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**The effect of prenatal exposure to methamphetamine on children's executive
functioning at age 4**

A thesis presented in partial fulfilment of the requirements for a degree of
Master of Educational Psychology
At Massey University, Albany, Auckland,
New Zealand.

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2011

Declaration

I certify that the thesis entitled “The effect of prenatal exposure to methamphetamine on children’s executive functioning at age 4” and submitted as part of the degree of Master of Educational Psychology is the result of my own work, except where otherwise acknowledged, and that this research paper (or part of the same) has not been submitted for any other degree to any other university or institution.

Signed _____

Date _____

Abstract

The use of methamphetamine, a highly addictive stimulant drug, during pregnancy is an increasing problem in New Zealand. However, at present, little is known about the effect of methamphetamine in utero on child development. The aim of this study was to assess the effect of prenatal methamphetamine exposure on preschool measures of executive function among 4-year-olds. To address this aim, 25 children who had been prenatally exposed to methamphetamine, and 25 control children who were matched for all other environmental and drug exposure-related variables, were assessed on three performance tests of executive function; the *Day/Night* task, the *Bear/Dragon* task and the *Gift Delay (wrap)* task. In addition, mothers or caregivers of these children completed the *BRIEF-P* measure of child executive functioning. Children who were exposed to methamphetamine in utero were rated as exhibiting significantly more executive functioning difficulties on the *BRIEF-P* scale than controls and also demonstrated a trend towards poorer performance on the *Day/Night* task. However, the methamphetamine-exposed children performed better than controls on the *Gift Delay (wrap)* task and no differences were found for the *Bear/Dragon* task with performance close to ceiling for both groups. The results of the study indicate that prenatal exposure to methamphetamine in the context of a range of environmental risk factors may influence certain aspects of executive function development in preschool-aged children and suggest that additional studies with larger sample sizes are warranted.

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The effect of prenatal exposure to methamphetamine on children's executive functioning at age 4

Chapter 1. Introduction

Children's educational outcomes may be influenced not only by their genes or by the multiple ecological contexts in which they live, but also by their prenatal environment. Prenatal exposure to neuroactive drugs has been found to have a range of potentially detrimental effects on child development which in turn may influence a youngster's educational performance, social adjustment, and ability to regulate behaviour (Billing, Eriksson, Jonsson, Steneroth, & Zetterstrom, 1994; Day et al., 1994; Delaney-Black, Covington, Templin, Ager et al., 2000; Delaney-Black, Covington, Templin, Kershaw et al., 2000; Ernst, Moolchan, & Robinson, 2001; Thomas, Kelly, Mattson, & Riley, 1998; Wakschlag et al., 1997; Yolton & Bolig, 1994).

The extent to which exposure to neuroactive substances in utero impacts child development is still relatively poorly understood. More detailed information is required to determine the effects of prenatal drug-exposure on development; particularly in relation to how prepared these children are to begin formal schooling at age 5 in New Zealand (Wouldes, LaGasse, Sheridan, & Lester, 2004).

The use of psychoactive substances during pregnancy is relatively common in New Zealand and is increasing (Fergusson, Horwood, & Ridder, 2007; Wouldes et al., 2004). New Zealand studies have indicated that up to 29% of all pregnant women consume alcohol, with a high proportion of these mothers drinking heavily (Mathew, Kitson, & Watson, 2001; McLeod, Pullon, Cookson, & Cornford, 2002; Watson & McDonald, 1999). Similar rates of tobacco use during pregnancy have been reported in New Zealand (Ford, Tappin, Schluter, & Wild, 1997) and rates of marijuana use are likely to be comparable (Wilkins, Bhatta, & Casswell, 2002). Of particular importance

in the New Zealand context however, is prenatal use of methamphetamine, also known as “P”, “Pure” or “Ice”. Methamphetamine is a member of the amphetamine group of drugs and is a highly addictive stimulant. Amphetamines are the second most widely used illicit drug in New Zealand (after marijuana) with approximately 6.8% of the total population and 5.3% of all women reporting using it at least once in their lifetime (Ministry of Health, 2007). Current evidence indicates an on-going rise in the use of amphetamine-type substances in New Zealand (Wilkins & Sweetsur, 2008) and among women of child-bearing age in particular (Hando, Topp, & Hall, 1997). For example, referrals to the Alcohol Drug and Pregnancy Team (ADAPT) from pregnant methamphetamine users increased from 10% in 2001, to 59% in 2003 (Wouldes et al., 2004). This high prevalence of methamphetamine use among pregnant women constitutes a particular challenge as there is a dearth of information regarding its long-term effects on child outcomes (LaGasse et al., 2011; Wouldes et al., 2004)

The motivation for this study, therefore, was to investigate the impact of prenatal exposure to methamphetamine on children’s cognitive development. Specifically, the aim was to assess the effect of prenatal methamphetamine exposure on preschool assessments of executive function, which provide an effective measure of school readiness (Blair, 2002). In addition to collecting child assessment data, mother or caregiver report measures were obtained of each child’s executive function behaviour in the home setting. This project was conducted as part of a large-scale, multi-site, longitudinal study called the Infant Development, Environment and Lifestyle (IDEAL) Study (LaGasse et al., 2011) which has a study site in Auckland, New Zealand. The IDEAL Study investigates the effects of prenatal exposure to methamphetamine and other psychoactive drugs on child physical health, social, emotional, and cognitive development. The results of this thesis project may help to inform decision-making in

terms of providing effective educational services for these children, and in the longer term, may help support the introduction of early intervention or parenting skills programmes specifically targeted at supporting drug-involved families in New Zealand.

Chapter 2. Literature Review

Parental drug misuse is a significant global issue and in New Zealand methamphetamine use in particular is a growing concern. Despite the high prevalence of methamphetamine use among pregnant women in New Zealand, there is still little known about the effects this substance may have on the cognitive, socio-emotional and behavioural development of children, particularly in relation to school readiness and educational outcomes (Wouldes et al., 2004). This study investigated this question by assessing executive function abilities among 4-year-olds. A quasi-experimental design was selected in order to compare the executive functioning skills of two groups of children (exposed vs. control). The following dependent variables (DVs) were chosen; children's performance scores on three preschool tasks which measure specific components of executive functioning (*Bear/Dragon*, *Day/Night*, and *Gift Delay (wrap)* tasks), and maternal/caregiver ratings of child behaviour on the *Behaviour Rating Inventory of Executive Function-Preschool Version*TM (*BRIEF-P*TM) (Gioia, Espy, & Isquith, 2001), a standardized report measure. The independent variable (IV) in this study was prenatal exposure to methamphetamine determined by maternal self-report and by a biological sampling procedure.

This chapter will review a range of research regarding the detrimental effects of parental drug use on child outcomes with a specific focus on the effects of methamphetamine use. Following this, there will be a description of executive function skills, their development and significance throughout early childhood, and a discussion of educational difficulties and child disorders which are characterised by executive dysfunction specifically. The final section of this chapter will review research which suggests that prenatal exposure to neuroactive drugs can significantly impair executive

functioning in children, and also discusses the role played by environmental contexts in influencing the emergence of executive capacities.

2.1. Parental Drug Use and Child Development

The current literature concerning the effects of maternal drug use on child development highlights the complex interaction between the biochemical effects that these neuroactive substances may have on the developing brain in utero, and the postnatal environmental risk factors that are associated with parental drug involvement. This section will first review some of the reported detrimental effects of maternal drug use on child outcomes. A discussion of some of the broader ecological risk factors associated with children raised in homes characterised by parental substance use will follow, in addition to a brief review of research on child protective factors.

2.1.1. The Effects of Prenatal Exposure to Neuroactive Drugs on Child Development

A number of studies have been conducted into the effects of prenatal exposure to neuroactive drugs such as alcohol, tobacco, and marijuana. Each of these substances has been associated with adverse outcomes for the exposed children. Children with either foetal alcohol syndrome (FAS) or alcohol-related neurodevelopmental disorder (ARND) have been found to have a range of developmental deficits including problems with attention (Coles et al., 1997), cognitive flexibility (Kodituwakku, Handmaker, Cutler, Weathersby, & Handmaker, 1995; Schonfeld, Mattson, Lang, Delis, & Riley, 2001), planning (Kodituwakku et al., 1995), memory (Burden, Jacobson, Sokol, & Jacobson, 2005), interpersonal skills (Thomas et al., 1998) and aggression (Brown et al., 1991). Other negative effects such as poorer school performance at age 11 (Olson, Sampson, Barr, Streissguth, & Bookstein, 1992) and an increased risk of antisocial and

externalizing behaviour problems later on in development (Sood et al., 2001; Steinhausen, Willms, & Spohr, 1993) have also been reported.

As with alcohol, prenatal exposure to tobacco has been linked to a range of unfavourable child outcomes including an increased prevalence of externalizing behaviour disorders (Day, Richardson, Goldschmidt, & Cornelius, 2000; Ernst et al., 2001; Wakschlag et al., 1997; Wakschlag, Pickett, Cook, Benowitz, & Leventhal, 2002; Weissman, Warner, Wickramaratne, & Kandel, 1999) and attention-deficit/hyperactivity disorder (ADHD) (Mick, Biederman, Faraone, Sayer, & Kleinman, 2002; Milberger, Biederman, Faraone, Chen, & Jones, 1996; Thapar et al., 2003) in particular. In New Zealand specifically, prenatal exposure to tobacco has been associated with higher rates of conduct disorder, alcohol abuse, substance abuse, and depression (Fergusson, Woodward, & Horwood, 1998).

Marijuana use during pregnancy may also have a deleterious effect on child development. Developmental outcomes associated with prenatal marijuana use include hyperactivity, impulsivity, inattention and externalizing problems (Goldschmidt, Day, & Richardson, 2000) as well as poorer outcomes on preschool tests of cognitive function (Day et al., 1994). It is clear therefore that prenatal use of neuroactive substances can significantly influence the developmental outcomes experienced by children.

2.1.1.1. Prenatal Exposure to Amphetamine and Methamphetamine

This project was primarily focused on the developmental effects of prenatal exposure to methamphetamine, a member of the amphetamine drug group.

Amphetamines are stimulant drugs which affect the central nervous system and can be highly addictive. Although it is likely that an increasing number of children in New Zealand are being exposed to methamphetamine prenatally (Wouldes et al., 2004), the

long-term effects of prenatal methamphetamine exposure on child development are only beginning to be investigated.

The effects of prenatal methamphetamine exposure on cognitive functioning have been investigated in a pilot study involving a small sample of children aged 3-16 (Chang et al., 2004). While motor skills and non-verbal intelligence did not differ between the methamphetamine-exposed children and controls, the exposed children were found to perform less well on measures of visual motor integration, attention, verbal memory and long-term spatial memory. In addition, prenatal methamphetamine exposure was found to significantly impair executive function performance.

A longitudinal study conducted in Sweden investigated the effects of prenatal exposure to amphetamine on child outcomes (Billing et al., 1994; Cernerud, Eriksson, Jonsson, Steneroth, & Zetterstrom, 1996). Amphetamine exposure was associated with negative behavioural outcomes at 8 years of age including increased aggressive behaviour, problems with social adjustment (Billing et al., 1994) and poorer academic performance at age 14–15 years relative to peers (Cernerud et al., 1996). However, these results were also linked to the presence of a number of life stressors in the caregiving environment, so these children may have been vulnerable to poorer outcomes due to a combination of prenatal exposure and psychosocial risk factors in their home settings. Methodological weaknesses such as small numbers of participants, lack of a control group, and use of only maternal self-report measures to indicate drug use, also makes interpretation of these findings problematic (Wouldes et al., 2004).

The only other study to report on the developmental impact of prenatal methamphetamine exposure in humans to date is the IDEAL Study. Initial results from both the American and New Zealand cohorts have indicated that methamphetamine-exposed infants show significant differences in early development when compared with

controls (LaGasse et al., 2011). Specifically, once other types of drug exposure had been controlled for, methamphetamine-exposed new-borns had poorer quality of movement and greater signs of physiological and central nervous system stress (LaGasse et al., 2011). Heavy methamphetamine use among pregnant mothers was also linked with lower rates of arousal and less excitability among offspring. The frequency of methamphetamine use during the third trimester of pregnancy in particular was found to result in increased lethargy and hypotonicity in infants (LaGasse et al., 2011). While the IDEAL Study is still underway in both countries, these initial findings of differences in neonate neurobehaviour provide evidence for the neurotoxicity of the drug, particularly since these effects were documented at an early stage in development before ecological factors could shape child outcomes (LaGasse et al., 2011). This finding is also in agreement with animal models of prenatal methamphetamine exposure which have demonstrated neurochemical changes to the central nervous system (Weissman & Caldecott-Hazard, 1995) such as degeneration of dopaminergic nerve terminals (Jeng, Wong, Ting, & Wells, 2005).

2.1.1.2. Relevant Research Findings from Prenatal Exposure to Cocaine

While few studies to date have investigated the long-term effects of prenatal methamphetamine exposure on child development, research literature regarding the effects of prenatal exposure to cocaine on child outcomes may provide a useful model for predicting the impact of methamphetamine. While cocaine and methamphetamine are composed of different chemicals, the two substances share similar pharmacological properties (Wouldes et al., 2004). Both drugs block the synaptic reuptake of dopamine and other catecholamines but methamphetamine also acts to increase levels of dopamine and norepinephrine by inhibiting monoamine oxidase, the enzyme that usually oxidises norepinephrine and serotonin (Bennett, Hyde, Pecora, & Clodfelter, 1993; Heller,

Bubula, Freeney, & Won, 2001). Furthermore, methamphetamine has a longer half-life than cocaine, which, when combined with its capacity to act at multiple mechanisms at the synapse, results in a drug with a potentially greater neurotoxic effect (LaGasse et al., 2011).

Cocaine negatively impacts state regulation in infants (Beeghly & Tronick, 1994; DiPietro, Suess, Wheeler, Smouse, & Newlin, 1995; Gottwald & Thurman, 1994; Lester et al., 2002) and has been shown to affect attention (Jacobson, Jacobson, Sokol, Martier, & Chiodo, 1996; Struthers & Hansen, 1992), motor performance (Mayes, Cicchetti, Acharyya, & Zhang, 2003) and inhibitory control (Bendersky, Gambini, Lastella, Bennett, & Lewis, 2003) in older children. Several studies have also suggested that prenatal exposure to cocaine increases the likelihood of externalizing problems in childhood (Bada et al., 2007; Delaney-Black et al., 2000; Hawley, Halle, Drasin, & Thomas, 1995; Yolton & Bolig, 1994) and predicts difficulty at school (Levine et al., 2008). These findings therefore strongly support the idea that prenatal exposure to drugs of this type, including methamphetamine, can significantly influence developmental outcomes.

2.1.2. Ecological Risk Factors Associated with Parental Drug Use

One of the most challenging aspects of child development research in this field is attempting to disassociate the neurodevelopmental effects of parental drug misuse on child outcomes, from the impact of ecological risk factors which are commonly associated with poverty (Dawe, Harnett, & Frye, 2008). Children and adolescents living in substance-involved families must be viewed as individuals enmeshed within a complex social system (Bronfenbrenner, 1979; Cicchetti & Toth, 1997), and any attempt to understand and improve life outcomes for these individuals should therefore

take into consideration the multiple contexts in which they and their families live and the complex social processes involved (Dawe et al., 2008).

It has been estimated that as many as a third of all children in the USA live with drug abuse in their homes (Kumpfer & Fowler, 2007). Parents with drug-related problems have been reported to spend approximately half as much of their time with their children as do non-drug-involved parents (Luthar, Cushing, Merikangas, & Rounsaville, 1998). The lives of children who have to live with family drug abuse involve high levels of instability, disorganization, unpredictability, and disruption. Growing up in a drug-involved family environment has been associated with a wide range of negative life outcomes for offspring including higher instances of mood disorders (Johnson, Boney, & Brown, 1990; Weissman et al., 1999), behavioural and emotional problems (Ornoy, Michailevskaya, Lukashov, Bar-Hamburger, & Harel, 1996; Stanger et al., 1999; Wilens, Biederman, Kiely, Bredin, & Spencer, 1995), and poorer educational outcomes (Hogan & Higgins, 2001; Kolar, Brown, Haertzen, & Michaelson, 1994). Therefore, even in cases where there has been very limited exposure to neuroactive substances in utero, children from drug-involved homes are at an increased risk developmentally as a result of certain environmental and psychosocial factors likely to be present in their home settings (Kumpfer & Fowler, 2007). Children exposed to drugs prenatally who are then raised in drug-involved families may therefore be doubly at risk of negative life trajectories (Wouldes et al., 2004).

It is not true to say, however, that all children raised in high-risk home environments experience adverse life outcomes; in fact many develop typically (Gilligan, 2000; Tweed & Ryff, 1991; Werner, 1993). Substance-involved parents may use specific strategies to protect their children from the risk factors associated with their lifestyle (Baker & Carson, 1999; Richter & Bammer, 2000), and further, some

individuals may be more *resilient* to the life stressors that are usually associated with parent drug misuse. The concept of resilience refers to an individual's capacity to function competently despite prior or current adverse life experiences (Gilligan, 2000; Velleman & Templeton, 2007) and is often explained by the presence of protective factors. These are individual or environmental characteristics that decrease the effects of stressful life events and for children include; good relationships with supportive adults, strong connections to effective schools/teachers, and links to adults and/or social groups in the wider community (Luthar & Zigler, 1991; Masten & Coatsworth, 1998; Velleman & Templeton, 2007). Studies focussing on child resilience and protective factors among substance-involved families in particular have highlighted the importance of a strong and nurturing relationship between the primary caregiver and child (Hofkosh et al., 1995; Kumpfer, Alvarado, & Whiteside, 2003). In addition, close relationships with members of an extended family can reduce the negative effects of parental drug use on development (Barnard, 2003). Effective early childhood education (ECE) and parenting skills programmes may also buffer the effects of living in drug-involved homes since they have been shown to considerably improve long-term outcomes for at-risk children (Kaminski, Valle, Filene, & Boyle, 2008; Baydar, Reid, & Webster-Stratton, 2003; Campbell et al., 1998; Gross et al., 2003; Webster-Stratton, Jamila Reid, & Stoolmiller, 2008; Webster-Stratton & Taylor, 2001).

2.1.3. Summary of Research on Parental Drug Use and Child Development

There is a growing body of evidence demonstrating that prenatal exposure to the most commonly used psychoactive substances in New Zealand such as alcohol, tobacco, marijuana, and methamphetamines/amphetamines, can have a considerable detrimental effect on foetal brain development and may influence subsequent child outcomes.

While considering this evidence, it is also important to recognise that children from

drug-involved families often live in high-risk home environments which can also significantly affect development. This is particularly true for children who do not have the necessary protective factors required for resilience.

2.2. Executive Function Skills

Executive function (EF) skills can be described as a set of interconnected cognitive abilities which function to enable conscious control of thoughts and actions. The term “executive function(s)” is often used to refer to a collection of different processes which together enable the coordinated control of behaviour to perform a task or achieve a goal (Espy, 2004; Miyake et al., 2000; Zelazo & Muller, 2002). Most definitions of EF skills typically make a reference to goal-setting and planning, cognitive flexibility, attention and the components of memory that facilitate attention (e.g. working memory), and self-regulatory and inhibitory processes (Meltzer, 2007). In a sense EF is best viewed as a broad umbrella term for a range of cognitive processes that together facilitate problem-solving, goal-setting and self-regulatory behaviour (Meltzer, 2007). EF skills are therefore involved in any action that requires the capacity to initiate, plan, and organize an activity or task, and in any situations which require inhibitory control.

EF skills have been linked to networks in the prefrontal cortex (PFC) region of the brain. Individuals with damage to the prefrontal region often have EF deficits (Anderson, 1998; Asarnow, Satz, Light, Lewis, & Neumann, 1991; Eslinger & Grattan, 1991). However, EF capacity has also been found to depend on the functionality of other brain regions as well (Anderson, Damasio, Jones, & Tranel, 1991) and some patients with damage to the PFC do not show impaired EF ability (Shallice & Burgess, 1991). It is clear therefore that our understanding of the neural basis of EF is still in its infancy.

2.2.1. Current Theories and Models of Executive Function

EF can be conceptualized in a variety of ways; as a unitary construct with multiple sub-processes (Baddeley, 1992; Norman & Shallice, 1986), as a set of dissociable components (e.g. working memory, behavioural inhibition) each with their own associations to different areas of the prefrontal cortex (Zelazo & Muller, 2002), or as a combination of both (Garon, Bryson, & Smith, 2008). The latter, “integrative framework” approach (Miyake et al., 2000), allows for the existence of independent EF components, but suggests that groups of these components may function cooperatively to facilitate appropriate behaviour (Garon et al., 2008). This view is consistent with the suggestion that EF can be sub-divided into a number of separate but interrelated key processes. These processes are inhibition, working memory and set shifting/cognitive flexibility (Carlson, Moses, & Hix, 1998; Dempster, 1992; Diamond, 2006).

Inhibitory control, also referred to as effortful control or response/behavioural inhibition, can be defined as the capacity to restrain or prevent a dominant verbal or motor response even when the environmental context or past experience predisposes towards making the response. Barkley (1997) suggests that behavioural inhibition is comprised of three key processes which facilitate the regulation of behaviour/responses; the ability to delay or prevent a response that leads to an immediate consequence, the ability to stop current behaviours when they are shown to be ineffective, and the ability to manage distractions in the environment that may interfere with the work of other EF processes or skills.

Working memory represents a “cognitive workspace” (p.7) (Kaufman, 2010) in which an individual can retain information temporarily before either thinking about or responding to this information. Adequate working memory capacity is therefore critical for planning, goal-setting, and also for activities that require the ability to retain novel

information in mind long enough to use it. The third critical EF process is set shifting, or cognitive flexibility. This EF process refers to an individual's capacity to move between tasks or change existing rules with relative ease. Therefore a person with problems with set shifting may appear inflexible with routines and may seem more rule-bound than others (Kaufman, 2010).

