, 2008), the construct of impulsivity has generally not been a central focus of clinically targeted intervention. While this research landscape is slowly shifting with increasing attention paid to modifying behavioural impulsivity facets in recent years (e.g., Bowley et al., 2013; Houben et al., 2011; Houben, Havermans, Nederkoorn, & Jansen, 2012), extremely few studies have examined trait-based measures of impulsivity as targets of intervention. This is likely due to the general perception of trait measures of impulsivity as relatively static constructs and resistant to change following short-term intervention. Indeed, while this thesis did not support initial hypothesis for CBM to act as an intervention to reduce rash impulsivity, results did indicate significant reductions in trait impulsivity occurring in the short term of one to two weeks during and after residential detoxification. Alone, this finding highlights that trait-measured rash impulsivity can be viably reduced given specific changes in intra-individual and external circumstances. Indeed, considering rash impulsivity as a critical factor affecting treatment retention (Helmus et al., 2001; Kravitz et al., 1999; Moeller et al., 2001; Patkar et al., 2004; Roll et al., 2004), future relapse
episodes (Patkar et al., 2004; Loree et al., 2014) and the maintenance of substance dependence (Dawe et al., 2004), harnessing opportunities to target rash impulsivity could allow clinicians to maximise likelihood of improved clinical outcomes. It is important to note that based on the present thesis’ research, it still remains unknown which specific mechanisms underlie these observed shifts in rash impulsivity. These findings encourage future examination of trait-measured rash impulsivity as a potential target of intervention that could aid in furthering understanding of impulsivity’s role in substance misuse and improving associated clinical outcomes.

7.3. Limitations and Future Research Directions

It remains important to consider the findings of the present thesis in the context of the limitations associated with the research. Firstly, while an aim of the present thesis was to examine the relationship between impulsivity and substance-related cognitive biases across a broad variety of addictive substances, it is noteworthy that the majority (14 of 19) of the studies included in the meta-analysis were primarily examining alcohol and the investigation of CBM was also designed to target alcohol misuse. While these research investigations were based upon the current state of the literature and the emerging evidence to support approach bias retraining for alcohol misuse, interpretations based on the reported results may only be extrapolated as an indicator of a preliminary relationship between impulsivity and cognitive biases across addictive substances. This limitation signposts the infant state of the research literature in this area. There appears to be a crucial need for expanded research to investigate aspects of impulsivity and cognitive biases concurrently for non-alcohol substances.
Indeed, among differing substances of addiction, previous research has indicated differentiating components within theories of addiction that drive continued substance misuse (e.g., Wise & Koob, 2014). Consequently, future research endeavours that examine non-alcohol substances will ultimately broaden generalisability of findings for addictive substances in general and allow more specific interpretations of evidence to be made within broader theories of addiction.

Related to the premature state of the current literature base, a distinct lack of well-designed longitudinal research does not permit a specific directionality to be inferred for impulsivity’s relationship with cognitive biases. This thesis has interpreted the findings in the context of concurrent elevations of both impulsivity and cognitive biases as determined in a variety of cross-sectional research designs. However, as previously proposed (e.g., Field & Cox, 2008), the presence of heightened impulsivity could be a risk factor for exacerbating the development of substance-related cognitive biases. From another perspective, heightened strength of cognitive bias towards substances could lead to substance misuse which then can increase impulsive tendencies and responses (de Wit, 2009; Verdejo-Garcia et al., 2008). Findings from the present thesis, therefore, do not allow a specific directionality to this relationship to be established. Further research utilising longitudinal study designs and large study samples would be particularly valuable in examining this research question.

Importantly, the majority of studies included in the meta-analytic review encompassed participants from non-clinical population groups. However, the examination of CBM training intervention was conducted
among a clinical population. As such, this discrepancy may have resulted in differing results based upon clinical characteristics not accounted for in previous research. Unfortunately, due to a lack of previous studies examining the impulsivity-cognitive bias relationship among clinical participants, investigating whether differences in this relationship occur based upon clinical or non-clinical background was not possible. It would be of high interest to examine whether the relationship between impulsivity and cognitive biases is consistent or different depending on this factor, particularly as findings would implicate impulsivity and cognitive biases’ relationship as a consistent component in substance misuse behaviours.

This thesis’ primary aim was to examine the relationship between two factors: impulsivity and cognitive biases. However, it is noteworthy that theoretical accounts of cognitive biases’ influence on substance misuse behaviour has recognised and implicated related contextual factors that may impact upon these processes. As example, Wiers et al. (2007) propose that motivation to control or inhibit responses is important when considering whether an individual will behave in accordance with their drive towards substances. In other words, it is not only important that an individual have the ability to inhibit response towards substance-related stimuli, but also be willing to do so. Similarly, the examination of executive functioning capacity has received increased attention as a factor affecting the progression for an individual to act in line with their substance-related cognitive bias (Grenard et al., 2008; Thush et al., 2008). Factors such as these would be highly interesting to examine in relation to the impulsivity’s association with cognitive biases. Further still, examining whether combining CBM with
motivation-targeted interventions or executive functioning training tasks for impulsive substance misusers may help in specifying conditions for which CBM can benefit the rash impulsive or reward sensitive individual most.