2.2.2. Development of Executive Functioning in Early Childhood

The first 5 years of a child's life are considered to be a critical period for the development of core EF processes (Garon et al., 2008) and are also associated with prefrontal cortex maturation. Fundamental components of EF such as inhibition and working memory are reported to develop first in infancy, while complex skills like planning, decision-making and problem-solving do not tend to appear until the early years of primary school (Espy, Kaufmann, & Glisky, 2001).

Barkley's (1997) model of EF development provides a sequence for the progression of critical EF skills throughout childhood. The first EF component to develop according to this model is inhibition. There are early indicators of inhibitory control in infants of just 5 and 6 months old when they demonstrate the ability to inhibit basic impulses (Barkley, 1997). Two other EF skills may also be present as early as 5 months of age. These are non-verbal working memory and self-regulation of affect, motivation and arousal. Non-verbal working memory allows young children to hold visual information in mind long enough to be able to predict other's behaviour and the consequences of their own behaviour. In addition, self-regulation enables infants to regulate emotional and motivational states (Dawson, 2010). These three EF skills combine to enable the child to regulate behaviour appropriately according to the emotional or motivational value of environmental stimuli.

EF skills further develop with the onset of speech, which typically occurs during the early preschool years. At this age children start verbally commanding themselves out loud and internalized speech begins (Barkley, 1997). Internalization of speech (i.e. self-speech) is considered as a distinct EF skill by Barkley (1997) and contributes to self-regulatory control. This, in the long-term, allows a child to be able to follow rules, problem-solve and self-monitor behaviour (Dawson, 2010).

Barkley (1997) suggests that children's verbal working memory capacity has typically increased substantially by age 4. Correspondingly, there is reported to be an increase in performance of EF assessments at this age, with a significant peak in EF ability between the ages of 3 and 6 years in particular (Carlson, 2005; Rothbart & Posner, 2001). At 6 years of age other components of EF capacities develop such as planning, problem-solving and goal-setting, which all increase as working memory capacity improves (Kaufman, 2010). The final component in Barkley's (1997) model is reconstitution, which can be described as cognitive and behavioural flexibility. The initial stages of reconstitution are observed among children aged 6 years, and include the ability to combine sets of complex behaviours or tasks in novel ways and therefore facilitate problem-solving, planning and creativity (Dawson, 2010).

In the research literature, developmental changes in EF performance during early childhood have often been conceptualised in terms of improvements in inhibitory control. This is because in many laboratory tasks measuring EF ability young children exhibit difficulties with perseveration, or the suppression of interfering automatic responses (Carlson et al., 1998; Dempster, 1992) which improves incrementally throughout early childhood. In this approach to explaining EF development, poor inhibitory control performance on EF tasks is viewed as the result of an underdeveloped

or ineffective inhibition system which is thus considered to be the root cause of the EF deficit (Zelazo & Muller, 2002).

2.2.3. The Importance of Executive Function to Cognitive, Socio-emotional, and Behavioural Aspects of Child Functioning

While EF can be viewed as encompassing many different cognitive and self-regulatory processes (Denkla, 2007; McCloskey, 2009), EF capacity has been effectively described as impacting behaviour in two core domains; the socio-emotional and behaviour regulation domain, and the metacognitive or cognitive/academic domain (Kaufman, 2010). These two different aspects of the EF construct have also been referred to using the terms “hot” and “cool” EF. The “hot” aspects of EF refer to the socio-emotional and behavioural domain, and “cool” aspects of EF to the non-emotional, cognitive domain.

The “hot” or affective components of EF are necessary in situations or events that have an emotionally significant consequence such as evaluating the motivational value of a stimulus (e.g. judging which bag of two bags contains more candy), or delaying gratification (Hongwanishkul, Happaney, Lee, & Zelazo, 2005). “Hot” EF processes used to regulate affect and motivation are critical to the social, emotional and behavioural aspects of child functioning. These EF skills act to modulate behaviour in the social world so that individuals can control their emotions and actions and ultimately behave in a manner that is considered acceptable to society (Kaufman, 2010).

The “cool” aspects of executive functioning are most likely to be involved in tasks or activities comprising abstract problems where context is less important (e.g. sorting items by colour, number, or shape) (Hongwanishkul et al., 2005). “Cool” EF facilitates academic learning; it enables a child to intentionally attend to incoming information and to use a range of strategies to comprehend and recall that information

(Kaufman, 2010). Further, the “cool” aspect of EF allows students to plan, organize and monitor their work, and to identify future learning goals or areas for improvement.

The dissociation between “hot” and “cool” EF is supported by the finding that “cool”, but not “hot” EF, is associated with performance on standardized IQ tests (Bar-On, Tranel, Denburg, & Bechara, 2003; Hongwanishkul et al., 2005). In general however, it is important to note that EF and intelligence are considered to be separate constructs and IQ tests are not thought to provide an accurate assessment of important components of EF such as self-regulation and inhibition (McCloskey, 2009). Furthermore, “cool” EF has also been found to be associated with measures of child temperament while “hot” EF has not (Hongwanishkul et al., 2005). While the distinction between “hot” and “cool” EF is useful, most everyday activities require the coordinated use of both aspects of executive functioning simultaneously, for example, school children may engage in problem-solving (“cool” EF) in order to earn a class reward (emotionally significant consequences, “hot” EF).

2.2.4. Summary of Executive Function Skills

EF skills can be defined as a set of separate but interconnected cognitive and self-regulatory processes that work cooperatively to control thoughts and behaviour, and to enable the realization of a task or goal. These processes are frequently referred to as planning, decision-making, problem-solving, attention (and the components of memory required to facilitate attention), cognitive flexibility, self-regulation, and inhibitory control. In a school context, EF plays a significant role in behavioural regulation, social adjustment, and knowledge acquisition. EF capacity in childhood could be described as impacting child outcomes in two critical ways; firstly it is important for the self-regulatory aspects of socio-emotional and behavioural functioning (“hot” EF), and secondly, it is an essential component of academic learning (“cool” EF). Deficits in

either (or *both*) of these EF components can result in considerable educational difficulties.

Regardless of which theoretical model of EF is espoused, a young child's capacity to inhibit dominant or prepotent behaviours in situations of conflict and in the face of prior experience, is regarded as one of the critical indicators of EF ability in early childhood (Garon et al., 2008). Further, working memory capacity, assessed by testing a child's ability to hold a rule in mind temporarily and respond to stimuli according to that rule, is also considered to be a key measure of EF among preschoolers. Therefore, as will be discussed in detail in Section 2.2.7.3., many tasks designed to measure executive functioning among preschoolers involve measuring response inhibition, either in isolation or in combination with working memory ability.

2.2.5. Executive Function and Educational Achievement

When young children begin formal schooling at age 5 more demands are placed upon their cognitive abilities. This transitioning process requires the use of complex skills such as inhibition and self-regulation, which in turn enable children to control and guide their thoughts and actions, and eventually engage in problem-solving, planning, and a range of other cognitive processes essential to learning (Carlson, 2005). Therefore effective transitioning to school requires the adequate development of abilities that map onto both "hot" and "cool" components of EF. EF performance has been closely associated with readiness to attend school (Blair, 2002), mathematical skills (Bull, Espy, & Wiebe, 2008; Bull & Scerif, 2001; Mazzocco & Kover, 2007) and overall academic achievement (Clark, Prior, & Kinsella, 2002; Riggs, Blair, & Greenberg, 2003). In addition, executive dysfunction involving poor working memory capacity has been closely associated with learning disabilities related to literacy skills and mathematics (Gathercole, Alloway, Willis, & Adams, 2006; McLean & Hitch,

1999; Swanson & Jerman, 2007). However, identification of executive function deficits at an early stage in childhood may prevent such educational difficulties, for instance interventions targeting cognitive and socio-emotional skills have been shown to improve EF skills in young children (Bierman et al., 2008; Diamond, Barnett, Thomas, & Munro, 2007).

In order to explain and understand EF processes in an educational context, Denckla (2007) suggests it can be useful to refer to EF as facilitating the “how and when” functions of the brain, or in other words, the “getting your act together” (p. 8) functions that enable students to regulate their feelings, emotions, and actions, and to plan, problem-solve and set learning goals.

2.2.6. Executive Function and Childhood Disorders

Deficits in executive functioning have been linked to a wide variety of childhood disorders and difficulties. Children with developmental disorders often exhibit marked impairments in EF ability, for example, executive dysfunction has been widely associated with autistic spectrum disorders (ASD) in particular (Colvert, Custance, & Swettenham, 2002; Ozonoff, Pennington, & Rogers, 1991; Zelazo, Jacques, Burack, & Frye, 2002). Deficits in executive function such as poor organization and planning, impulsivity, cognitive inflexibility, and difficulties with problem-solving have also been recognised as key etiological characteristics of ADHD (Barkley, 1997; Denckla, 1996a; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). Due to the link between executive functioning and socio-emotional competence, characteristics of executive dysfunction can also become risk factors that predispose youngsters to the development of conduct disorder (CD) and substance use disorder (Giancola, Mezzich, & Tarter, 1998a, 1998b; Nigg et al., 2006). EF dysfunction has also been reported among individuals with phenylketonuria (Diamond et al., 1997),

Fragile X Syndrome (Wilding, Cornish, & Munir, 2002), Tourette Syndrome (Denckla, 1996a), and childhood head trauma (Dennis, Barnes, Donnelly, Wilkinson, & Humphreys, 1996).

In a sense, adequate executive functioning in early childhood lays the necessary foundation for academic achievement, behaviour regulation, social and emotional competence, and positive child outcomes overall. Therefore early interventions which specifically address EF deficits may help to remediate difficulties with learning, social competence, and behaviour at school, and therefore have the potential to reduce the severity of childhood disorders.

2.2.7. Assessment of Executive Function Skills in Childhood

Given that developmental, neurological, and behavioural disorders often emerge in early childhood, there is a significant need to be able to measure EF skills, both for diagnostic purposes and so that educational programming can be adapted to best support the child. Direct methods of assessing EF involve collecting information either through observing the child or by engaging the child in tasks which measure EF. Indirect assessment procedures involve collecting information from other sources such as report measures from the child's parent(s) or teacher.

2.2.7.1. Direct Methods of Assessing Executive Function: Standardized

Assessments

Child executive functioning can be measured using standardized tests. Various standardized assessments of EF ability have been developed for children including; the *NEPSY* (Korkman, Kirk, & Fellman, 1998), the *Delis-Kaplan Executive Functions Scale (D-KEFS)* (Delis, Kaplan, & Kramer, 2001), and the *Behavioural Assessment of Dysexecutive Syndrome in Children (BADSC)* (Wilson & Burden, 1996). Standardized

tests provide an opportunity to gain a norm-referenced measure of executive functioning which can be useful for diagnostic purposes.

However, standardized tests of child EF have often been criticised for lacking the necessary appeal for children and for their inadequate normative data due to the fact that they are based on prior adult tests (Anderson, 1998). Standardized tests of EF also require children to use skills not directly associated with executive functioning such as language and motor functioning, and therefore may produce confounded results if the child does not possess adequate ability in these areas (Dawson, 2010). Further, many standardized EF tests involve the completion of tasks within a symbol system context (i.e. using written language, numbers, sequences, shapes etc.) and therefore require the use of only very specific components of EF and do not adequately assess other critical domains relating to self-regulatory ability or inhibition (McCloskey, 2009). Another key criticism of standardized tests of EF is that these assessments often provide an overall composite score of executive functioning; this encourages a unitary view of a child's executive capacities which promotes the conceptualisation of EF as a single trait or aptitude (Denkla, 1996; McCloskey, 2009).

Assessing executive functioning ability among preschoolers is particularly challenging since at this developmental stage young children often lack the necessary verbal, motor and self-regulatory skills required to complete lengthy structured assessments (Isquith, Crawford, Espy, & Gioia, 2005). Therefore standardized measures of EF are not appropriate for testing preschool-age children.

2.2.7.2. Indirect Methods of Assessing Executive Function: Parent and Teacher Behaviour Checklists and Behaviour Rating Scales

Standardized behaviour checklists and behaviour rating scales may be used in order to provide a broader insight into a child's everyday executive functioning in the

home or classroom setting. Behaviour checklists and rating scales therefore demonstrate a higher ecological validity when compared to standardized tests of EF since they are based on child functioning in real-life contexts (Dawson, 2010; Isquith et al., 2005).

Behaviour rating scales have been developed to specifically assess executive functioning in children, for example the *Behaviour Rating Inventory of Executive Function*TM (*BRIEF*TM) (Gioia, Isquith, Guy, & Kenworthy, 2000) which was normed on children aged 6-18 years. Two other versions of the *BRIEF* have subsequently been developed. The *BRIEF-P* (Gioia et al., 2001), normed on children aged 2-5 years, and the *Behaviour Rating Inventory of Executive Function-Self-Report Version*TM (*BRIEF-SR*TM) (Guy, Isquith, & Gioia, 2004), an adolescent self-report version of the scale, normed on adolescents aged 11-16 years.

This study involved an in-depth investigation into the executive functioning of preschool children in particular and therefore a short description of the *BRIEF-P* is provided in the next section in order to clarify its selection as an appropriate assessment method for this project. A more detailed account of the contents of the *BRIEF-P* is given in Chapter 3.

2.2.7.2.1. The Behaviour Rating Inventory of Executive Function-Preschool Version (*BRIEF-P*)

The *BRIEF-P* was selected as an assessment measure for this study since it provides an effective means of evaluating young children's global executive skills in multiple contexts and situational demands, and therefore has high ecological validity. In addition, the *BRIEF-P* has demonstrated reliability and validity in terms of predicting child disorders, behaviour problems and learning difficulties. For instance, the clinical scales in the *BRIEF-P* have been shown to correspond to EF profiles of common

childhood difficulties including; ADHD, language disorders, learning disabilities, traumatic brain injuries, lead exposure and pervasive developmental disorders (Gioia, Isquith, Kenworthy, & Barton, 2002). Therefore it was anticipated that this parent report measure would be effective at indicating executive functioning differences between the two groups of children participating in this study.

Furthermore, studies using factor analysis have provided support for the three-factor model of executive functioning as represented by the three indexes in the *BRIEF-P* (Inhibitory Self-Control (ISCI), Flexibility (FI), and Emergent Metacognition (EMI) (Isquith, Gioia, & Espy, 2004). Gioia et al. (2002) also report appropriate internal consistency and test-retest reliability for both parent and teacher ratings on the five clinical scales within the *BRIEF-P* (Inhibit, Shift, Emotional Control, Working Memory, and Plan/Organize).

A further rationale for selecting the *BRIEF-P* for this study is due to the convergent and discriminant validity which has been demonstrated between this measure and other commonly used preschool rating scales such as the *Child Behaviour Checklist (CBCL)* (Achenbach & Rescorla, 2000) and the *Behaviour Assessment System for Children (BASC)* (Reynolds & Kamphaus, 2004) (Isquith et al., 2005). However, as Isquith et al. (2005) have noted, using a behaviour rating approach does have some caveats; the use of informant rating techniques to measure functioning is always vulnerable to rater bias, particularly in terms of the overrating of child behaviours. Isquith et al. (2005) therefore suggest using the *BRIEF-P* as a complimentary assessment tool alongside the use of developmentally appropriate, controlled performance tasks that assess specific components of child executive functioning.

2.2.7.3. Assessing Executive Function Using Research Laboratory Tasks

Executive functioning in children can also be assessed using age-appropriate neurocognitive performance tasks which are designed to measure specific aspects of EF. These types of tasks are particularly well suited to preschool-aged children who often do not possess sufficient attentional, verbal, and motor skills required to complete standardized assessments of EF. These EF tasks are usually carried out in research laboratories with videotape equipment which enables children's responses to stimuli to be recorded and then scored accurately afterwards.

Performance measures on EF tasks have been shown to improve significantly with age during early childhood (Carlson, 2005; Diamond & Taylor, 1996; Frye, Zelazo, & Palfai, 1995; Hughes, 1998). Furthermore, a range of studies have demonstrated that different EF tasks are able to tap into distinct components of executive functioning in young children (Carlson, Moses, & Breton, 2002; Diamond, Kirkham, & Amso, 2002; Espy & Bull, 2005; Hughes, 1998). Therefore, despite the fact that components of EF usually work together in a coordinated manner, it is quite possible to assess inhibitory control separately from working memory capacity and vice versa, in preschoolers (Carlson, 2005). Performance scores on different EF tasks measuring working memory and inhibition in particular have also been shown to be reliably correlated (Reck & Hund, 2011).

The rationale for attempting to measure inhibitory control in early childhood is based on the finding that poor response inhibition plays a critical role in a range of child disorders and socio-emotional/behaviour difficulties (Barkley, 1997; Murray & Kochanska, 2002; Rhoades, Greenberg, & Domitrovich, 2009; Scheres, Oosterlaan, & Sergeant, 2001; von Stauffenberg & Campbell, 2007). Further, there appears to be an association between performances on response inhibition tasks in early childhood and

measures of social and moral competence later in life (Kochanska, Murray, Jacques, Koenig, & Vandegest, 1996; Kochanska, Murray, & Harlan, 2000). Patterns emerging in current developmental literature strongly suggest that effective response inhibition in the preschool years may be closely related to self-regulatory capacity, social and emotional functioning, and the development of cognitive abilities such as problem-solving and planning in later childhood. Therefore improving the current understanding of this key component of executive functioning may help to inform models of early intervention for children at risk.

Preschool tasks that measure inhibitory control typically involve the assessor asking the child to suppress a dominant or habitual response when confronted with certain visual stimuli. While there have been many preschool tasks developed to measure inhibitory control, Garon et al. (2008) suggest differentiating between those which involve minimal or no working memory demands, and those which involve more modest demands by using the terms *simple response inhibition tasks* and *complex response inhibition tasks*.

One of the most common paradigms for measuring simple response inhibition is delay of gratification. For example, in the *Delay of Gratification Task* (Mischel, Shoda, & Rodriguez, 1989) the child has to choose between a small but immediate reward, or a larger reward for which they have to wait. Other examples include the *Children's Gambling Task* (Kerr & Zelazo, 2004) and the *Less is More* (Carlson, Davis, & Leach, 2005) task. It is important to note that in the “hot” vs. “cool” EF framework described above, these tasks tap predominantly into “hot” EF since they involve decision-making driven by emotional or motivational consequences.

In contrast, complex response inhibition tasks often require the child to hold a specific rule in mind, respond to a task while retaining that rule, and simultaneously

inhibit a natural or dominant response (Garon et al., 2008). A classic example of such a task is the game *Simon Says* that has been modified for assessment purposes (Strommen, 1973). Complex response inhibition tasks therefore combine both working memory *and* inhibitory control components of EF. Research has demonstrated that EF tasks which measure working memory and inhibition in combination are the most challenging for young children to complete (Carlson, 2005). Many of these tasks could be considered to target mostly “cool” EF.

Preschool tasks which assess working memory capacity in isolation require children to retain information in mind over a specific time delay but do not expect them to inhibit any natural inclination. A common method of measuring working memory capacity in early childhood is to use a word or digit span task which measures a child’s ability to memorize a string of words or digits and repeat them in reverse order. As expected, performance on such tasks increases with age (Davis & Pratt, 1995; Espy & Bull, 2005; Gathercole, 1998).

2.2.7.4. Executive Function Tasks Selected for Thesis Study

In order to evaluate the executive functioning capacity of the preschool children involved in this project, a set of three simple and developmentally appropriate EF tasks were selected that could be performed by the children during a single visit to the research laboratory. These three EF tasks are described in detail in Chapter 3, where a discussion of the materials, setting variables, sequence, scoring system, and interobserver rating procedures is provided. The following three sections provide a rationale for the selection of these EF tasks for this study.

2.2.7.4.1. The *Bear/Dragon* Executive Function Task

The *Bear/Dragon* (Reed, Pien, & Rothbart, 1984) EF performance task is a complex response inhibition task measuring inhibitory control and working memory

capacity. It requires children to follow instructions given by one puppet (bear) but inhibit those given by another puppet (dragon). Tasks like the *Bear/Dragon* have been shown to be developmentally sensitive during early childhood (Carlson, 2005; Carlson & Moses, 2001; Dowsett & Livesey, 2000; Kochanska et al., 1996; Reed et al., 1984; Strommen, 1973). Incremental improvements in performance on these tasks are described as occurring specifically between the ages of 3 and 5 years among typical children (Garon et al., 2008). The *Bear/Dragon* task was therefore chosen for this thesis predominantly since it has been shown to be effective at discriminating between different abilities in executive functioning performance among this age-group. Furthermore, the *Bear/Dragon* task is a fun and engaging game which was predicted to be highly appealing to the children participating in the project.

2.2.7.4.2. The *Day/Night* Executive Function Task

The *Day/Night* (Gerstadt, Hong, & Diamond, 1994) EF task is another complex response inhibition task assessing both inhibitory control and working memory. Similarly to the *Bear/Dragon* task, it involves the child retaining information in mind, responding to a given rule, and inhibiting a dominant response. In this task children have to inhibit prepotent responses and remember to say “*day*” when they see the picture depicting night, and to say “*night*” when they are shown the picture depicting day. The *Day/Night* task was chosen for this thesis since age-related changes in performance on this task have been reported in typical children of preschool age between 3 and 5 years (Carlson, 2005; Diamond, 2002; Diamond & Taylor, 1996; Gerstadt et al., 1994; Simpson, Riggs, & Simon, 2004) and therefore it would be likely to produce a discriminant measure of executive functioning. This performance task has also previously been reported to be an effective measure of EF difficulty among children with atypical development (Diamond et al., 1997). In addition, the *Day/Night*

task has been shown to demonstrate good internal reliability in a number of recent studies (Chasiotis, Kiessling, Hofer, & Campos, 2006; Rhoades et al., 2009; von Stauffenberg & Campbell, 2007) and respectable test-retest reliability (Thorell & Wåhlstedt, 2006). Child performance on this task in particular has been found to predict future educational outcomes relating socio-emotional competence (Rhoades et al., 2009).

Further, unlike the *Bear/Dragon* task which requires children to respond to puppet instructions using only appropriate actions, the *Day/Night* paradigm requires a verbal response (i.e. children saying either “*day*” or “*night*” accordingly when they see a picture) which was expected to make it a more challenging task for the children to perform. EF tasks that measure inhibition and working memory and that also involve a semantic demand such as the *Day/Night* task and also the *Grass/Snow* task (Carlson & Moses, 2001) are considered to be more difficult for preschoolers (Carlson, 2005; Garon et al., 2008). Furthermore, in a review of 17 EF tasks for preschoolers, Carlson (2005) found the *Day/Night* task to be significantly harder than the *Bear/Dragon* task for this age range of children. The mean pass rate among 4-year-olds for the *Bear/Dragon* task (90 %) was much higher than that for the *Day/Night* task (58%) and therefore it was anticipated that the children in the present study would show similar results to this. Overall, it was expected that there might be discriminative differences between children’s performances on the *Day/Night* task when compared with the *Bear/Dragon* task.

2.2.7.4.3. The *Gift Delay (wrap)* Executive Function Task

The *Gift Delay (wrap)* (Kochanska et al., 1996) EF task is a form of the delay of gratification paradigm and requires children to inhibit a natural, prepotent response for a period of time. Participants have to wait and not peek while the assessor wraps their

gift. It is therefore a simple response inhibition task as it measures inhibitory control without also assessing working memory as participants do not have to hold a rule in mind. This task was chosen for this project for several reasons. Firstly, like the other two EF tasks selected, it has been found to show age-related improvements among typical children during the preschool period (Carlson, 2005; Kochanska et al., 1996) and would therefore be a good determinant of executive functioning capacity among the cohort of children in the study. In the review of preschool EF tasks by Carlson (2005), the *Gift Delay (wrap)* task was shown to be equally difficult for 4-year-olds to perform as the *Day/Night* task, with both tasks yielding a mean pass rate of 58%. Therefore this task was expected to be similarly challenging for the children in the present study as the *Day/Night* task and would therefore discriminate effectively between the EF capacities of the two groups of children.

A second rationale for selecting the *Gift Delay (wrap)* task was because it provided a way of measuring child inhibitory control without simultaneously tapping into working memory capacity. This test therefore enabled an evaluation of a “hot”, or affective, component of executive functioning without also testing “cool” EF. Given the suggestion that certain childhood difficulties may be due to deficits in “hot” or “cool” EF specifically (Zelazo & Muller, 2002), it was predicted that child performance on this task might vary between the two groups of children. In addition, as discussed previously (section 2.2.3) “hot” aspects of EF have not been found to be as closely related as “cool” components (i.e. working memory/cognitive flexibility), to measures of either intellectual functioning or child temperament (Hongwanishkul et al., 2005). Therefore, performance measures on the *Gift Delay (wrap)* task were hoped to isolate key child differences in EF ability that were not related to individual differences in either general intelligence or temperament. Further, both the *Bear/Dragon* task and the

Day/Night tasks were viewed as involving some aspects of social imitation/verbal skills that these children may have acquired or practiced in their ECE settings. Therefore another key reason for selecting the *Gift Delay (wrap)* task was because it was expected that children's performance measures on this task would be less dependent on the length or frequency of ECE attendance, given that other environmental variables were controlled. Finally, the *Gift Delay (wrap)* task was also chosen since it was expected to be an effective way of rewarding children's completion of the other two EF tasks as it involved giving them a gift.

2.2.7.5. Summary of Assessment of Executive Function Skills in Childhood

There are several different approaches to assessing executive functioning in childhood. The particular approach to EF assessment adopted may depend on the age or ability of the child, the specific purpose (i.e. whether it is for school assessment/intervention planning or research interest), and may also be influenced by the particular conceptualization of EF that is supported. In order to gain a broad insight into child EF skills used in a variety of contexts and situations, it is advisable to gain information from different sources or settings.

In the context of this project which involved the measurement of EF ability among preschool-aged children, a framework of assessment was adopted which included both direct and indirect approaches. The purpose of this investigation was research-focused rather than school-based, and therefore direct assessment methods involved measuring EF ability using three controlled EF performance tasks. Indirect measures of child executive functioning involved administering the *BRIEF-P*.

2.3. The Effects of Prenatal Exposure to Neuroactive Drugs on Executive Function

There is increasing evidence that children exposed to neuroactive substances throughout foetal development may be at a heightened risk of executive dysfunction

(Fried & Smith, 2001; Jacobson et al., 2011; Kodituwakku, Kalberg, & May, 2001; Mattson, Goodman, Caine, Delis, & Riley, 1999; Noland et al., 2003; Streissguth, Bookstein, Sampson, & Barr, 1989). Prenatal exposure to alcohol has been related to impaired EF performance among preschoolers and young school-aged children, including deficits in both response inhibition and working memory even when environmental factors were accounted for (Noland et al., 2003; Streissguth et al., 1989). Studies of older children (7-11 years) indicate that these EF deficits are likely to persist as children develop (Burden et al., 2005; Mattson et al., 1999). Similar negative effects on EF have been linked to prenatal (but not postnatal) tobacco exposure (Julvez et al., 2007). Prenatal marijuana exposure also influences EF development (Fried & Smith, 2001) with inhibitory control being particularly susceptible (Fried, Watkinson, & Gray, 1998). In addition, cocaine-exposed children have demonstrated difficulty when completing EF tasks (Espy, Kaufmann, & Glisky, 1999) and prenatal exposure to cocaine has also been indirectly linked to executive functioning through its significant effect on head circumference at birth (Eyler et al., 2009). Increased head circumference at birth (adjusted for gestation) has been found to predict better performance on EF tasks among children of 5 and 7 years of age (Eyler et al., 2009).

There have been very few studies to date examining the long-term effects of prenatal methamphetamine exposure on children's executive functioning capacity. In a pilot study conducted on a small sample the effects of prenatal methamphetamine exposure (for at least two thirds of the pregnancy) on cognitive development were investigated among children from ages 3-16 (Chang et al., 2004). It was reported that the methamphetamine-exposed children showed deficits in aspects of inhibitory control when compared with non-exposed peers. The methamphetamine-exposed children showed poorer performance on all measures of sustained attention including impulsivity

(Chang et al., 2004). These deficits were also significantly related to lower volumes of subcortical brain structures including the hippocampus, putamen and the globus pallidus measured with MRI (Chang et al., 2004). Therefore this study suggests that prenatal methamphetamine exposure may impair aspects of executive functioning relating to inhibitory control and impulsivity. It also identifies specific neuroanatomical variations that may be associated with these deficits. While the children from both groups of the pilot study were only matched for gender and age, they were reported to come from similar socioeconomic backgrounds. Interestingly, the results from this pilot study are consistent with findings from another recent study investigating the effects of methamphetamine use in adulthood (Schwartz et al., 2010). Schwartz et al. (2010) reported that methamphetamine use among recently abstaining adults was associated with variations in brain anatomy and that these changes were linked to poorer inhibitory control performance on an adult version of the delay of gratification paradigm.

Recent evidence from the current IDEAL-NZ Study has demonstrated that infants who have been prenatally exposed to methamphetamine and other psychoactive drugs may be at an increased risk of executive dysfunction later on (LaGasse et al., 2011). These predictions have been made based on differences which were identified in the neurobehaviour of the exposed infants both at birth and at one month old (see Section 2.1.1.1. for further details), variations which are believed to be linked to atypical EF development in childhood (LaGasse et al., 2011).

Taken as a whole, the studies reviewed in this section indicate that EF in general, and inhibitory control in particular, are susceptible to prenatal drug exposure. Given the importance of EF for typical child development in terms of socio-emotional competence and educational engagement/achievement, it is important to further our current knowledge of the effects of drug exposure on EF. A broader understanding of

the impact of methamphetamine exposure on EF in particular will enable appropriate interventions to be developed that target specific and predictable deficits for which these children have a higher risk due to their drug exposure.

2.4. The Role of Ecological Factors in the Development of Executive Function Skills

While it is assumed that we are all born with innate self-regulatory/inhibitory instincts and individual differences in neurology plays a role in determining their quality (Barkley, 1997) environmental influences can also shape executive functioning (Kaufman, 2010). The development of EF is facilitated by environments that allow a child to practice and experiment with emerging EF abilities. Conversely, a chaotic, disorganized or dysfunctional home environment with multiple life stressors may impede the development of early executive skills (Kaufman, 2010; Lewis, Dozier, Ackerman, & Sepulveda-Kozakowski, 2007; Rhoades, Greenberg, Lanza, & Blair, 2011). Deficits in executive function have been linked to socioeconomic disadvantage (Mezzacappa, 2004; Noble, McCandliss, & Farah, 2007; Noble, Norman, & Farah, 2005) and child maltreatment (Beers & De Bellis, 2002).

In addition, proximal factors such as the quality of a child's relationships and interactions with parents, siblings, teachers and peers also influences EF development (Bernstein & Waber, 2007). A strong relationship has been demonstrated between parenting skills and EF development (Bernier, Carlson, & Whipple, 2010; Bibok, Carpendale, & Muller, 2009; Hughes & Ensor, 2009; Rhoades et al., 2011). Indeed, the quality of parent-child interactions observed in early childhood has been found to be positively related to performance on EF tasks involving both response inhibition and delay of gratification paradigms (Kochanska et al., 2000; Sethi, Mischel, Aber, Shoda, & Rodriguez, 2000).

2.5. Overall Summary

Prenatal exposure to psychoactive substances is associated with a variety of detrimental child outcomes. While there is currently little known about the long-term effects of methamphetamine exposure on child development, current research suggests that it may have a neurotoxic effect. However, child development outcomes should be viewed as a combination and interaction of both biological influences and environmental factors; children raised in drug-involved homes are more vulnerable to negative developmental trajectories even without prenatal exposure to neuroactive substances.

EF skills are a set of cognitive and self-regulatory processes which function cooperatively to guide thoughts, actions, and enable the completion of tasks or goals. Atypical EF development therefore has implications in an educational context since EF influences academic performance, social competence and behaviour regulation. Early childhood is a critical period for the development of EF skills, which can be effectively assessed using parent report measures and laboratory performance tasks. Exposure to neuroactive drugs in utero has been connected to EF deficits in childhood; prenatal exposure to methamphetamine in particular was linked to impaired attention and inhibitory control. Certain ecological factors such as effective parenting practices or the provision of ECE may buffer the effects of parental drug involvement and thus foster the development of EF skills.

2.6. Thesis Aims and Hypotheses

Aim:

The primary aim of this study was to investigate the effects of prenatal exposure to methamphetamine on measures of preschool executive function.

Hypotheses:

1) Children who have been exposed to methamphetamine throughout foetal development will show poorer outcomes on *all* measures of executive function performance than those children who have not been exposed to methamphetamine but matched for all other contextual factors. Specifically;

- a) Methamphetamine-exposed children will exhibit poorer mean inhibition and activation scores than the control children as measured by the *Bear/Dragon* task.
- b) Methamphetamine-exposed children will demonstrate a lower mean percent correct score than the control children on the *Day/Night* task.
- c) Methamphetamine-exposed children will show a higher mean frequency of peeking and a shorter mean latency to peek than the control children on the *Gift Delay (wrap)* task.
- d) Methamphetamine-exposed children will be rated by their mothers/caregivers as exhibiting significantly more executive function difficulties than control children on the *BRIEF-P* which will be demonstrated by a higher overall Global Executive Composite score.

2) Across the whole cohort of children, all measures of EF (tasks and parental reports) will correlate with one another, whereby better performance on one measure will correlate with better performance on another.

3) Child performance scores on the three executive function tasks for the whole cohort of children will be related; however, performance on the *Day/Night* and *Gift Delay (wrap)* tasks will be lower than on the *Bear/Dragon* task.

4) ECE attendance (length of time and frequency per week) within the whole cohort of children will act as a moderating variable on performance on the EF

tasks and ratings on the *BRIEF-P* measures; greater total ECE experience will be correlated with better EF performance on *all* measures.

Chapter 3. Methods

3.1. Research Framework and Experimental Design

In order to investigate the influence of prenatal methamphetamine exposure on child executive functioning it was necessary to assess two groups of children. One group was prenatally exposed to methamphetamine (experimental group) and the other group was not (control group). Both groups were matched for maternal socioeconomic status and maternal educational achievement so that child risk factors associated with particular life circumstances could be controlled. Further, since both the methamphetamine users and the control mothers took a variety of other neuroactive substances during pregnancy (e.g. alcohol, tobacco and marijuana) these drugs served as background variables in this study.

An ecological model of EF assessment has been espoused in this thesis whereby both direct and indirect methods were used to evaluate the children's executive functioning capacity in different contexts. EF data were gathered from two sources; observations of EF task performance in a controlled laboratory setting and mother/caregiver behaviour ratings of EF from the *BRIEF-P* (Gioia et al., 2001). The three EF performance tasks administered targeted specific components of EF (inhibitory control and working memory) and the *BRIEF-P* enabled a more global assessment of EF in everyday contexts.

This study employed a quasi-experimental design in order to investigate the effects of prenatal exposure to methamphetamine on preschool children's performance of EF tasks and maternal/caregiver ratings of child EF behaviour. A quasi-experimental framework was selected as it appeared to be the most suitable means of determining the relationship between the independent variable (IV) (prenatal exposure to

methamphetamine) and the dependent variables (DVs) (performances on executive function tasks and caregiver ratings of child behaviour).

3.2. Participants

The three EF performance tasks were administered to a cohort of 50 preschool-aged children. The *BRIEF-P* report measure was administered to these children's mothers or primary caregivers. The children and their mothers/caregivers had already been recruited as part of an existing longitudinal study, the IDEAL-NZ Study, based at The University of Auckland.

Recruitment of participants to the IDEAL-NZ Study occurred during the mothers' pregnancy. Women who were considered to be suitable participants were referred to the study by their midwives during the prenatal period. Once the mothers had been informed about the study goals, they were asked to provide written consent. However, it was not until after each child was born that any maternal self-reporting measures or biological sampling to indicate drug use were collected.

Maternal exclusion criteria for participation in the IDEAL-NZ Study included; use of hallucinogens or cocaine during pregnancy, history of institutionalization for either disabilities or socio-emotional problems, low cognitive functioning, psychotic behaviour or history of psychosis, and inability to speak either any English or Maori. Exclusion criteria for the children in the study included being one of multiple births, major congenital abnormality, chromosomal abnormality associated with mental or neurologic deficiency, TORCH infection, and the previous recruitment of a sibling into the study.

3.2.1. Participant Demographics

All mothers and children participating in the IDEAL-NZ Study were matched for age, race/ethnicity, socioeconomic status, infant birth weight category, and maternal

education level (i.e. the completion of 5th form NCEA certificate or equivalent).

Identified ethnicity was equivalently matched in both the control and experimental groups. Detailed analysis of the IDEAL-NZ Study participant characteristics revealed that there were no differences in income between the families in either the control or experimental groups (LaGasse et al., 2011). There were no preterm babies included within this study.

All mothers participating in the IDEAL-NZ Study were matched for the use of other psychoactive substances during pregnancy (e.g. alcohol, tobacco and marijuana) which were considered as background variables in this thesis. The self-reported use of drugs for the 50 mothers participating in this project *specifically* can be seen in Table 1. The data provided in Table 1 are from three time periods; the initial drug use interview which recorded substance use during pregnancy, (completed at the children's birth), the 1 month interview, and the recent interview completed when the child was approximately 4.5 years (54 months) old. As can be seen in Table 1, the mothers participating in this thesis in the experimental group reported more use of neuroactive drugs overall than the control group. Table 2 indicates on-going methamphetamine use reported in several different interviews over four years by mothers in the experimental group. Table 3 shows the gender, age, identified ethnicity, type and length of ECE experience, and linguistic information of the 50 children who participated in this thesis.

Table 1. Previous and current maternal self-reported drug use as a percentage of each group. Exp. group = Experimental group.

* One participant did not self-report methamphetamine use during pregnancy in the interview but was placed in the experimental study group based on results from meconium analysis which indicated methamphetamine had been used.

Drug	Self-reported use during pregnancy (n=50)		Self-reported use at 1 month study visit (n=47)		Self-reported use at 4.5 years (54 month) study visit (n=49)	
	Exp. group	Control group	Exp. group	Control group	Exp. group	Control group
Alcohol	68	36	63.6	36.4	88	83
Tobacco	92	44	90.9	50	88	50
Marijuana	76	24	77.3	27.3	48	25
Methamphetamine	96*	0	39.1	4	36	4.2

Table 2. Self-reported on-going methamphetamine use by mothers in the experimental group of this study as a percentage of total interviewed on each visit. The number of participants using the substance at a particular time period is provided in parenthesis.

During pregnancy (n=25)	At 1 month study visit (n=23)	At 12 month study visit (n=22)	At 24 month study visit (n=24)	At 36 month study visit (n=25)	At 54 month (4.5 years) visit (n=25)
96 (24)*	39.1 (9)	40.9 (9)	41.6 (10)	32 (8)	36 (9)

*As detailed above, one participant out of the total of twenty-five did not self-report methamphetamine use during pregnancy but biological sampling suggested otherwise.

Table 3. Child participant demographics at the 4.5 year (54 month) EF assessment for each study group.

		Total Cohort (n = 50)	Experimental group (n=25)	Control group (n=25)
	Mean Age (in months)	55.7 (<i>SD</i> = 2.5)	56 (<i>SD</i> = 2.6)	55 (<i>SD</i> = 2.3)
	Gender	25 males, 25 females	12 males, 13 females	13 males, 12 females
Self-identified ethnicity	White /Pakeha	48%	56%	40%
	Maori	39%	44%	34%
	Pacific Islander	11%	0%	22%
	Other/European	2%	0%	4%

Type of ECE as %	No ECE	14%	16%	12%
	Kindergarten/ Day-care	66%	60%	72%
	Kohanga Reo	8%	12%	4%
	In-home ECE provider	4%	4%	4%
	New Entrant at primary school	8%	8%	8%
ECE attendance	Mean length of attendance (in months)	26.3 months (<i>SD</i> = 17.3)	22 (<i>SD</i> = 19)	26 (<i>SD</i> = 18)
	Mean frequency of attendance (hours per week)	19.3 (<i>SD</i> = 10.9)	19 (<i>SD</i> = 11)	20 (<i>SD</i> = 11)
Primary language spoken	English	90 %	88%	92%
	Bilingual (spoke English and Maori)	8%	12%	4%
	Other*	2%	0%	4%

*English language abilities were considered adequate to perform the three EF tasks.

3.3. Materials

3.3.1. The *Bear/Dragon* Executive Function Task

The *Bear/Dragon* task (Reed et al., 1984) is a complex response inhibition task which can be used for children aged 3 and above. It measures aspects of both working

memory capacity and inhibitory control. In most versions of this task the child is seated at a table with the assessor and is introduced to a bear and dragon puppet. The child is told that the bear is a “nice” puppet (using a high-pitched, soft voice), while the dragon puppet is a “naughty” puppet (using a gruff, low-pitched voice) (Carlson, 2005). The assessor then explains that they will be playing a game with the puppets and if the “nice” bear asks the child to do something, he should do it, while if the “naughty” dragon asks him to do something, he shouldn’t listen to him and should not do it. After a series of practice trials to check that the child understands the rules and to correct any mistakes, there are 12 test trials with the bear and dragon puppets instructing the child to perform various simple actions (e.g. “touch your head”, “clap your hands”). All of the instructed actions require the child to perform easy hand movements that can be carried out while sitting down. A child’s ability to ignore the dragon’s commands is therefore used to infer inhibitory control (Carlson, 2005). Scoring on the *Bear/Dragon* task can be carried out either by converting the child’s actions into an index of self-control (i.e. 0 = no movement, 1 = movement), or alternatively, by allocating inhibition/activation points depending on the description of the child’s movements (Kochanska et al., 1996). The second scoring method used by Kochanska et al. (1996) provides a more sensitive measure of response inhibition. For example, coding behaviour on both bear and dragon trials using this scoring method would be; 0= no movement at all, 1 = wrong movement, 2 = partial correct movement, and 3 = full, correct movement (Kochanska et al., 1996). This scoring system yields an overall inhibition score (i.e. how effectively the child has inhibited the dragon) and an overall activation score (i.e. how effectively the child has followed the bear’s instructions correctly).

The administration of the *Bear/Dragon* EF task in this study required two soft plush puppets; one bear and one dragon, (see Appendix D for a photograph of the puppets used in the task).

3.3.2. The *Day/Night* Executive Function Task

The *Day/Night* task (Gerstadt et al., 1994) is another complex response inhibition task that assesses working memory capacity and inhibitory control and is designed for children aged 3 and above. The *Day/Night* task is a Stroop-like task. In the standard Stroop task participants are presented with a list of colour words printed in colours that do not correspond to the words (e.g. the word yellow printed in blue ink). Participants have to inhibit their dominant behaviour which is to read the colour words, and must instead name the colour in which the words are written.

In the typical preschool version of the *Day/Night* task the assessor explains that she has two pictures to show the child. The two pictures are then presented, one depicting the day and one depicting the night. The assessor tells the child that they will be playing a “silly” game with the two pictures; when the child sees the sun picture she is instructed to say “*night*” and when she sees the moon/stars picture she is instructed to say “*day*”. After some practice trials to check the child understands the rules, a series of 16 test trials follow whereby the pictures are presented in an unpredictable order (eight of each type of picture) with no rule reminders, corrections or reinforcement. Performance on the *Day/Night* task is scored by calculating the total number of correct responses and converting it into percentage accuracy. Some versions of the task also measure the child’s latency to respond to each picture.