Additionally, it is central to recognise that while the current thesis utilised a two-factor conceptualisation of impulsivity in its research investigation (based upon converging evidence to support the two-factor model), other models of impulsivity have been previously proposed in the literature. Therefore, interpretations made in the present thesis may be limited by the constraints of the two-factor model of impulsivity that do not capture additional variables that other models implicate. As example, the UPPS-P (Lynam et al., 2006; Whiteside & Lynam, 2001) model of impulsivity posits a central role for heightened positive and negative affective states that affect the tendency to engage in rash behaviour (Cyders & Smith, 2008; Stautz et al., 2017). Affective emotional states do not comprise a core component of the two-factor model of impulsivity (Gullo et al., 2014). Though previous research has failed to indicate differential relationships between the UPPS-P model and attentional bias (Coskunpinar & Cyders, 2013), the consideration of multiple models of impulsivity in future research will be ultimately allow greater understanding of how impulsivity relates to substance-related cognitive biases.

Finally, consideration of multiple models of impulsivity additionally implicates the benefits of using multi-modal forms of impulsivity assessment in future research. In particular, the use of both trait- and behavioural-based forms rash impulsivity and reward sensitivity would provide greater understanding towards how these factors relate to substance-related
cognitive biases. Indeed, it has been previously argued that behavioural-based measures of impulsivity may provide greater temporal ‘closeness’ to cognitive biases (Coskunpınar & Cyders, 2013), which may allow more precise measurements of an individual’s impulsive state as opposed to trait measures. Combining both approaches in addition to considering multiple models of impulsivity would ultimately be beneficial to understanding these factors in substance misuse overall.

7.4. Conclusion

This thesis examined the relationship between impulsivity and substance-related cognitive biases utilising a two-factor conceptualisation of impulsivity. Firstly, results of this thesis highlighted that a consistent relationship is observed between impulsivity and cognitive biases across the literature, expanding upon previous research and theoretical accounts of addiction that have suggested a dynamic and potentially synergistic association between the two constructs contributing to substance misuse behaviour. This association showed relative consistency across cognitive bias type, impulsivity measurement type, gender, and age, suggesting that the interplay between impulsivity and cognitive biases may be a reliable factor affecting an individual’s development and maintenance of substance misuse.

Furthermore, novel findings from this thesis also suggest that CBM-related interventions may be appropriately applied for individuals high in rash impulsivity or reward sensitivity – subsets of the clinical population that are at higher risk for poorer addiction treatment outcomes and retention rates. Consequently, this thesis provides evidence to support the
use of multi-modal forms of impulsivity assessment in clinical settings in order for clinicians to direct treatment interventions such as CBM towards highly rash impulsive or reward sensitive individuals who would otherwise be more likely to respond poorly to conventional treatment pathways alone. In addition, this thesis has highlighted that residential detoxification contexts may constitute a prime setting for novel interventions such as CBM to take place, particularly if further adjunctive treatment options are also available. Furthermore, findings also provide indication that trait rash impulsivity may be a potential treatment target to reduce substance misuse during and following detoxification. These findings converge with recent evidence to indicate that interventions targeted towards impulsive personality traits (e.g., Conrod et al., 2011, 2013; Newton et al., 2016; O’Leary-Barrett et al., 2010) can improve upon short- and long-term substance misuse treatment outcomes. Thus, the enhancement of clinician knowledge regarding impulsivity and cognitive biases is suggested to promote understanding of these factors’ role among clinical presentations, and also to encourage further investigation of their clinical utility as proxy markers of appropriate treatment interventions.

Findings from the present thesis expand on existing literature by providing new evidence of the relevance of the relationship between impulsivity and cognitive biases in substance misuse. However, it is important to acknowledge that, while growing, research examining this relationship is still in its early stages. Future research is suggested in order to replicate the present thesis’ results, and to expand on findings to allow broader generalisability and greater explanatory power for both community
and clinical samples. In so doing, the understanding of these factors in substance dependence will be enhanced in order to ultimately improve upon existing treatment pathways and related clinical outcomes.
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Appendices
Appendix A


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Appendix B


_Alcoholism: Clinical and Experimental Research._

DOI: 10.1111/acer.13163
Appendix C

Review search terms

(“impulsiv*” OR “disinhibit*” OR "response inhibit*" OR "motor inhibit*" OR "cognitive inhibit*" or "inhibitory control" OR "sensation seeking" OR "sensation-seeking" OR "novelty-seeking" OR "novelty seeking" OR "delay discount*" OR "delay-discount*" OR “reward discount*” OR “reward-discounting” OR "reward sensitiv*" OR "reward-sensitiv*" OR “reward- seek*” OR "reward seek*" OR “reward dependen*” OR “reward-dependen*” OR “urgency”)

AND

("cognitive bias*" OR "implicit cognit*" OR “automatic process*” OR “attention* bias” OR "attention*-bias" OR “memory bias” OR “memory-bias” OR “implicit association” OR “implicit evaluation” OR “memory association” OR “approach bias” OR “approach-bias” OR “automatic action tendenc*” OR “approach tendenc*”)

General limiters:
- Peer reviewed
- English language
Appendix D

Exclusion of classic-Stroop as impulsivity measure

Studies that used the classic-Stroop as an impulsivity measure were not included in the present meta-analysis. This was due to: (1) methodological similarities with the addiction-Stroop commonly used as an attentional bias measure, which may lead to inflated effect size estimates and (2) current understanding of the Stroop effect as one related to cognitive interference (see Macleod & MacDonald, 2000 for review) as opposed to traditionally conceptualised impulsivity.