Two sets of different picture cards were used for the *Day/Night* EF task in this study; one set depicting day and one set depicting night. The front of the day picture cards had a white background with a yellow sun drawing, while the front of the night

picture cards had a black background and a white moon and four white stars (see Appendix D for a photograph of the *Day/Night* task stimuli). For the test trials there were 16 picture cards in total; eight of the day picture and eight of the night picture. All picture cards measured 20 x 20 cm and were laminated. In order to ensure a standardized presentation of the order of the picture cards and for ease of use, they were made into a spiral-bound flip book. Two laminated cards were also made for the pretest trials, one of the day picture and one of the night.

3.3.3. The *Gift Delay (wrap)* Executive Function Task

The *Gift Delay (wrap)* task (Kochanska et al., 1996) is a form of the delay of gratification paradigm suitable for children aged 22 months and above. In this EF task children are required to suppress a dominant response for a particular period of time. The *Gift Delay (wrap)* task is therefore categorised as a simple response inhibition task since it measures inhibitory control in isolation, placing no working memory demand on participants. In the *Gift Delay (wrap)* task children are rewarded for their completion of other tasks and/or assessments carried out and are informed that they are going to receive a special present. Once the assessor has got the present she explains that she has forgotten to wrap it up. The assessor then asks the child to turn around in her chair so that it may be wrapped now and that way, it will still constitute a “surprise” for the child. Once the child has turned around and has been reminded by the assessor not to “peek”, the gift is wrapped in a typical but noisy way for 60 seconds. After 60 seconds, the child is able to turn around and is given the wrapped gift and allowed to keep it. In this task both peeking behaviour (type and frequency) and latency to first peek can be recorded.

For the *Gift Delay (wrap)* task in this study each participant was assigned an age-appropriate gift. The gift consisted of a children’s colouring book and a set of

multi-coloured colouring pens. The task also required the materials to wrap the gift (i.e. wrapping paper, scissors and tape). A wall clock measuring seconds was used to time the wrapping process.

3.3.4. General Equipment used for Executive Function Tasks

All three of the EF performance tasks required the use of a table and two chairs, a hidden camera (or hand-held camera), and a DVD recording device so that the children's responses to stimuli could be recorded for scoring. Further, each EF task required the use of a score sheet which enabled the observer to score the responses to task stimuli. A script was also provided on the task score sheet to ensure standardized presentation of this task (see Appendix C for copies of the three EF task score sheets).

3.3.5. The *BRIEF-P* Parent Report Measure

The *BRIEF-P* (Gioia et al., 2001) is a 63-item inventory which can be completed by either the parent or teacher of a pre-schooler (aged 2 years, 0 months through to 5 years, 11 months) in approximately 10-15 minutes. The rater indicates whether the child performs a specific behaviour by selecting; *often*, *sometimes* or *never*. The *BRIEF-P* yields an overall EF score, termed the Global Executive Composite (GEC). There are also three broad indexes; Inhibitory Self-Control (ISCI), Flexibility (FI), and Emergent Metacognition (EMI). The *BRIEF-P* also includes five clinical scales which have been empirically validated to relate to executive functioning in this age group (Isquith et al., 2004). The first scale is Inhibit; this relates to a child's control of impulses and behaviour and requires the appropriate modulation of behaviour at the proper time and in the proper context. The second scale, Shift, refers to a child's capacity to make effective transitions, that is, to move from one situation to the next without difficulty. Emotional Control is used to describe how well a child regulates emotional responses appropriately depending on situational demands or contexts. The

fourth scale is Working Memory, which reflects a child's capacity to hold information in mind long enough to use it effectively in order to complete a task, or respond appropriately to stimuli. The final clinical scale of the *BRIEF-P* is Plan/Organize, this relates to a child's ability to anticipate future events and consequences, his capacity to use instructions and goals to guide behaviour, and also how effectively he can implement the necessary steps ahead of time in order to perform an action or task appropriately.

In addition to these five clinical scales representing the key domains of EF, the *BRIEF-P* also includes two validity scales, Inconsistency and Negativity. Inconsistency provides a measure of whether the parent or teacher has responded to the 63 items in a consistent way, while Negativity determines whether she or he has answered the questions in an unusually negative manner.

Normative data on the *BRIEF-P* was collected from child ratings from 460 parents and 302 teachers from urban, suburban, and rural areas. This normative data reflects the 1999 USA Census estimates for race/ethnicity, gender, socioeconomic status, and age (Isquith et al., 2004). A sample of preschool children with various developmental and behavioural disorders was also included in the dataset. Specific clinical populations comprised children with ADHD, prematurity, language disorders, brain trauma, and ASD.

Administering the *BRIEF-P* in this study required the parent rating form and a pen. In order to standardize the protocol of introducing the parent rating form to the mother/caregiver, a script was written and used which outlined the main purposes of the *BRIEF-P* (see Appendix E for script).

3.3.6. Additional Materials

In order to effectively evaluate the children's general behaviour during their completion of the three EF performance tasks, a simple behaviour rating scale was completed by an observer (see Appendices F and G for the child behaviour rating form and the operational definitions of behaviours).

Further materials used in this study included an achievement certificate which each child was given when they arrived at the child development laboratory (or at the start of the home visit). Each time the children completed a task they received a sticker on the certificate which had a number of empty spaces, so that by the end of their visit they would have a fully completed certificate. The reward certificate therefore functioned as an effective reinforcer for positive behaviour and also enabled children to see their progression through the tasks.

3.4. Procedure

3.4.1. Setting of Executive Function Assessments

There were two experimental settings for the EF assessments with the children and mothers. The majority (84%) of the assessments occurred at an on-campus research facility at the University of Auckland. However, since some families were unable to travel to the research facility, eight assessments took place in the family home (16% of total).

3.4.1.1. Assessments at the Child Development Laboratory

Executive functioning assessments were completed by children and their mothers during a single morning visit to the child development laboratory. Families enlisted in the IDEAL-NZ Study were contacted and invited to come in to complete some developmental assessments and the child and the mother/caregiver attended together. Both the EF performance tasks and the *BRIEF-P* were administered on the

same day during the visit. Efforts were made to standardize the assessment process so that setting variables would remain constant.

The three EF performance tasks were administered to the participants consecutively in a small, bright room with a partially hidden camera in the wall so that child responses to the task stimuli could be accurately recorded for scoring purposes. The room had a wooden table and two regular, adult-sized chairs. The child's chair had a pillow. The testing room had no window and the walls were bare except for two, small pictures (see Appendix H for photographs of the testing room). There were no other distractors present.

The majority of the EF assessments were completed in the morning, at approximately 11.30 am. Due to the fact that a nutritional assessment involving a healthy food sample was carried out directly before the presentation of the EF tasks, it was possible to ensure that all children taking part in the assessment had recently had a snack and a drink. Furthermore, in order to control for fatigue, all participants had been given a brief break (5 minutes duration) prior to completing the EF performance tasks.

The *BRIEF-P* was administered with the mother/caregiver in a small, private office at the research laboratory. Since the child was typically engaged in an activity with another adult during this time, the mother/caregiver was able to complete the *BRIEF-P* without the child's presence or any interference. The *BRIEF-P* was carried out at approximately 10am (prior to the child EF tasks) however, the parent rating forms were not scored until both the child and mother had left the research laboratory to prevent any parent information from influencing the experimenter's EF task presentation.

3.4.1.2. In-Home Child Assessments

The in-home executive functioning assessments were completed during a single visit to the family home. Both the EF performance tasks and the *BRIEF-P* were administered on the same day. The three EF performance tasks were administered to the participants consecutively in the home environment (lounge or kitchen). In absence of a hidden camera, a hand-held video camera was used to record EF response data. While attempts were made to keep the setting variables constant, the in-home child assessments varied considerably to those carried out at the research laboratory. For example, during the in-home assessments the hand-held camera was very visible to the child which may have caused some reactivity. Furthermore, on occasion there were distractors in the home setting which could not be controlled, such as a younger sibling talking or a television on in the background. Attempts to reduce distractions were made including finding a quiet space that had minimal interferences. The in-home EF tasks were completed both during morning sessions (at approximately 11.30am) and also during afternoon sessions (after lunch). Snacks were provided to the child prior to assessment to ensure they were not hungry.

The *BRIEF-P* was administered with the mother/caregiver in a private area of the home. Another adult was working with the child during this time which allowed the mother/caregiver to complete the *BRIEF-P* without the child's presence or interference.

3.4.2. Data Collection of Prenatal Exposure to Neuroactive Substances

Information regarding prenatal exposure to neuroactive substances was collected in two principal ways. Firstly, the IDEAL-NZ Study staff visited the mother at the hospital soon after the child was born and conducted the *Substance Use Inventory (SUI)*, a detailed questionnaire which is designed to assess the type, frequency and quantity of different drugs used during the three month period prior to pregnancy and in

each subsequent trimester (LaGasse et al., 2011). The *SUI* was based on the *Maternal Inventory of Substance Use (MISU)* which has been used in other similar studies (Shankaran et al., 2004). The interview questions were read to the mother in order to provide standardization across participants. Methamphetamine exposure was therefore initially determined by maternal self-report from this measure. Self-reported use of other psychoactive substances during pregnancy, such as alcohol, tobacco, and marijuana, were also collected and considered as secondary variables of interest for participants in both the experimental and control groups. In order to measure on-going drug use, the mothers in the study were interviewed again using the *SUI* at several stages throughout the children's development, including at the 4.5 year (54 month) visit.

The second approach used to determine prenatal exposure to psychoactive drugs involved collecting samples from the new-born's stool. Meconium analysis is an accurate method of quantifying the amount of drug misuse during pregnancy. Meconium specimens were collected during the study staff's first visit to the hospital for analysis of drug metabolites. Tests on these samples were then conducted at a central laboratory in the USA. Detailed descriptions of the tests themselves are provided in LaGasse et al., (2011). Due to the considerable time it took to ship the meconium specimens to the USA, children were enrolled into the IDEAL-NZ Study based on maternal self-report alone. However, once the meconium samples had been processed, the self-report data were reviewed. If the mother gave a negative self-report on methamphetamine use during pregnancy but the meconium sample was positive, the child was re-allocated to the experimental group.

All assessors involved in the IDEAL-NZ Study are blinded regarding all aspects of each mother's drug use both during and after pregnancy and regarding each child's

prenatal exposure to psychoactive substances. Assessors were unblinded to this information for this study only once data collection and scoring had been completed.

3.4.3. Experimental Protocol for Executive Function Tasks

The three EF performance tasks were administered consecutively in the following order; *Bear/Dragon*, *Day/Night*, and *Gift Delay (wrap)*. This order was selected because the *Bear/Dragon* task was considered to be the most enticing for young children and was predicted to be an effective way of making the children feel comfortable with the experimenter and encourage them to enter the testing room. In addition, the *Gift Delay (wrap)* task had to be administered at the end of the testing session as it involves rewarding the child for their participation with a present.

The child's parents/caregivers were not present during the administration of the EF tasks, except where this was specifically requested by the child. On those instances the examiner asked the parent not to help the child with the tasks. The three tasks took approximately 15 minutes to complete in total. As each task was relatively short, no breaks were given in between the three EF tasks.

3.4.3.1. The *Bear/Dragon* Executive Function Task

The *Bear/Dragon* task was conducted as described previously in Section 3.3.1. A script was used throughout this task in order to ensure appropriate standardization across participants (see EF score sheet for script in Appendix C). There were 18 trials in total, six pretest trials and 12 test trials.

In the six pretest trials puppet instructions were administered in an alternating order with three different commands from each puppet. Similarly to other versions of this task, the puppet commands all involved easy and familiar hand movements that could be performed while sitting down at the table (e.g. "*Touch your nose*", "*Clap your hands*"). The pretest trials enabled the experimenter to check that the child understood

the rules of the game. Explicit feedback was provided by the experimenter after each practice trial so that any wrong responses could be corrected and also so that the child was reinforced for responding correctly. In the practice trials prompting was also permitted. After the six practice trials, all children moved on to the test trials regardless of their performance.

The sequence of the 12 test trials (six commands from each puppet) was randomized and then presented in a fixed order to each child. This was done so that they would be more challenging than the pretest trials and also to prevent the child from predicting what might come next. As previously reported by Reck and Hund (2011), the bear (b) and dragon (d) trials were presented in the following order; b, b, d, b, d, d, d, b, d, b, d, b. The actions that each puppet requested the child to do were also in a predetermined fixed sequence to maintain consistency across participants (see EF score sheet for puppet requests in Appendix C). In the test trials no feedback or prompting was provided by the examiner. If the child made an error then the game carried on. If the child did not respond at all, or did something unrelated to the task (e.g. talk, or leave the chair), the examiner waited for 5 seconds and then continued to the next trial. Therefore there was a time window of approximately 5 seconds within which the child needed to perform the requested action.

Child behaviour on the *Bear/Dragon* task was coded according to the adapted version of the scoring system suggested by Kochanska et al (1996). Therefore child responses to puppet requests using this system consisted of; 0= no movement at all, 1 = wrong movement, 2 = partial correct movement, and 3 = full, correct movement. Operational definitions of these movements were established prior to testing the participants and were shared with other study members for interobserver rating purposes (see Appendix G for operational definitions of these movements). This coding system

produced an overall inhibition (dragon) score and an overall activation (bear) score for each participant. In addition, the total number of correct inhibition (dragon) trials was recorded in order to provide a single inhibitory control index.

3.4.3.2. The *Day/Night* Executive Function Task

The *Day/Night* task was administered as discussed in Section 3.3.2. A script was used during this task in order to ensure consistency in the protocol across participants (see EF score sheet for script in Appendix C). There were a total of 22 trials, six pretest and 16 test trials. During the pretest phase, the pictures of day and night were presented to the child on cards in an alternating order (three presentations of each different picture). The pretest trials enabled the experimenter to check that the child understood the rules of the “silly” game. Explicit feedback was provided by the experimenter during the practice trials so that any wrong responses could be corrected and also so that the child was reinforced for responding correctly. After the six practice trials, all children moved on to the test trials regardless of their performance.

In the testing phase, the sequence of the 16 pictures (eight of each type of picture), were presented in a fixed order for each participant to ensure standardization. The order of presentation of the day (d) and night (n) pictures were consistent with that reported by Reck and Hund (2011); n, d, d, n, d, n, n, d, d, n, d, n, n, d, n, and d. No rule reminders, reinforcement, or corrections were provided by the experimenter during the test phase. If the children were reluctant to respond to the stimuli or appeared distracted or off-task, the only permitted prompts to engage them in the task were: “*What do you say for this one?*” Or: “*Look at the picture, what do you say?*”

If the child self-corrected his/her response and the new response was right, this counted as a correct response, but was also recorded separately as a self-correction. Any vocabulary confusions (i.e., saying “*moon*” instead of “*night*”) when “*night*”

would have been the correctly inhibited response, were scored as incorrect but the vocabulary confusion was also recorded on the score sheet. Further, if the child did not respond to a picture at all, or said “*I don’t know*” it was scored as incorrect, but the frequency of these two behaviours were recorded on the score sheet. Overall performance on the *Day/Night* task was scored by calculating the total number of correct responses and converting it into percentage accuracy.

3.4.3.3. The *Gift Delay (wrap)* Executive Function Task

The *Gift Delay (wrap)* task was administered to participants as described in Section 3.3.3. A script was written and used to ensure the standardization of task protocol across all participants. Each gift consisted of a colouring book and set of coloured pens. On retrieving the child’s gift from another room, the examiner then announced she had “forgotten” to wrap it up and therefore would need the child to turn around so it may be wrapped and then still a surprise. The examiner turned the child’s chair around, encouraged the child to sit down with her back facing the table, and then gave a reminder not to “peek”. Timing of the child’s latency to peek (in seconds) did not begin until the examiner finished saying these words: “*Now, don’t look until I say you can.*” After this, the gift was wrapped noisily over a period of 60 seconds and then presented to the child. Participant peeking behaviour during the wrapping process was recorded on video so that it could be scored accurately afterwards. An operational definition of peeking behaviour was established prior to testing the participants and was then shared with other study members for interobserver rating purposes (see Appendix G for a detailed operational definition of peeking). For the purposes of this study, peeking behaviour for the *Gift Delay (wrap)* EF task was defined as any physical attempt the child made to see the present during the wrapping process while seated with his/her back to the examiner in the chair. This included turning around either completely

(i.e. full torso) or partially, or else just turning the head over the shoulder enough to try and see the present. Only peeks occurring within the 60 second wrapping period were counted. Since an overall measure of peeking behaviour was obtained for each participant (i.e. the peek resistance score, see below) it was also necessary to categorize the different types of peeks observed (see EF score sheet in Appendix C for details). In instances where the child peeked, got out of the chair, was off-task, or spoke, the examiner continued to wrap the gift. No rule reminders, corrections or reinforcement were provided throughout the wrapping process. The examiner did not engage in any conversation with the child. The gift was given to the child regardless of their performance on the task.

Scoring for the *Gift Delay (wrap)* task consisted of three separate components; latency to first peek (measured in seconds), number of total peeks during 60 seconds, and the peek resistance score. The peek resistance score, as described by Reck and Hund (2011), was used in order to provide an overall index of the type of peeking behaviour occurring. Peeking behaviour was scored for each separate peek according to the following; 0 = full torso turns in order to peek, 1 =subtle over the shoulder head turns /subtle movements, 2 = no peeking occurred at all. Children were then assigned an overall peek resistance score of 0 if *any* of the peeks were full torso peeks, a score of 1 if they peeked but not blatantly, and a score of 2 if no peeking occurred at all during the 60 seconds.

3.4.4. Experimental Protocol for Administration of the *BRIEF-P*

The *BRIEF-P* (Gioia et al., 2001) was administered by the examiner to the mother or primary caregiver of the child (see Section 3.3.5. for a description of the contents of the *BRIEF-P*). Prior to beginning the *BRIEF-P*, the examiner read out the script which introduced the behaviour rating scale to parents and outlined its purpose

(see Appendix E for *BRIEF-P* script utilized) in order to ensure appropriate consistency across all participants. For this study, the examiner read aloud each of the 63 questions on the *BRIEF-P* rating form to each mother/primary caregiver. This method of administration differs from typical administration which usually involves a parent completing the *BRIEF-P* independently. This method of administering the *BRIEF-P* was selected in order to avoid any potential misunderstandings of the questions and was also a method of controlling for variations in maternal literacy.

3.4.5. Other Relevant Child Data Collected

An observer used the child behaviour rating form to independently rate the children from the video while the examiner was simultaneously administering the three EF tasks. The behaviour rating scale was divided into three separate sections to correspond to each EF task (*Bear/Dragon*, *Day/Night*, and *Gift /Delay*). Additional relevant child behaviour which was recorded on the form by the observer included the child's motivation/interest in the EF tasks, rapport/interaction with the examiner, affect during testing, and level of adult support required during testing (from the mother/caregiver or other family member). Furthermore, the behaviour rating form provided space to list any additional reinforcers that may have been required during testing to motivate the children (see Appendices F and G for the EF behaviour rating form and operational definition of behaviours).

After completing the *BRIEF-P*, each mother or primary caregiver was asked to indicate to the examiner the type and frequency of the child's current and prior early childhood education (ECE) if appropriate (some children in the study had no prior or current ECE). Furthermore, the date that each child began some form of ECE was noted so that each participant's total length of ECE experience could be calculated.

3.5. Interobserver Agreement

Interobserver agreement rating was obtained for each scoring component of the three EF performance tasks. Interobserver agreement was calculated for approximately 30% of all of the EF assessment sessions which were collected periodically over a period of 8 months.

Interobserver agreement was calculated by comparing data collected by the primary rater with that recorded by one of two other secondary observers. All observations were video recorded which made replaying EF assessment tasks for a second observer very straight forward. On each occasion, the second observer simultaneously recorded EF behaviour independently from the primary rater, and the data were subsequently compared. A coefficient and percentage of interobserver agreement were calculated for each scored component of an EF task and then for the EF task overall. Finally, the total interobserver agreement for the set of three EF tasks for the particular participant was also calculated.

The two secondary observers were both employed as part of the IDEAL-NZ Study and have had extensive experience working with young children and collecting child development data. As with the primary rater, both of the secondary observers were blind to participant information regarding the amount and type of drug exposure each child had experienced in utero.

The possibility of observer error was limited as each session was video recorded and scored afterwards once the family had left the centre. Therefore in instances where the child's response was uncertain, difficult to interpret, or inaudible, it was possible to rewind and replay the DVD and discuss responses with other observers. It was therefore possible to check observer accuracy several times to ensure that each child was given the correct score on the three EF tasks. Interobserver ratings were collected

from EF tasks for 30%, or fifteen out of fifty participants. The overall interobserver rating for the three EF tasks was 98.5% and was therefore considered to be highly acceptable.

Further, in order to ensure child behaviour was evaluated consistently during the EF performance tasks, interobserver agreement rating was also calculated for the child behaviour rating component. Similarly to the interobserver rating for the EF tasks detailed above, this was carried out on 30% of all participants (fifteen out of the total of fifty) and occurred periodically over a period of 8 months. The overall interobserver agreement for the child behaviour rating form was 94.3% and was therefore considered to be very satisfactory.

3.6. Data Analysis

Statistical analysis of the child EF data was carried out using SPSS. Statistical analysis of the *Bear/Dragon* and *Day/Night* tasks was carried out on the data from test trials only. Pretest trials in both of these tasks were provided to familiarize the child both with the examiner and the task and therefore were not included in the statistical analysis. Furthermore, each child's peek resistance score in the *Gift Delay (wrap)* task was not incorporated into the statistical analysis of the dataset since the latency to first peek and the total number of peeks provided parametric variables to quantify child performance on this task.

Data from the executive function assessments that generated parametric data (the *Day/Night* task, the *Gift Delay (wrap)* task and the *BRIEF-P* measures) were subjected to a MANOVA with fixed factors of methamphetamine exposure (exposed children vs. non-exposed controls) and gender (males vs. females). Early childhood education (ECE) measures (length of ECE attendance in months and total ECE hours per week) were included as covariates. Independent samples t-tests and Pearson correlation

coefficients were then used to further explore the effect of prenatal methamphetamine exposure on the measures of executive function and the relationship between the different measures. Correlational analyses were conducted for the whole group of 50 children and for each sub-group of 25 methamphetamine-exposed and 25 control children.

Data from the *Bear/Dragon* task were non-parametric and so independent samples Mann Whitney U tests were used to investigate the effect of drug exposure and Spearman's Rho correlation coefficients were used to explore the relationship between this executive function measure and the other measures mentioned above.

In order to facilitate comparison between this dataset with data from other similar studies of child executive functioning, scores on each of the three EF tasks were converted into a pass/fail category. Allocation to either the pass/fail group was determined using a binomial theorem suggested by Carlson (2005). In order to be scored as passing the *Bear/Dragon* task children must have correctly inhibited 5/6 of the dragon trials (or have correctly inhibited the dragon 80% of the time). To pass the *Day/Night* task children needed to score 12/16 trials correct, or achieve a percent correct score of 75% or above. Finally, passing the *Gift Delay (wrap)* task was determined by whether children peeked or not, as suggested by Carlson (2005).

The proportion of passes and fails for the methamphetamine-exposed and control children were therefore calculated for each test. The proportions were compared by calculating 95% confidence intervals for each proportion using Wilson Score Intervals. Non-overlapping 95% confidence intervals would have indicated a significant difference in pass/fail rates between the two groups of children.

Within the group of children prenatally exposed to methamphetamine, nine out of twenty-five of the children's mothers reported current methamphetamine use at the

4.5 year/54 month assessment in the *SUI* interview. Independent samples t-test were conducted on the executive function results described above in order to assess whether on-going maternal methamphetamine use was an important environmental risk factor for EF development.

3.7. Ethical Considerations

The IDEAL-NZ Study was granted full ethical approval from both the Auckland District Health Board (DHB) and the Waitemata DHB. In addition, approval was also sought and received through the Northern Regional X Ethics Committee which is administered by the New Zealand Ministry of Health. Additional approval of the amendments to the study protocol for the children aged 4 was granted by Northern Regional X Ethics Committee in March 2011 (see Appendix A). The study participants included Maori individuals and so consultation with relevant iwi and Maori Health care agencies was also required. The IDEAL-NZ Study was granted ethical approval by the Maori Research Committees at both the Auckland DHB and the Waitamata DHB. Informed consent was obtained from each of the mothers of the children involved in the IDEAL–NZ longitudinal study prior to engaging in any child assessment procedures. The mothers also gave consent on behalf of their children to participate in the research study. Initial written consent from the mothers was obtained during their pregnancy when they were first recruited to the study. Full written consent to participate in the 4.5 year/54 month assessments was subsequently obtained from each mother/caregiver on arrival at the research laboratory when they were provided with an information sheet about the project. A copy of the consent and information forms given to mothers for the assessment session is provided in Appendix B.

Chapter 4. Results

4.1. Participant Demographics

Fifty children were assessed during the course of this Master's study, 25 of whom were exposed to methamphetamine prenatally. The mean age of the methamphetamine-exposed group was 56 months ($SD = 2.6$ months) and the mean age of the control group of children was 55 months ($SD = 2.3$ months). The ages of the children in the two groups did not differ reliably from one another ($t_{48}=1.02, p = .3$).

The methamphetamine-exposed group contained 12 males and 13 females and the control group contained 13 males and 12 females. The total number of early childhood education (ECE) experience per week varied considerably within the cohort but did not differ reliably between the exposed and control children (exposed children $M = 19$ hours, $SD = 11$; control children $M = 20$ hours, $SD = 11, t_{48} = 0.4, p = .7$). However, within the exposed group, males had significantly fewer hours of total ECE experience than did females (males = 13.8 hours per week, $SD = 11.6$; females = 24.5 hours per week, $SD = 7.3$). The control group had started ECE an average of 4 months earlier than the exposed group, but this was not found to be a reliable difference (exposed children $M = 22$ months of attendance, $SD = 19$; control children $M = 26$ of attendance, $SD = 18, t_{48} = 0.8, p = .4$).

There were two experimental settings for the assessments in this study; research laboratory and home setting. Eight children were tested in a home setting, five of whom were prenatally exposed to methamphetamine and three of whom were control children. The results for these children did not differ statistically from the children tested in the laboratory setting for any measure of executive functioning (the three EF performance tasks and the *BRIEF-P*, independent samples t-tests, $p > .05$) or for ratings of behaviour, parental consistency and parental negativity on the *BRIEF-P*. Therefore the children

tested in a home setting were not considered to differ from those tested in the research laboratory setting.

4.2. The Effect of Prenatal Methamphetamine Exposure on Measures of Preschool Executive Function

To investigate the effects of prenatal methamphetamine exposure on preschool executive functioning, a multivariate general linear model (MANOVA) was conducted on the results of the *Day/Night* task (percent correct), the *Gift Delay (wrap)* task (number of peeks and latency to first peek) and the *BRIEF-P* rating scale (Global Executive Composite T-scores). Gender (male/female) and methamphetamine exposure (exposed/control) were included as fixed factors and ECE experience (length of ECE attendance and total number of ECE hours per week) were also included as covariates. The results of the *Bear/Dragon* task were not included in this overall analysis as the data were non-parametric.

Across all measures of preschool executive function included in the analysis there was a significant effect of methamphetamine exposure ($F_{4,41} = 4.0, p = .008$) and no significant effect of gender ($F_{4,41} = 1.2, p = .32$). There was no gender by methamphetamine exposure interaction ($F_{4,41} = 0.8, p = .52$) indicating that the effect of methamphetamine exposure was the same for both boys and girls. There was also no overall effect of ECE experience either for length of ECE attendance ($F_{4,41} = 0.16, p = .96$) or total ECE hours per week ($F_{4,41} = 0.12, p = .24$).

An examination of the between subjects effects detected by the model revealed the following significant effects. Total hours of ECE attendance was significantly related to the total number of peeks in the *Gift Delay (wrap)* task ($F_{1,44} = 4.7, p = .035$). In addition there was a significant effects of methamphetamine exposure on the latency to first peek measure of the *Gift Delay (wrap)* task ($F_{1,44} = 4.6, p = .038$) and the *BRIEF-*

P Global Executive Composite score ($F_{1,44} = 4.1, p = .048$). There were also marginal effects of methamphetamine exposure on percent correct for the *Day/Night* task ($F_{1,44} = 3.0, p = .089$) and the number of peeks in the *Gift Delay (wrap)* task ($F_{1,44} = 3.6, p = .065$). There were no other significant between subjects effects or interactions including no significant effect of gender for *any* task.

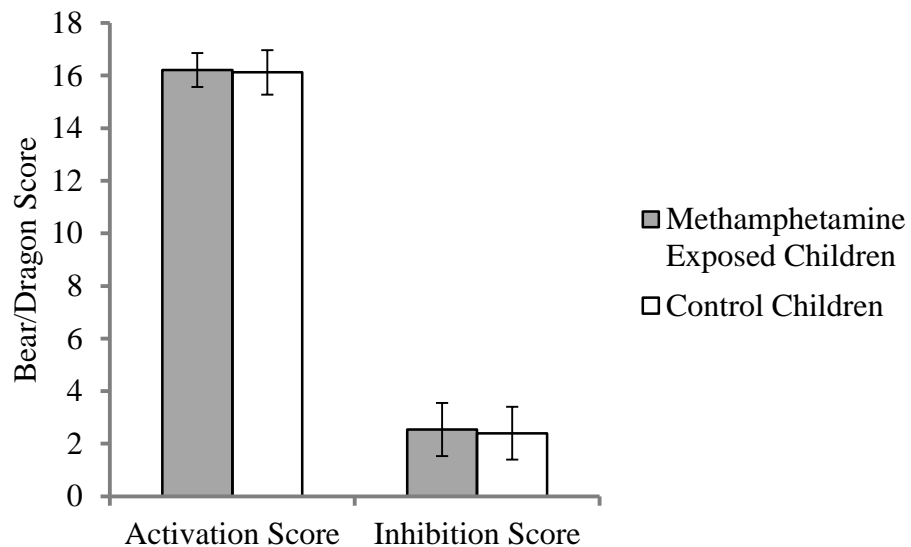
In the following sections the significant effect of prenatal methamphetamine exposure identified in the overall analysis is explored in detail for each measure of preschool executive function. In particular, the directions of the effects are identified. In addition, the relationships between the different measures of executive function and their relationships with other factors such as ECE experience are further explored. As there was no effect of gender in the overall model, this factor was not considered further.

4.2.1. The Effect of Prenatal Methamphetamine Exposure on Executive Function Performance Tasks

The mean activation (bear request) score on the *Bear/Dragon* EF task for the methamphetamine-exposed children was 16.2 ($SD = 3.2$) and the mean activation (bear request) score for the control children was 16.1 ($SD = 4.2$). The mean inhibition (dragon request) score were 2.5 ($SD = 5.1$) for the exposed children and 2.4 ($SD = 5.0$) for the control group of children. The two groups of children did not significantly differ on either measure as can be seen in Figure 1 ($p = .6$ for both comparisons, independent samples Mann-Whitney U test). Twenty out of twenty-five children passed the test for both the methamphetamine-exposed group and the control group. Further, there were no reliable differences found in *Bear/Dragon* task performance between children in the exposed group with mothers who self-reported on-going methamphetamine use at the

54 month assessment, and those in the exposed group with mothers who did not report on-going methamphetamine use.

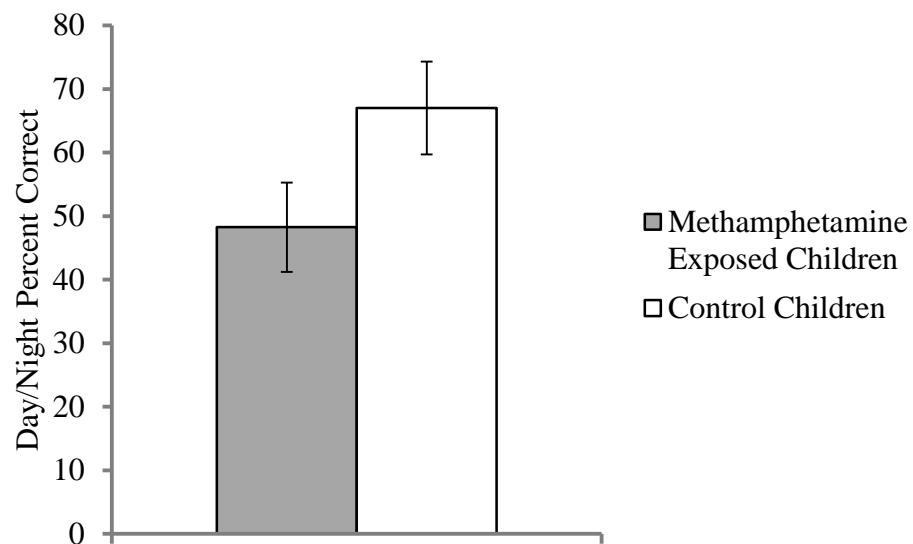
Figure 1. *Bear/Dragon* task results for the two groups of children (larger scores show better performance for activation and poorer performance for inhibition). Error bars show ± 1 standard error of the mean on this figure and all subsequent figures



The mean percent correct on the *Day/Night* performance task was 48.3% ($SD = 35.1$) for the exposed children and 67% ($SD = 36.6$) for the control children. This difference between the groups was marginal ($t_{48} = 1.9, p = .07$, two-tailed independent samples t-test) as shown in Figure 2. However, children in the exposed group whose mothers self-reported on-going methamphetamine use at the 54 month assessment, demonstrated significantly worse performance on this EF task compared to those children whose mothers reported no current use of the substance ($t_{23} = 2.3, p = .03$, on-going use = 28.5% correct, $SD = 34$, no current use = 59.4% correct, $SD = 31$). Eight out of twenty-five exposed children and fourteen out of twenty-five control children passed this test. These proportions did not reliably differ from one another (exposed children proportion passed = 0.32, 95% confidence intervals = 0.17 to 0.52; control children proportion passed = 0.56, 95% confidence intervals = 0.37 to 0.73).

The percentage of trials scored as involving vocabulary confusion (i.e., child says “moon” to mean “night”/ “sun” to mean “day” etc.) was also measured for the *Day/Night* task. There was no difference between the methamphetamine-exposed and control children in terms of the percentage of trials that resulted in vocabulary confusion. The exposed children had vocabulary confusion on 7% of trials ($SD = 14.4$) and the control children on 5.5% of trials ($SD = 15.1$), ($t_{48} = 0.36$, $p = 0.72$). The same was true for self-corrections during the *Day/Night* task. Methamphetamine-exposed children self-corrected their responses to stimuli on 2.5% of trials ($SD = 4.4$) and the control children self-corrected responses on 3% of trials ($SD = 5.1$), ($t_{48} = 0.6$, $p = .6$). Neither vocabulary confusions nor self-corrections were found to be related to age, gender or ECE experience across the whole cohort of 50 children.

Figure 2. The mean percent correct scores on the *Day/Night* task for the two groups of children.



The *Gift Delay (wrap)* task had two primary measures, the number of peeks in 60 seconds and the latency to first peek. The mean number of peeks (see Figure 3) was 0.8 ($SD = 1.3$) for the methamphetamine-exposed group and 1.6 ($SD = 1.9$) for the control group. This difference was statistically marginal ($t_{48} = 1.8$, $p = .09$). The mean

latency to first peek (Figure 4) was 46 seconds ($SD = 21$) for the exposed group and 33 seconds ($SD = 24$) for the control group. This difference was statistically reliable whereby the methamphetamine-exposed children resisted peeking for a significantly longer period of time than did the control children ($t_{48}=2.1, p = .04$). Self-reported ongoing maternal methamphetamine use indicated at the 54 month interview was not found to result in any reliable differences in measures from the *Gift Delay (wrap)* task among the children in the exposed group.

Seventeen out of twenty-five exposed children and ten out of twenty-five control children passed the *Gift Delay (wrap)* test. These proportions did not reliably differ from one another (exposed children proportion passed = 0.68, confidence intervals = 0.48 to 0.83; control children proportion passed = 0.40, 95% confidence intervals = 0.23 to 0.60).

Figure 3. Mean number of peeks in 60 seconds on the *Gift Delay (wrap)* task for the two groups of children (fewer peeks = more resistance/inhibitory control).

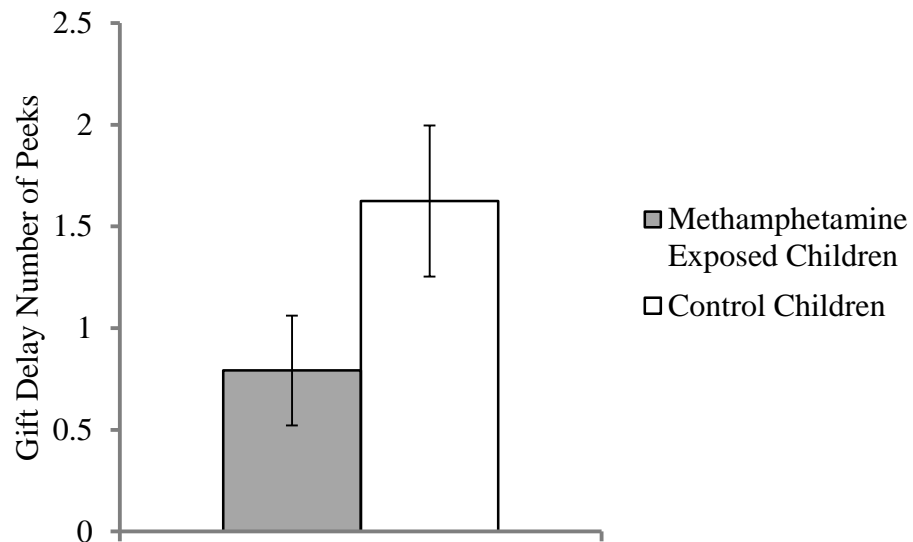
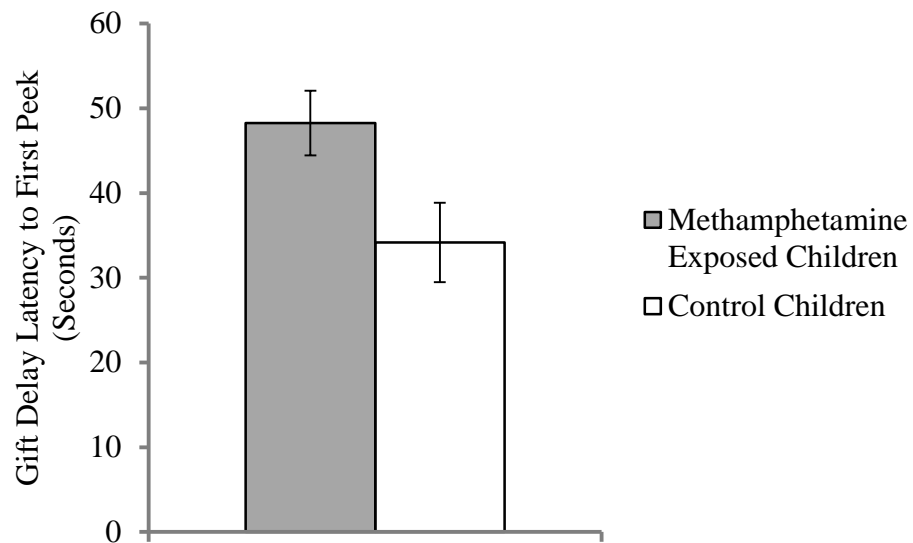


Figure 4. Latency to first peek on the *Gift Delay (wrap)* task for the two groups of children (greater latency to peek = more resistance/inhibitory control).



4.2.2. The Effect of Prenatal Methamphetamine Exposure on Parent Rating on the *BRIEF-P*

The parental inconsistency scores and parental negativity scores did not differ reliably between the mothers of exposed children and the mothers of control children. The mean consistency score for mothers of exposed children was 4.1 ($SD = 2.1$) and for the mothers of control children 3.5 ($SD = 1.7$), ($t_{48} = 1.1$, $p = .27$). The mean negativity score was 0.9 ($SD = 1.3$) for mothers of exposed children and 0.4 ($SD = 1$) for mothers of control children ($t_{48} = 1.4$, $p = .17$).

The Global Executive Composite score on the *BRIEF-P* provides a summary measure of all five clinical scales assessed. A higher Global Executive Composite Score therefore indicates greater overall executive dysfunction. Methamphetamine-exposed children received a significantly higher Global Executive Composite score than control children on the *BRIEF-P* parent rating scale (see Table 4 for statistics). In addition, a higher proportion of the exposed children exhibited clinically significant

Global Executive Composite T-scores on the *BRIEF-P* (eight out of twenty-five vs. one out of twenty-five for controls) although this difference was not statistically reliable.

Several subcategories of the *BRIEF-P* also differed significantly between the groups with exposed children receiving higher ratings (see Table 4). Among the clinical scales of the *BRIEF-P*, significant differences were found in the Shift, Emotional Control, and Plan/Organize measures. Marginal differences were also found for the Working Memory scale, but no significant differences were found for the Inhibit scale. Among the three EF indexes, significant differences were found for Flexibility, marginal differences were revealed for Emergent Metacognition but no differences existed at all between the two groups of children for Inhibitory Self-Control.

Table 4. Group differences on *BRIEF-P* measures of executive function. t-values calculated using independent samples t-test. *denotes a significant difference ($p < .05$).

<i>BRIEF-P</i> Measures (Scales/Indexes)	Experimental (methamphetamine- exposed) group Mean T-Score (SD)	Control group Mean T- Score (SD)	t-value	p-value
Inhibit Score	58.0 (12.8)	54.6 (9.5)	1.06	0.29
Shift Score	51.7 (10.1)	46.8 (5.8)	2.07	0.044*
Emotional Control Score	58.0 (11.9)	51.2 (12.2)	2.01	0.05*
Working Memory Score	59.6 (14.1)	53.5 (10.6)	1.74	0.089
Plan/Organize Score	57.8 (15.4)	50.1 (9.3)	2.14	0.037*
Inhibitory Self- Control Index	59.0 (13.4)	53.5 (10.1)	1.62	0.11
Flexibility Index	55.4 (10.8)	48.9 (8.6)	2.38	0.021*
Emergent Metacognition Index	59.7 (14.8)	52.7 (10.1)	1.96	0.056
Global Executive Composite	59.2 (13.9)	52.3 (9.4)	2.06	0.045*

4.2.3. Ratings of Child Behaviour during the Executive Function Tasks

An overall rating of behaviour was calculated by an observer for each child across all three executive function performance tasks. The ratings did not differ between methamphetamine-exposed and control children. Exposed children had a mean rating of 2.1 ($SD = 3.5$) and control children of 3.0 ($SD = 4.6$), ($t_{48} = 0.8$, $p = .4$). Interestingly, behaviour ratings for the whole cohort of 50 children were reliably negatively correlated with both total hours of ECE per week ($r = -0.32$, $p = .02$), shown in Figure 5, and length of ECE attendance ($r = -0.37$, $p = .008$), shown in Figure 6. Although these relationships were weak (explaining approximately 12% of the variance in the behaviour rating data) they do suggest that ECE experience may have some positive impact on behavioural regulation at this stage of early childhood.

Figure 5. The relationship between the overall behaviour rating for the executive function tasks (larger numbers = poorer observed behaviour during tasks) and the total hours of ECE experience per week at the time of assessment.

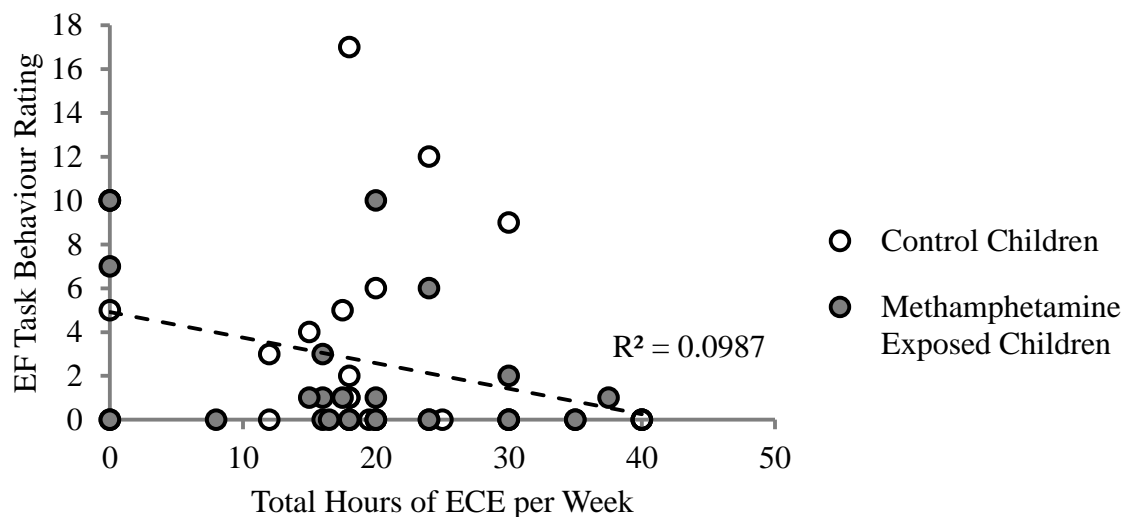
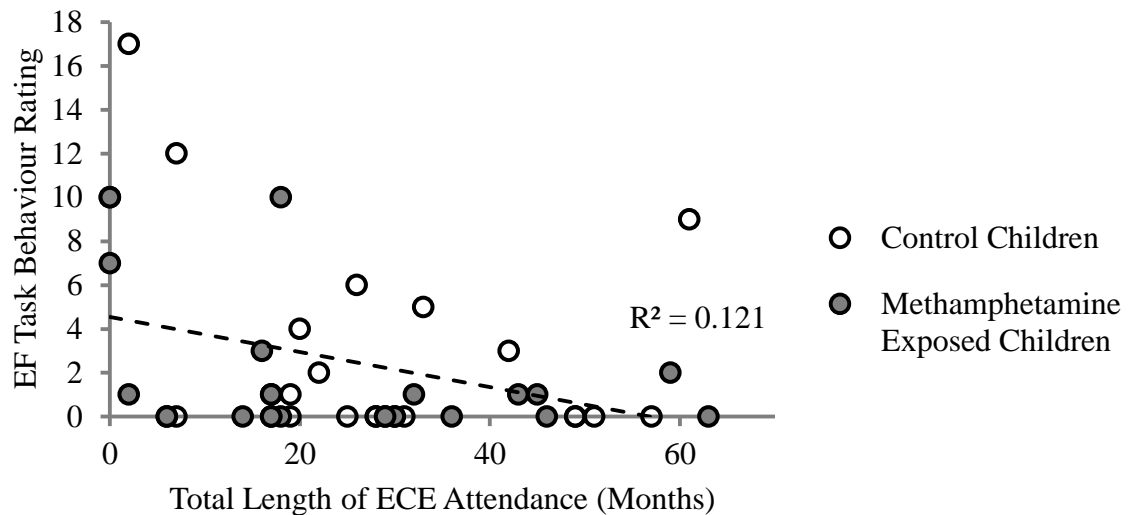


Figure 6. The relationship between the overall behaviour rating for the executive function tasks (larger numbers = poorer observed behaviour during tasks) and the total length of early childhood education attendance in months at the time of assessment.



4.3. The Relationship between Different Measures of Executive Function

4.3.1. Relationships for the Whole Cohort of 50 Children

4.3.1.1. Relationships between the Three Executive Function Tasks

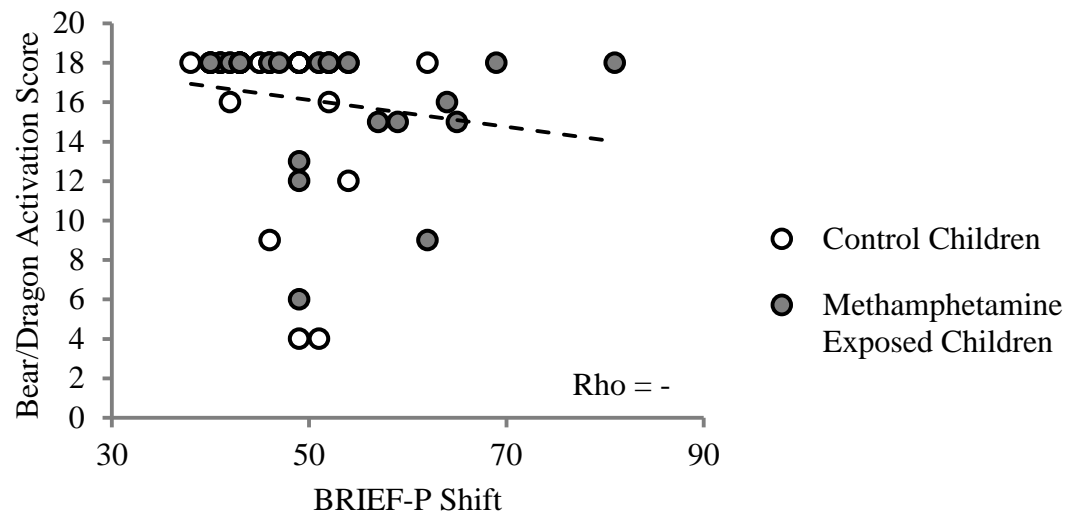
The scores generated by the three EF performance tasks were not reliably correlated with one another. The only reliable relationship was within the *Gift Delay* (*wrap*) task itself, whereby the number of peeks had a significant negative correlation with the latency to first peek, as would be expected ($r = -0.79, p < .001$).

4.3.1.2 Relationships Involving the *BRIEF-P* T-Scores

As expected, subtests of the *BRIEF-P* were significantly correlated with the overall measure of Global Executive Composite ($n = 50$, Pearson's $r > 0.64, p < .0001$) and with one another ($p < .006$). There were also weak but reliable relationships between *BRIEF-P* measures and the three executive function tasks conducted with the children. The *Bear/Dragon* activation (bear request) score had a significant negative correlation with the Shift *BRIEF-P* measure (Spearman's Rho = $-0.37, p = .008$) as

shown in Figure 7 and a marginal negative correlation with the Inhibit *BRIEF-P* measure ($Rho = -0.28, p = 0.051$). The inhibition (dragon request) score for the *Bear/Dragon* task was not reliably correlated with any *BRIEF-P* measures.

Figure 7. The relationship between the *Bear/Dragon* task activation score and the *BRIEF-P* Shift measure.



The percent correct score on the *Day/Night* task showed a significant negative correlation with *BRIEF-P* Global Executive Composite score ($r = -0.3, p = 0.034$, Figure 8), the Working Memory score ($r = -0.29, p = .041$, Figure 9) the Plan/Organize score ($r = -0.33, p = .021$, Figure 10) and the Emergent Metacognition score ($r = -0.31, p = .027$, Figure 11). The *Day/Night* percent correct score also showed a marginal negative correlation with the *BRIEF-P* Inhibit score ($r = -0.27, p = .055$).

respectively. The latency to first peek metric had a marginal negative correlation with the *BRIEF-P* Global Executive Composite score ($r = -0.26, p = .063$) and reliable negative correlations with the *BRIEF-P* Inhibit ($r = -0.38, p = .007$, Figure 15) and Inhibitory Self-Control ($r = -0.33, p = .019$, Figure 16) scores.

Figure 12. The relationship between number of peeks on the *Gift Delay (wrap)* task and the *BRIEF-P* Global Executive Composite measure.

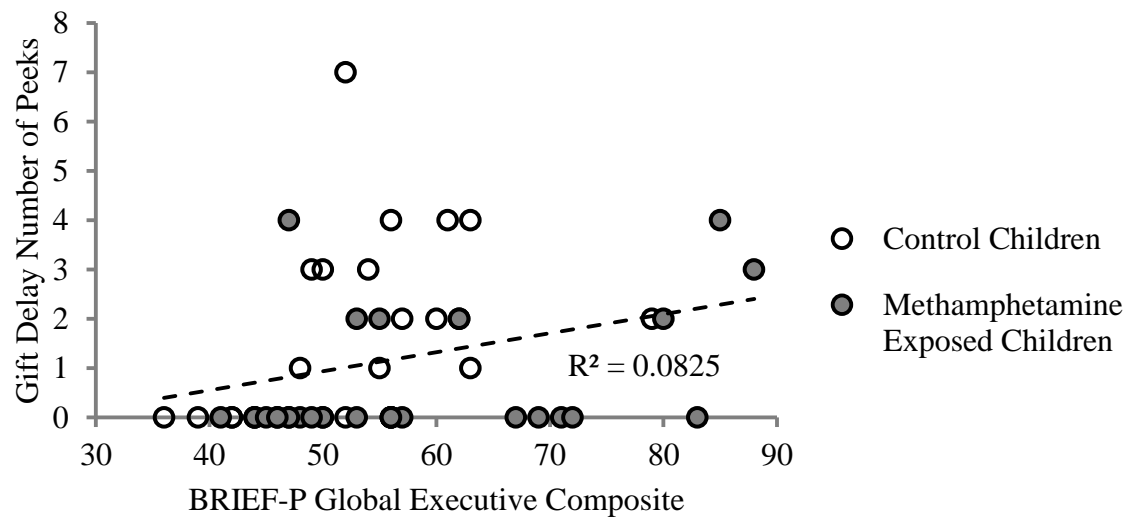


Figure 13. The relationship between the number of peeks on the *Gift Delay (wrap)* task and the *BRIEF-P* Inhibit measure.

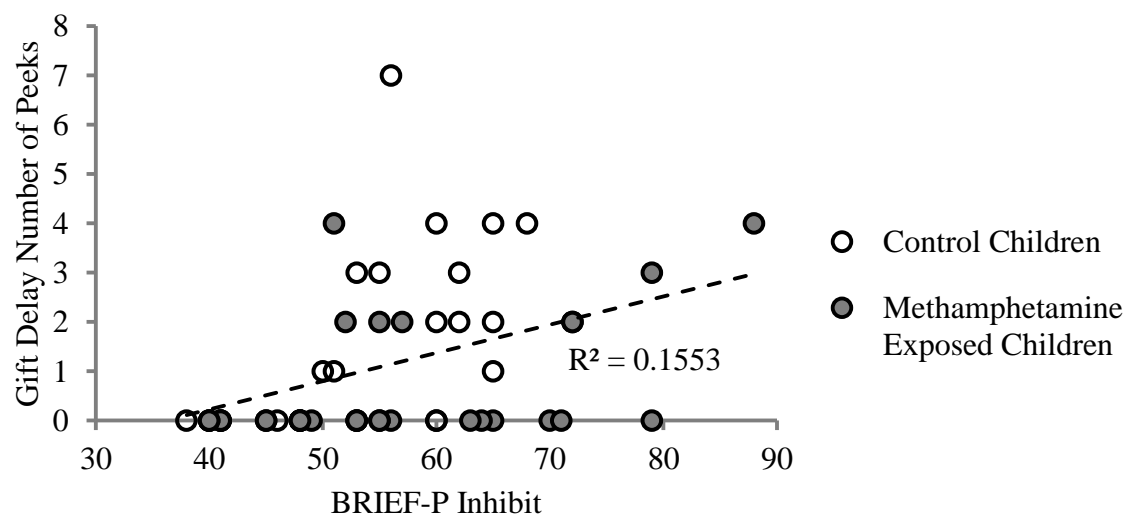
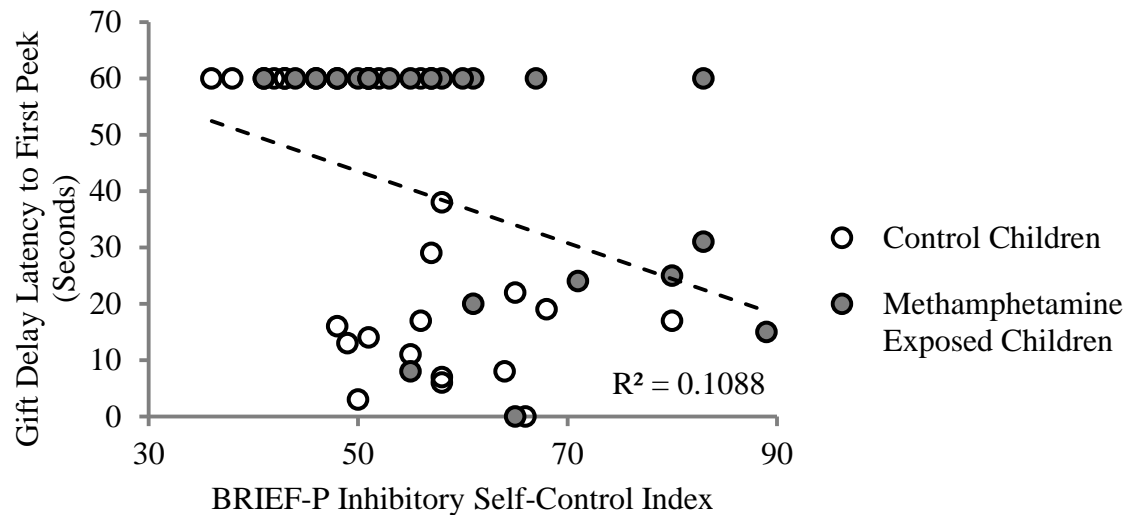


Figure 16. The relationship between the latency to first peek on the *Gift Delay (wrap)* task and the *BRIEF-P* Inhibitory Self-Control Index.



4.3.1.3. The Relationship between Age and Early Childhood Education Experience on Measures of Executive Function

Age was not significantly correlated with *any* measure of preschool executive functioning (EF tasks or *BRIEF-P*), but did show a significant positive correlation with the length of ECE attendance ($r = 0.31, p = 0.03$) as would be expected (a greater amount of time has passed since older children started ECE vs. younger children).

Neither measure of ECE attendance (i.e. length of ECE attendance or total number of ECE hours per week) was reliably correlated with any *BRIEF-P* measure or with the percent correct score for the *Day/Night* task. There was, however, a negative correlation between the total number of ECE hours per week and the number of peeks on the *Gift Delay (wrap)* task ($r = -0.35, p = .012$), as shown in Figure 17, indicating that children receiving more ECE hours per week peeked less frequently. In addition, the total activation (bear request) score on the *Bear/Dragon* task was positively correlated with the length of ECE attendance ($\rho = 0.29, p = .042$), whereby children

who had started ECE earlier were able to follow instructions given by the bear puppet more accurately. This relationship is shown in Figure 18. No other ECE-related correlations were present in the dataset, with the exception of the anticipated positive correlation between length of ECE attendance and total ECE hours per week ($r = 0.63, p < .001$).

Figure 17. The relationship between the number of peeks on the *Gift Delay (wrap)* task and the total hours of ECE per week.

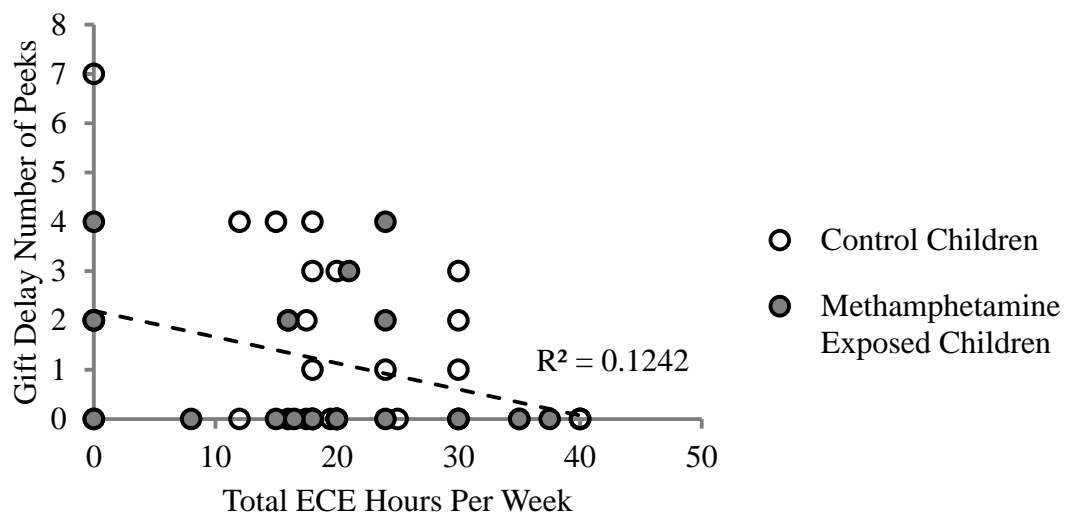
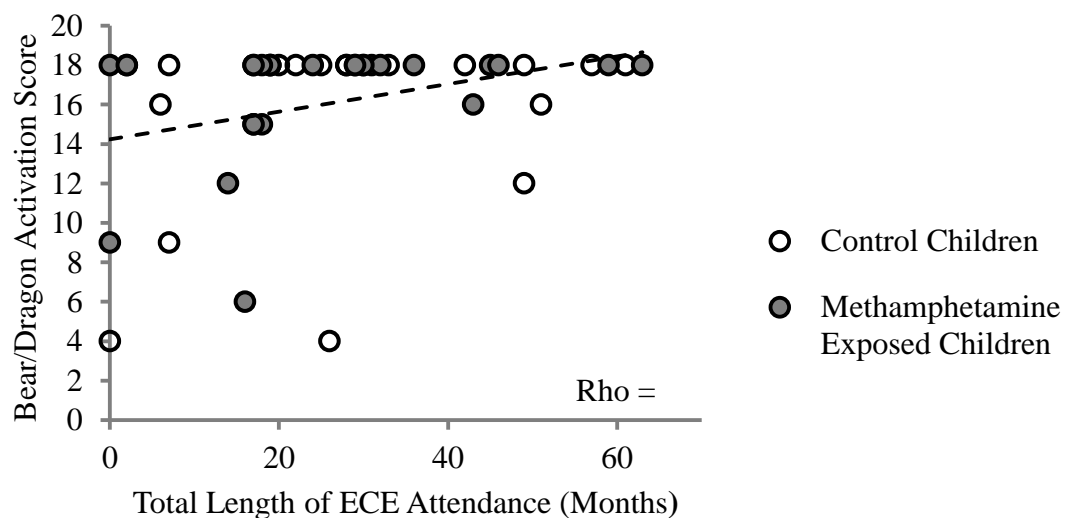


Figure 18. The relationship between the activation score on the *Bear/Dragon* task and the total length of ECE attendance at the time of assessment.



4.3.2. Relationships for the Methamphetamine-Exposed Children

4.3.2.1. Relationships between the Three Executive Function Tasks

The three executive function tasks were not reliably related to one another within the methamphetamine-exposed group. The only reliable relationship was between the number of peeks and the latency to first peek for the *Gift Delay (wrap)* task which is expected ($r = -0.71, p < .001$).

4.3.2.2. Relationships involving the *BRIEF-P* T-scores

For this subset of children there was a reliable positive correlation between the *BRIEF-P* Inhibit score and the number of peeks on the *Gift Delay (wrap)* task ($r = 0.40, p = .048$). The other relationships found for the whole cohort were not statistically reliable within the methamphetamine-exposed sub-group, although the trends were in the same direction.

4.3.2.3. The Relationship between Age and Early Childhood Education Experience on Measures of Executive Function

A similar pattern of weak but reliable relationships found for the whole cohort of 50 children were also present in the sub-group of children who were prenatally exposed to methamphetamine. Length of ECE attendance was negatively correlated with the number of peeks on the *Gift Delay (wrap)* task ($r = -0.4, p = .05$) and positively correlated with the activation score on the *Bear/Dragon* task ($\rho = 0.41, p = .049$). Age was not reliably correlated with any measure.

4.3.3. Relationships for Control Group of Children

4.3.3.1. Relationships between the Three Executive Function Tasks

For the control group there was a reliable positive correlation between the inhibition score on the *Bear/Dragon* task and the number of peeks on the *Gift Delay (wrap)* task ($\rho = 0.47, p = .017$) whereby poorer inhibition scores (i.e. a larger score)

on the *Bear/Dragon* task was related to more peeks (i.e. poorer inhibitory control) on the *Gift Delay (wrap)* task. In addition, as found for the overall data and for the methamphetamine-exposed children, there was a reliable relationship between the number of peeks and the latency to first peek for the *Gift Delay (wrap)* task ($r = -0.73, p < .001$).

4.3.3.2. Relationships involving the *BRIEF-P* T-Scores

There were several statistically reliable correlations involving the *BRIEF-P* T-scores for the control group of children. The number of peeks on the *Gift Delay (wrap)* task was positively correlated with the *BRIEF-P* Inhibit score ($r = 0.054, p = 0.005$). Similarly, the latency to first peek on the *Gift Delay (wrap)* task was negatively correlated with the *BRIEF-P* Inhibit score (larger Inhibit scores predicted less time to first peek) ($r = -0.66, p < .001$). This suggests that these mothers were able to accurately judge their child's inhibitory behaviours. The *BRIEF-P* Shift score was also negatively correlated with the latency to first peek on the *Gift Delay (wrap)* task ($r = -0.42, p = .035$), as were the Working Memory scores ($r = -0.49, p = .012$), the Inhibitory Self-Control scores ($r = -0.61, p < .001$), the Emergent Metacognition scores ($r = -0.44, p = .029$) and the Global Executive Composite scores ($r = -0.6, p < .001$). In addition, the number of peeks on the *Gift Delay (wrap)* task was positively correlated with the Inhibitory Self-Control score ($r = 0.46, p = .019$) and the Global Executive Composite score ($r = 0.45, p = .026$). There were no reliable relationships between the results of the *Day/Night* task or the *Bear/Dragon* task and the *BRIEF-P* measures for this control group of children.

4.3.3.3. The Relationship between Age and Early Childhood Education Experience on Measures of Executive Function

Consistent with the methamphetamine-exposed group, the executive function measures for the control group were not reliably related to age (which was a controlled variable in this study). There was a reliable negative relationship between the total number of ECE hours per week and the number of peeks on the *Gift Delay (wrap)* task ($r = -0.48$, $p = .012$). This is in agreement with the positive association found between ECE experience and performance on the *Gift Delay (wrap)* task identified for the methamphetamine-exposed sub-group of children and the cohort of 50 children as a whole.

Chapter 5. Discussion

5.1. Summary of Findings

This study investigated the effects of prenatal exposure to methamphetamine (IV) on measures of executive functioning (DVs) among 4-year-olds. When all measures of executive function that generated parametric data were accounted for in a multivariate analysis, methamphetamine-exposed children were found to be significantly different to control children. When each individual EF assessment measure was then considered separately, several differences between the two groups of children emerged. Children who had been prenatally exposed to methamphetamine were rated as having significantly weaker EF skills by their mothers/caregivers on the *BRIEF-P* (Gioia et al., 2001) than controls. In addition, methamphetamine-exposed children showed a trend toward poorer performance on the *Day/Night* task than controls. Furthermore, those children in the exposed group whose mothers had self-reported current methamphetamine use at the 54 month interview, were found to perform significantly worse than those children whose mothers did not report recent use of the drug. In contrast, methamphetamine-exposed children performed significantly better than controls on the *Gift Delay (wrap)* task. Finally, there were no differences between the exposed and control children on the *Bear/Dragon* task. Several weak but reliable relationships were also found between the different executive function measures, assessments of child behaviour from an observer rating scale, and early childhood education (ECE) experience. Therefore the principal hypothesis that those children exposed to methamphetamine prenatally would exhibit poorer outcomes on *all* measures of executive function when compared to controls, was not fully supported by the results of this study.

This chapter will discuss the above findings in detail with reference to some of the broader implications of these results. The first section of the chapter will explore the effect of prenatal methamphetamine exposure on child performance of the three EF tasks specifically and will offer potential explanations for the unexpected outcomes from the *Bear/Dragon* and *Gift Delay (wrap)* tasks. Further, comparisons will then be made between these task data and those reported in previous studies of typical preschool executive functioning. In the subsequent section, the impact of prenatal methamphetamine exposure on maternal/caregiver ratings of EF on the *BRIEF-P* will be examined and the educational implications of these results will be emphasised. Following on from this, the relationships between the individual EF assessments will be explored including how well the different EF measures correlated with one another and how effectively the *BRIEF-P* predicted EF task performance among the study cohort. The impact of ECE on different variables in this study shall also be considered. The final three sections of this chapter provide recommendations for future research, study limitations and a conclusion.

5.2. The Effects of Prenatal Methamphetamine Exposure on Executive Function Performance Tasks

The finding that methamphetamine-exposed children demonstrated a trend towards poorer performance on the *Day/Night* task, lends partial support to the initial hypothesis which stated that they would exhibit worse mean performance than controls. Since the *Day/Night* task is a complex response inhibition task, this result suggests that the exposed group of children had marginally poorer inhibitory control and working memory capacity than the controls. This outcome is consistent with previous studies. For example, prenatal exposure to methamphetamine has been linked to poor inhibitory control specifically (Chang et al., 2004) and exposure to cocaine (a substance that is

predicted to have similar pharmacological effects to methamphetamine) in utero has also been found to result in impaired inhibition among young children (Espy et al., 1999). Therefore while the difference between the *Day/Night* scores in each group was not found to be statistically significant, it did identify variations that might be meaningful. It is also worth noting that two children (one from each study group) received very poor behaviour rating scores of 6 and 7 for this task. These scores were more than three standard deviations away from the mean (M score = 0.6, SD = 1.55). If these two children were to be excluded from the data analysis, there would be a statistically reliable difference between the groups for the *Day/Night* task (p = .04). Therefore, it could be that a larger sample of both methamphetamine-exposed and control children are required in order to reveal highly reliable differences between the groups on this task.

Additionally, due to the availability of maternal self-report data at the recent 54 month drug use interview, it was possible to determine which mothers in the experimental group were still using methamphetamine. Therefore performance scores on the *Day/Night* task could be compared for those children who had been exposed to methamphetamine prenatally and whose mothers reported recent or on-going use of the substance, with those children whose mothers no longer reported using it. The nine children in the exposed group whose mothers reported current use of methamphetamine demonstrated significantly worse performance on this EF task compared to those children whose mothers reported no recent use (p = .03). The results from this analysis therefore suggest that lifestyle influences associated with on-going maternal drug involvement may constitute additional risk factors for the development of executive functioning for these children. On-going maternal drug use may affect a number of environmental factors reported to be critical to EF development in young children such

as the quality of mother-child interactions and maternal engagement, parenting skills, maternal psychosocial functioning, and access to resources (Bernier et al., 2010; Sethi et al., 2000; Mezzacappa, 2004; Rhoades et al., 2011).

Prenatal methamphetamine exposure made no difference to the proportion of vocabulary confusions or self-corrections of answers exhibited during the *Day/Night* task, perhaps suggesting that verbal skills were approximately equivalent in both groups of children. However, a more reliable measure of verbal ability would be needed to confirm this premise.

The children in the methamphetamine-exposed group did not show a higher mean frequency of peeking or a shorter mean latency to peek than the control children on the *Gift Delay (wrap)* task. In fact, quite unexpectedly children in the methamphetamine-exposed group significantly outperformed those in the control group on the latency to peek measure and were able to inhibit peeking for much longer (46 vs. 33 seconds for the control group). There were also subtle differences between the total number of peeks exhibited, with the exposed children peeking less frequently. Therefore, overall, the methamphetamine-exposed children demonstrated higher levels of resistance to peeking and so this finding does not support the anticipated result stated in the hypothesis.

Given that the *Gift Delay (wrap)* task is designed to measure inhibition exclusively, this outcome suggests that the exposed group of children have more effective inhibitory control than the non-exposed group. This finding is not consistent with prior research that suggests that prenatal methamphetamine exposure may impair impulse control specifically, as discussed above. Therefore it is important to explore other potential explanations for this outcome. Firstly, the finding that the methamphetamine-exposed children were more compliant in this EF task might be a

reflection of more authoritative or punitive parenting practices occurring in the home. On-going maternal drug involvement has been associated with more rigid, harsh and punitive parenting practices (Miller, Smyth, & Mudar, 1999; Schuler, Nair, & Black, 2002). Therefore one possible explanation for the methamphetamine-exposed children's performance on this task could be that their compliance was higher because they were more accustomed to receiving negative consequences at home if they fail to follow adult commands. The examiner's use of the phrase "*Now, don't look until I say you can*" might have resembled commands used by the mother/caregiver, and thus these children could have expected to be reprimanded by an adult if they had peeked during wrapping.

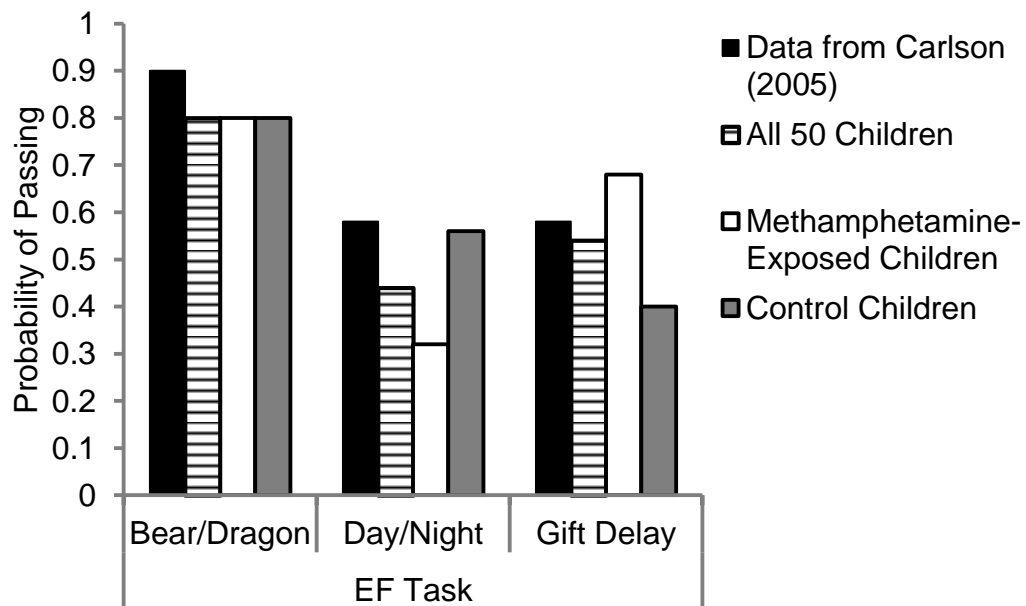
Another possible explanation for the higher performance of the methamphetamine-exposed children on the *Gift Delay (wrap)* task is that the children from drug-involved families may have been more socially disadvantaged than the controls and therefore were more motivated to control their behaviour in order to receive a gift. While maternal socioeconomic status was controlled for in this study, children living with mothers with either on-going or previous heavy drug problems involving methamphetamine might be living in more deprived circumstances than controls due to differences in the allocation of resources.

Either way, the exposed children's prepotent impulse to see/receive the gift immediately was effectively inhibited and outweighed by their motivation to receive positive consequences from the adult(s). This seems a highly likely explanation for the observed outcome since the delay of gratification paradigm is associated with "hot" EF and is considered to involve decision-making that has emotional and motivational significance.

Methamphetamine-exposed children did not exhibit poorer mean inhibition or activation scores than controls on the *Bear/Dragon* task and therefore this result does not support the expected outcome stated in the hypothesis. The absence of any performance differences between the groups in the *Bear/Dragon* task, a complex response inhibition task involving both working memory and inhibition, could be accounted for by the fact that children in both groups found this task to be particularly easy (80% of children in both the control group and exposed group passed the task). Therefore because this task was easy for *all* children in the cohort, it was not discriminative enough to reveal differences in executive functioning capacity. This ceiling effect therefore limited the value of this task in terms of demonstrating any effects of methamphetamine exposure.

The findings from this study regarding the performance on the *Bear/Dragon* task are also consistent with the results of a review of EF tasks conducted by Carlson (2005). EF task data of 602 preschool children across 9 studies were analysed in order to identify both trends in age and difficulty range. Among the 17 EF tasks reviewed for the 4 year-old age group, the *Bear/Dragon* task was reported to be the easiest to complete with 90% probability of passing (Carlson, 2005). The *Day/Night* and *Gift Delay (wrap)* tasks were found to be equivalently difficult and both had a 58% probability of passing. The difference between the likelihood of a child passing each EF task in this study compared with those studies reviewed by Carlson (2005) can be seen in Figure 19. It is worth noting that most of the children participating in the studies described by Carlson (2005) were reported to be White and middle class.

Figure 19. A comparison between the probability of 4-year-old children passing the three EF tasks in the present study and normative data reported by Carlson (2005).



Across the whole cohort, children in this study demonstrated a lower probability of passing the *Bear/Dragon*, *Day/Night*, and *Gift Delay (wrap)* tasks when compared with the age-equivalent participants of the other 9 studies. However, methamphetamine-exposed children in the present study had a considerably lower likelihood of passing the *Day/Night* task than the children from the review by Carlson (2005). Conversely, the control group of children from this study demonstrated a percentage probability that was very similar to the children in the review. Therefore taken together this supports the hypothesis that prenatal methamphetamine exposure does indeed impair performance on the *Day/Night* task when compared to both the control group and to a larger normative sample of EF data. The other pattern revealed in this dataset as a whole is that the exposed group from the present study had a much higher probability of passing the *Gift Delay (wrap)* task, even when compared to the normative example provided by Carlson (2005). This finding supports the premise discussed previously regarding the role of punitive parenting practices in influencing the

inhibitory behaviours of the exposed group on this task, and also suggests that the exposed children may have been more highly motivated for incentives.

Carlson (2005) also categorised performance measures on EF tasks according to specific age windows; young 4 (48-53 months), older 4 (54-59 months), and young 5 (60-65 months). While the number of participants in the present study within the youngest (48-53 months) and oldest (60-65 months) age windows were too small to make valuable comparisons to the set of normative data (see Appendix I for these other Tables), the middle age window (54-59 months) which consisted of 40 participants in the present study did make an evaluation possible. Table 5 below shows the percentage of each group of children (i.e. exposed vs. control) aged 54-59 months passing the EF tasks from this study in comparison to the findings from Carlson (2005).

Table 5. Percentage passing executive function tasks for older 4 age group (54-59 months) compared with results from Carlson (2005). The number of participants aged 54-59 months in each group in this thesis is provided in parenthesis.

			Data from Carlson (2005)	Data from this Thesis study		
EF Task	Pass Criteria	Pass Criteria as %	Older age 4 group (54-59 mths)	Total Cohort (54-59 mths) (n=40)	Experimental (methamphetamine-exposed) group (54-59 mths) (n=22)	Control group (54-59 mths) (n=18)
<i>Bear/Dragon</i>	5/6 trials	80	94	74	75	72
<i>Day/Night</i>	12/16 trials	75	68	45	35	56
<i>Gift Delay (wrap)</i>	No peek occurred	—	60	53	65	39

It is interesting to note that the percentage of children (aged 54-59 months) among the total cohort passing the *Bear/Dragon* task in this thesis study was much smaller than in Carlson's (2005) review (74% in this study vs. 94%). This pattern of poorer performance in the present study continues for both the *Day/Night* and *Gift Delay (wrap)* tasks. Therefore across all three EF tasks the cohort of children in this thesis study performed worse than the children in the other EF studies reviewed by

Carlson (2005). There may be several reasons for this difference ranging from variations in the children's socioeconomic background, parental education level, or ECE attendance. Alternatively, the differences between the EF outcomes from the present study and those reported in the normative review may be due to the fact that the entire cohort of children involved in this thesis were exposed to combinations of psychoactive substances during pregnancy and therefore were more vulnerable to EF deficits *overall*. Given that multiple studies have demonstrated that prenatal exposure to alcohol, tobacco, and marijuana can impair EF ability (Julvez et al., 2007; Noland et al., 2003; Fried & Smith, 2001; Mattson et al., 1999; Kodituwakku et al., 2001) this is a possible explanation.

Critically, the review of EF task performance by Carlson (2005) indicated that children aged 54-59 months were almost twice as likely to pass the *Day/Night* task as the methamphetamine-exposed sub-group in the present study (68% vs. 35% exposed) (see Table 5) which provides additional support for the hypothesis that prenatal methamphetamine exposure has a negative effect on performance of this task. Similarly to the findings between the exposed vs. control groups in the present study and those for the 4-year-olds as a whole, methamphetamine-exposed children aged 54-59 months as a sub-group were also more likely to pass the *Gift Delay (wrap)* task than the children reported in the review paper (65% vs. 60%) indicating that they showed greater resistance to peeking when compared to many other children of this age range.

5.3. The Effects of Prenatal Methamphetamine Exposure on Parental Ratings of Executive Function on the *BRIEF-P*

Children exposed prenatally to methamphetamine in this study were rated as exhibiting significantly more executive function difficulties on the *BRIEF-P* (Gioia et al., 2001) by their mother/caregiver, than control children. The average Global

Executive Composite score, an overall measure of preschool executive dysfunction, was significantly higher for the exposed group compared with the control. Therefore the results from the *BRIEF-P* report measure for children in this study fully support the initial hypothesis that prenatal methamphetamine exposure has a significant deleterious effect on child executive functioning. Furthermore, a higher proportion of the exposed children received *clinically significant* levels of executive dysfunction than control children (eight out of twenty-five of the exposed children vs. one out of twenty-five of the control children). While T-scores of 65 and above are considered to be indicative of clinically significant executive dysfunction on the *BRIEF-P*, four out of twenty-five of the methamphetamine-exposed children received scores in the mid-80s suggesting severe EF impairment.

Of the five domains of EF on the *BRIEF-P*, the most significant differences between exposed and control children were revealed in these aspects; Shift, Emotional Control, and Plan/Organize. Therefore mothers/caregivers reported that the exposed children had more difficulty than controls with; making transitions, switching attention and problem-solving (Shift); regulating emotional responses appropriately (Emotional Control); and anticipating future events, managing tasks, and ordering information or actions for a purpose (Plan/Organize). Significant differences were also found between the groups in the Flexibility Index of the *BRIEF-P*, a composite of the Shift and Emotional Control scores. Methamphetamine-exposed children were therefore rated as having significantly more difficulty than controls in terms of their ability to move flexibly among actions, responses, emotions or behaviour.

Therefore taken as a whole, the results from the *BRIEF-P* parent report measure suggest that prenatal exposure to methamphetamine has a significant negative effect on executive functioning among children in this study. This is indicated by higher overall

Global Executive Composite scores, and also by specific weaknesses identified in key EF domains involving cognitive flexibility/set shifting, regulation of emotion/affect, and problem-solving/goal-setting/planning. These reported EF deficits would be likely to have considerable implications in an educational context where such EF skills are necessary in order for students to be able to switch between activities/tasks, be flexible with routines/rules, regulate their behaviour appropriately, plan, organize and monitor their work, and set future learning goals. Therefore based on maternal/caregiver reports of EF, the methamphetamine-exposed children may experience more problems at school in these specific areas. The findings from the *BRIEF-P* are thus consistent with previous research and predictions suggesting that prenatal methamphetamine exposure may impair neurodevelopment (Chang et al., 2004; LaGasse et al., 2011; Wouldes et al., 2004).

However, despite the fact that both maternal consistency and negativity scores on the *BRIEF-P* did not differ between the two groups, it is important to recognise that maternal/caregiver ratings of children among the methamphetamine-exposed group may have been more vulnerable to rater bias. Behaviour ratings of children in the exposed group were more likely to be biased due to the adult's knowledge of methamphetamine use during pregnancy which may have resulted in the overrating of certain behaviours or else lowered expectations of the child's abilities. In addition, the adult's level of current drug involvement may also influence child behaviour rating on the *BRIEF-P*. For instance, mothers with substance use problems are more likely to report control problems with their children (Kandel, 1990) and are also reported to feel more stressed and demonstrate less coping strategies when dealing with child misbehaviour (Kelley, 1998) which in turn may affect their tolerance levels and therefore their reports of child competence on the *BRIEF-P*. Other aspects contributing to rater bias which might have

been present among the exposed group but not the control, are specific psychosocial factors related to on-going or prior methamphetamine use such as depression or anxiety. Symptoms of depression and anxiety are common side-effects of methamphetamine use (Sommers, Baskin, & Baskin-Sommers, 2006; Zweben et al., 2004). A mother suffering from depression or anxiety may rate their child's EF competence differently than a mother without these problems.

5.4. Relationships between the Children's Executive Function Task Performance and the Parental Ratings of Executive Function on the *BRIEF-P*

Across the whole cohort of children the *BRIEF-P* measures did not correlate strongly with the results from the *Bear/Dragon*, *Day/Night* or the *Gift Delay (wrap)* tasks. This indicates that contrary to the initial hypothesis, results across all *BRIEF-P* scales/indexes were not strongly predictive of children's performance on EF tasks. However, it was not the case that the *BRIEF-P* measures were completely unrelated to the EF tasks. Among the whole cohort, some measures on the *BRIEF-P* were weakly or moderately predictive of children's EF task performance. For instance, a child's overall level of executive function difficulty measured using the Global Executive Composite was found to predict accuracy on the *Day/Night* task; children who were rated as having the greatest EF deficits by their mothers/caregivers also performed most poorly on the *Day/Night* task. This finding lends further support to the validity of this EF task as providing an accurate assessment of executive functioning among preschoolers (Carlson, 2005; Chasiotis et al., 2006; von Stauffenberg & Campbell, 2007).

Other components of the *BRIEF-P* that were found to predict accuracy on the *Day/Night* task include; Working Memory, Plan/Organize and Emergent Metacognition. A subtle relationship was also found with Inhibit and *Day/Night* accuracy. Strong associations between this task and EF domains on the *BRIEF-P* suggest that the task

may tap into several components of executive functioning, and could involve working memory to a greater extent than inhibitory control.

The Global Executive Composite score was also found to be predictive of peeking behaviour in the *Gift Delay (wrap)* task; children with the most difficulties in executive function peeked the most. This finding would be expected given the fact that inhibitory control during early childhood is often considered to be a major indicator of overall EF capacity among children (Zelazo & Muller, 2002). Both the Inhibit score and the Inhibitory Self-Control index were found to be indicators of the number of peeks and also the latency to peek. Since this task involved measuring inhibitory control exclusively, associations with these *BRIEF-P* components were expected.

Another *BRIEF-P* measure which was found to be particularly predictive of task performance was Shift; the greater the child's rated difficulty in the Shift scale, the lower the activation score (i.e. ability to follow the bear's instructions) on the *Bear/Dragon* task. Similarly, there was a subtle relationship found between rated difficulty in the Inhibit scale and a lower activation score. Therefore the rule following/switching aspects of the *Bear/Dragon* task appear to correspond to EF domains measured by the Shift and Inhibit scales of the *BRIEF-P*. Children who found it hardest to follow the instructions given by the bear puppet in this task, were reported to have problems with transitions, shifting attention, problem-solving, and controlling impulses. The association between following instructions and the Shift domain is expected since the *Bear/Dragon* task requires the child to switch rules according to which puppet is commanding them.

5.5. Relationships between the Different Executive Function Tasks

The study hypothesis that across the whole cohort, children's performance on the three EF tasks would be related to one another was not supported by the results. No

strong correlations were found between the different performance scores on the EF tasks. It is particularly notable that performance scores for the *Day/Night* and *Bear/Dragon* tasks were not found to correlate. Given that these two tasks assess the same components of EF (inhibition and working memory) a correlation between these two measures would have been expected. However, since most children in the cohort (80%) passed the *Bear/Dragon* task it is likely that this masked any associations. There could also be other possible explanations for the absence of correlations for most of the EF task data. Firstly, it may be that the tasks tapped into distinct facets of EF, although previous research would suggest otherwise. Studies of preschool EF have reported moderate but reliable relationships between the performance scores of these three tasks (Reck & Hund, 2011). Another possibility is that the relatively small sample size, combined with the presence of several risk factors across both groups of children, led to variation in EF task performance that influenced some tasks more than others. For instance, if more directive parenting practices may have affected the *Gift Delay (wrap)* data for the methamphetamine-exposed children as discussed previously, this could have reduced the association between data from this measure and the *Day/Night* task.

Performance scores on any of the three EF tasks were not found to be related to one another among the methamphetamine-exposed group. However, for the control children specifically, the total inhibition score on the *Bear/Dragon* task was found to predict frequency of peeks on the *Gift Delay (wrap)* task. Therefore the control children who had difficulty inhibiting the dragon's requests also had difficulty inhibiting peeking. This suggests that these two tasks were tapping into the inhibition component of EF for this sub-group of children.

5.6. Differences between Executive Function Tasks and Ratings of Executive Function on the *BRIEF-P*

The relationship between mother/caregiver ratings of children's EF abilities and the children's observed performance on EF tasks differed between the two groups in the study. The ratings of EF by mothers of the exposed children were not found to be very predicative of EF task performance. For instance, the only association found between the *BRIEF-P* data and the EF task data for the exposed sub-group was that a greater Inhibit score resulted in a higher frequency of peeks on the *Gift Delay (wrap)* task. This suggests that children who could not resist peeking in the laboratory task were more likely to have problems with impulse control at home, which lends further support for the validity of the *BRIEF-P*.

However, the *BRIEF-P* ratings of EF from the mothers of the control children were more similar to the task results; several associations were revealed between the *BRIEF-P* and EF data. Similarly to the exposed group, ratings on the Inhibit scale by mothers of the control children were found to accurately predict frequency of peeking. The Inhibit score was also found to relate to latency to peek on the same task. Interestingly, the child's overall EF rating, the Global Executive Composite, was also predictive of latency to peek, as were the Shift, Working Memory, Emergent Metacognition and the Inhibitory Self-Control scores. Strong associations for this task were also found between each child's overall EF score and frequency of peeking. Taken as a whole then, this strongly suggests that the *Gift Delay (wrap)* task was providing an effective measure of executive functioning among the control children as it produced similar findings to the *BRIEF-P*. In addition, this pattern of results hints at the idea that mothers of the control children were more accurate in their assessment of their children's EF on the *BRIEF-P*. However, there were no relationships revealed between

EF ratings on the *BRIEF-P* by control mothers and performance data on either the *Day/Night* or *Bear/Dragon* tasks. This outcome was anticipated for the *Bear/Dragon* task since children found it easy and so this likely masked any differences, but it was not expected for the *Day/Night* task.

5.7. The Impact of Early Childhood Education Experience

Based on prior research regarding the protective capacity of ECE and school connectedness for at-risk children (Masten & Coatsworth, 1998; Webster-Stratton et al., 2008) it was hypothesised that children in the study who had a greater total amount of ECE experience would demonstrate better performance on EF tasks and would also be rated as more competent in EF skills by their mothers/caregivers. Further, since methamphetamine-exposed children could be described as the most at-risk of poor outcomes, it might be expected that children with the most ECE experience in this sub-group would perform better on EF assessments than those with less. This hypothesis was only partially borne out by the data. The weak but reliable relationship between ECE and the *Gift Delay (wrap)* EF task indicates that children with more ECE experience tended to peek less frequently. This outcome was found for the cohort of 50 children overall and for each subset. Since the *Gift Delay (wrap)* task provides a measure of “hot” EF, it was speculated that performance measures on this task would perhaps isolate differences in EF ability that were not related to “cool” EF, such as individual differences in general intelligence or temperament, and it was also anticipated that the *Gift Delay (wrap)* would be the *least* likely to be effected by ECE experience since it does not involve social imitation skills or following rules. Therefore the finding that this “hot” EF task demonstrated the most reliable relationship with ECE attendance in this study is contrary to expectation.

Children who had started ECE earlier were also marginally more likely to achieve higher scores on the *Bear/Dragon* task in terms of total activation (i.e. bear request). This finding was also consistent for the whole cohort and for both groups. Therefore more preschool experience was associated with the ability to follow instructions more accurately. This outcome is more expected and could be due to the fact that ECE likely improves children's social imitation skills and ability to follow rules as a result of more interaction with adults and peers in an educational setting. The children with greater ECE experience may also have been more accustomed to interacting with another adult in a formal setting than those with less ECE.

However, unexpectedly, ECE was not found to have any impact on other tests of EF which included all the *BRIEF-P* measures and the *Day/Night* task. As a whole therefore, ECE did not emerge as a major moderating factor relating to EF development in this cohort of 50 children and further, it did not play a significant role in ameliorating the effects of methamphetamine exposure among the experimental group in particular. This may be because all of the children had not attended preschool long enough for it to constitute a protective factor, or additionally, it could have been related to the fact that there were several different types of ECE settings among the cohort of children and some types may be more or less effective than others.

All children in both groups were rated by an independent observer while they were completing the three EF tasks. While the overall ratings of child behaviour were not shown to vary between the experimental and control groups, indicating that children behaved equivalently, there was a relationship found between ECE and rated behaviour. Specifically, a child's total number of ECE hours per week and overall length of attendance were both found to be related to the total behaviour score on the rating form. Across the whole cohort, children with the most ECE experience were able to regulate

their behaviour most effectively during the EF task session. This finding suggests that although ECE experience was not found to be a strong moderator of EF development overall, it does appear to have had a positive impact on behavioural regulation among the 50 children in this study. This outcome is in agreement with research demonstrating the beneficial influence of ECE attendance on child behaviour later at primary school (Campbell et al., 1998; Webster-Stratton et al., 2008).

5.8. Limitations of the Study

There are several limitations to this study which should be considered when evaluating these results. While every effort was made to assess as many 4-year-old children as possible within the available timeframe, a limitation of this study was the relatively small sample size of participants thus restricting generalizability. It is anticipated that more reliable results pertaining to the effects of methamphetamine exposure on executive functioning would have been revealed had there been a larger sample size of children.

Further, more precise information about methamphetamine effects on EF would have been revealed if specific details and measures of methamphetamine use during pregnancy had also been included in this thesis study other than maternal self-report. This would have enabled comparisons between varied quantities and frequencies of maternal drug use and differential effects on EF measures. Also, methamphetamine use at various stages of the pregnancy could then be associated with effects on child EF (i.e. effects of methamphetamine use on EF in first trimester vs. third trimester). However, such effects could only be meaningfully interpreted within a significantly larger sample than the one used here.

In addition, it is not possible to rule out bias in the maternal/caregiver ratings of child behaviour on the *BRIEF-P*. While the validity of the *BRIEF-P* as a reliable means

of measuring child EF difficulties has been demonstrated (Isquith et al., 2005; Gioia et al., 2002), the use of informant rating techniques to measure child behaviour is always vulnerable to bias. In this study there may have been an even greater risk of bias because the mothers of the methamphetamine-exposed children were not blinded and therefore had knowledge of their own drug use during pregnancy. Therefore they may have evaluated their children's EF skills more negatively due to preconceived ideas of the detrimental effects of drug use during pregnancy. Additionally, other maternal factors associated with drug involvement (e.g. depression) may also have influenced ratings of child behaviour among these mothers.

Furthermore, a broader insight into the children's executive functioning would have been possible if an assessment of EF had also been carried out in the children's ECE settings. Teacher ratings of children on the *BRIEF-P* would have provided another source of useful information which may have varied from those of the mothers/caregivers. However, as several of the children in the study did not attend ECE, it was not possible to collect this information for the whole cohort in this particular study. Therefore the absence of information from the children's early education settings could be considered a limitation of this study.

A final more general limitation which should be noted is the use of self-report data in any study. Mothers in this study responding to questions during the drug use interview may have answered inaccurately due to either social desirability or expectancy effects. Therefore, data obtained through self-report methods and not via direct observation or measurement has the potential to affect the validity of the study results.

5.9. Recommendations for Future Research

This study involved assessing the EF skills of 50 preschool children, 25 of whom were prenatally exposed to methamphetamine and 25 of whom were controls. Background variables present for both the experimental and control groups in this study were the use of other neuroactive substances other than methamphetamine during pregnancy, namely; alcohol, tobacco, and marijuana. In order to provide a broader insight into the combined effects of several drugs on child functioning at this stage of development, it is recommended that the interactions between these different variables should be explored in future studies. Further analysis could reveal that specific combinations of drugs may have the most deleterious effects on EF in early childhood.

In addition, since both the experimental and control groups in this study had multi-drug exposure prenatally, the detection of a trend towards poorer EF among the methamphetamine-exposed children, both in terms of the *BRIEF-P* data and the *Day/Night* task data, may have been relatively subtle due to the combined effects of the psychoactive drugs which were present during foetal development for children in both groups. The effects of prenatal alcohol, tobacco, and marijuana exposure on measures of response inhibition and working memory have been demonstrated in multiple studies (Fried & Watkinson, 2001; Jacobson et al., 2011; Mattson et al., 1999; Noland et al., 2003) therefore the impact of these background substances may have masked the effects of methamphetamine exposure in this project. Given the fact that all the children in the study were prenatally exposed to some kind of psychoactive substance, then it is reasonable to assume that methamphetamine use in the context of these other drugs would not have a dramatic effect on measures of EF. Therefore, future research should investigate the differential impact of these substances in order to determine if

methamphetamine *specifically* has the most detrimental effect on EF, however a larger sample size would be needed to emphasize these differences.

Since ecological factors also play a critical role in determining EF ability in children, a further consideration for future research would be to examine prenatal methamphetamine exposure in combination with specific environmental contexts to see how they may affect functioning. For instance, the results of this study suggest that prenatal exposure to methamphetamine may have a long-term impact on preschool executive functioning, however while some environmental factors (maternal education, socioeconomic status, and multi-drug use) were controlled, it is important to note that other contextual factors such as maternal psychosocial functioning were not, and thus may also have influenced these findings. As discussed previously, maternal methamphetamine use has been widely associated with symptoms of depression (Cohen, Greenberg, Uri, Halpin, & Zweben, 2007; Zweben et al., 2004), and it is therefore likely that mothers of children in the experimental group would have had higher rates of mental illness than the mothers of children in the control group. Therefore variation in executive functioning between these two groups in this study could have been due to differences in maternal depression. While data from the current IDEAL-US Study suggests maternal methamphetamine use in combination with depression does not contribute significantly to neurodevelopmental differences in offspring (Paz et al., 2009), there are no published data as yet from the New Zealand portion of the IDEAL study to confirm this is the case with this cohort of children. Therefore when interpreting the findings of this study it is critical to acknowledge that there could be many lifestyle factors that contribute to these results. Future research should therefore examine the impact of maternal depression in combination with current risk factors on child EF outcomes.

Developing a broader understanding of which family or maternal factors, educational contexts, or peer-related processes enable these children to achieve the most positive outcomes may inform planning of early intervention programmes or parenting skills groups designed for methamphetamine-involved families in New Zealand. Specifically, since there is strong evidence to suggest that effective early intervention can improve executive function deficits among young children (Bierman et al., 2008; Diamond et al., 2007), then an area of future research could be to investigate which types of educational programmes are particularly suited to addressing EF deficits among New Zealand children who were prenatally exposed to methamphetamine and/or living with on-going maternal methamphetamine use. Furthermore, research has shown that young children's EF skills can be significantly improved through parenting behaviours (Lunkenheimer et al., 2008) and additionally, that the most effective interventions for drug-involved families which target child behaviour and adjustment in early childhood have primarily involved parenting skills training (Kaminski et al., 2008). Therefore it would be useful for future research to examine the long-term effects of parenting skills programmes on the educational outcomes (and EF skills) of children prenatally exposed to methamphetamine.

The use of performance tasks such as those described in this study provides an effective means of measuring EF skills in young children. Further research investigating the effects of prenatal exposure to methamphetamine on children's executive functioning are advised using a larger battery of these tasks so that a broader range of EF components can be assessed. The three tasks used in this study tapped into inhibitory control and working memory, however it would be useful in future studies to have a measure of set shifting capacity and also perhaps an age-appropriate measure of problem-solving ability, particularly since results from the *BRIEF-P* suggested

weaknesses in these EF domains among the exposed children in this study. Additionally, the *Bear/Dragon* and *Day/Night* tasks were both complex response inhibition tasks and therefore provided a measure of inhibition and working memory combined. It would be interesting to compare these results to performance scores on tasks that tap into working memory capacity in isolation (e.g. forward digit span tasks). Furthermore, the use of EF tasks assessing either set shifting or working memory (without inhibition) would have the added advantage of enabling an isolated measure of “cool” EF and might indicate some more consistent differences between the EF capacities of exposed vs. control groups if compared to performance on “hot” EF tasks.

Finally, since drug abuse is a chronic illness involving many facets of functioning (psychosocial, emotional and physical), children living in families characterised by parental substance misuse are likely to be vulnerable throughout their development, not just in early childhood. Therefore it is critical that research also explores the effects of both prenatal and *on-going* maternal methamphetamine use on child outcomes in the context of other high-risk ecological factors. As these children start primary school more complex demands will be placed on them, both in terms of behaviour regulation, engagement in academic learning, and socio-emotional functioning. Therefore it may be that the effects of prenatal methamphetamine exposure on executive functioning do not become apparent until they are older and at primary school. It would therefore be interesting to measure EF during their first few years of primary school and also include a wider variety of EF assessment methods including classroom observations and teacher behaviour rating scales in addition to other standardized measures.

5.10. Conclusion

This study investigated the influence of prenatal methamphetamine exposure on children's executive functioning at 4 years of age using three performance tasks and a standardized parental report measure. Children prenatally exposed to methamphetamine were rated as exhibiting more executive function difficulties on the *BRIEF-P* than controls and showed a trend towards poorer performance on the *Day/Night* task than controls. Conversely, the methamphetamine-exposed children showed better performance on the *Gift Delay (wrap)* task than controls and did not differ from controls on the *Bear/Dragon* task, although this latter result is probably due to the presence of a ceiling effect.

The *BRIEF-P* and *Day/Night* results are consistent with the study hypothesis that prenatal methamphetamine exposure can negatively impact executive functioning at age 4. The subtle nature of the results most likely relates to the presence of background variables in both groups, such as exposure to other neuroactive drugs, which may have masked methamphetamine specific effects. However, studies with larger sample sizes are required to confirm this conjecture. Furthermore, when interpreting the results of this study it is important to acknowledge the potential influence of other maternal lifestyle factors, such as mental illness, on the reported outcomes among the methamphetamine-exposed group of children. The significance of maternal lifestyle factors on children's emerging EF skills was highlighted in this study by the negative influence of continued maternal methamphetamine use on child EF performance. Among the experimental group, children with mothers who reported current methamphetamine use performed most poorly on the *Day/Night* task.

The finding that methamphetamine-exposed children achieved significantly higher performance scores on the *Gift Delay (wrap)* task, a delay of gratification

paradigm which measures inhibitory control, was unexpected. This result could potentially be explained by differences in parenting practices between the two groups and therefore emphasises the importance of considering ecological variables when interpreting tests of cognitive function.

As a whole, the results of this study are broadly consistent with the hypothesis that prenatal methamphetamine exposure can negatively influence specific aspects of EF and indicate that further research in this area with larger sample sizes is warranted in New Zealand to assess the need for targeted intervention programmes for exposed children and their families. The study also highlights the importance of administering multiple assessments of EF which enable an evaluation of children's abilities in different life contexts. It is notable that conclusions drawn from this work would have differed greatly if only the *BRIEF-P* measure or only the *Gift Delay (wrap)* task had been used to assess executive function among these children.

Finally, it is important to note that although suggestive differences between the methamphetamine-exposed and control children were found in this study, these differences were relatively subtle. Therefore, with the provision of suitable support for drug-involved families, such as mental health services and parenting skills/early intervention programmes, it is likely that these preschool children would be capable of achieving equivalent outcomes at school to similarly matched peers.

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Appendices

Appendix A

Ethics Amendment Approval Form



22 March 2011

Northern X Regional Ethics Committee

Ministry of Health
3rd Floor, Unisys Building
650 Great South Road, Penrose
Private Bag 92 522
Wellesley Street, Auckland
Phone (09) 580 9105
Fax (09) 580 9001

Dr Trecia Wouldes
University of Auckland
Dept of Psychological Medicine, 6th Flr, Ecom Hs
Faculty of Medical & Health Sciences
Private Bag 92 019
Auckland 1142

Dear Trecia

Ethics ref: **AKY/04/10/284** (please quote in all correspondence)
Study title: **The development of infants exposed prenatally to methamphetamines. PIS/C V#5, 3/11**
Principal Investigator: Dr Trecia Wouldes
Co-Investigators: Dr Barry Lester, A/Professor Linda La Gasse, Dr Simon Rowley, Professor Ed Mitchell
Locality: The University of Auckland

Thank you for your letter dated 10 March 2011.

The following amendment was reviewed by the Chairperson of the Northern X Regional Ethics Committee under delegated authority.

Ethical approval has been given for :

- Protocol amendment 10 March 2011
- Questionnaires; forms 423, 426, 427, 441, 405, 452
- Strengths & Difficulties Questionnaire
- Food Frequency Questionnaire
- NZ ISAAC Questionnaire
- Rating form
- Participant Information Sheets/Consent Forms V#5 dated March 2011

(Please ensure that the PIS/CF are headed who they are for and have the same footers and in the Consent Form that the first paragraph reads 'I have read and I understand information sheet dated March 2011. At present they are hard to follow)

Yours sincerely,

Pat Chainey
Administrator
Northern X Regional Ethics Committee

Appendix B

IDEAL-NZ Study Consent Form and Parent Comparison Information Form

Mother and Child Consent Form

Clinical Division - Health Psychology


THE UNIVERSITY OF AUCKLAND
 FACULTY OF MEDICAL AND
 HEALTH SCIENCES

SCHOOL OF MEDICINE

**MOTHER AND CHILD CONSENT
 FORM**
**Infant Development, Environment and
 Lifestyle - "IDEAL STUDY"**

 The University of Auckland
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 Auckland Hospital Support Building
 Grafton, Auckland
 www.health.auckland.ac.nz

 Telephone: 64 9 373 7599 extn 86221
 Facsimile: 64 9 373 7013
 Email: t.wouldes@auckland.ac.nz

REQUEST FOR INTERPRETER

English	I wish to have an interpreter.	Yes	No
Maori	E hiahia ana ahau ki tetahi kaiwhakamaori/kaiwhaka pakeha korero.	Ae	Kao
Samoan	Out e mana'o ia I ai se fa'amatala upu.	Ioe	Leai
Tongan	Oku ou fiema'u ha fakatonulea.	Io	Ikai
Cook Island	K a inangaro au I tetai tangata uri reo.	Ae	Kare
Niuean	Fia manako au ke fakaaoga e taha tagata fakahokohoko kupu	E	Nakai

I have read and I understand the attached information sheet dated March 2011 that invites me and my child to take part in the IDEAL STUDY that is designed to follow the development of my child at 4 ½ and 5 ½ years of age. **YES NO**

I have had the opportunity to use whanau support or a friend to help me ask questions and understand the study. **YES NO**

I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time and that this will in no way affect my or my child's continuing health care. **YES NO**

I understand that my participation in this study is confidential and that no material which could identify me or my child will be used in any reports on this study. **YES NO**

I understand the compensation provisions for this study. **YES NO**

I have had adequate time to consider whether to take part. **YES NO**

Mother and Child Consent Form

I know who to contact if I have any questions about the study.	YES	NO
I consent to a sample of my child's saliva being collected so that it can be tested for a substance called "cortisol" which is a measure of stress.	YES	NO
I consent to a sample of my saliva being collected so that it can be tested for a substance called "cortisol" which is a measure of stress.	YES	NO
I consent to a sample of my saliva being collected so that it can be tested to see whether some genes are associated with stress.	YES	NO
I consent to a sample of my saliva being collected so that it can be tested to see whether some genes are associated with early childhood stress.	YES	NO
I consent to myself and my child being videotaped playing together with toys.	YES	NO
I consent to my child being videotaped for eye movements during the vision testing.	YES	NO
I wish to receive a copy of the results of this study.	YES	NO

I _____ hereby consent to take part in this study.

Date: _____ Signature: _____

I _____ hereby consent for my child to take part in this study.

Date: _____ Signature: _____

CONTACT DETAILS FOR RESEARCHERS:

Dr Trecia Wouldes
Phone: DD: 923 6221

Dr Nicola Anstice
Direct Dial: 923 2956.

Project explained by: _____

Project Role: _____

Date: _____ Signature: _____

Comparison Group Participant Information

Clinical Division - Health Psychology



SCHOOL OF MEDICINE

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Infant Development, Environment And Lifestyle Study

“IDEAL STUDY”

Comparison Group Participant Information

You are invited to continue your participation with your child in our Infant Development, Environment And Lifestyle (IDEAL) Study being carried out under the direction of Dr Trecia Wouldes, a developmental psychologist in the Department of Psychological Medicine at the University of Auckland.

WHAT IS THE STUDY?

The purpose of the study is to learn more about the growth and development of children born to mothers who have used any methamphetamine during their pregnancy. Dr. Trecia Wouldes would like to extend the NZ IDEAL Study by collecting further data at 4½ and 5 ½ years of age to determine whether children exposed to drugs that are often referred to as Xtasy, “P”, Pure, Ice, Crystal Meths, or Speed, as well as alcohol or other drugs are prepared for formal schooling. Indicators for “school readiness” are likely to include good health or not meeting developmental milestones that originate during early childhood.

The IDEAL Team would like to welcome you back to attend further developmental follow-ups as part of the comparison group of mothers because your infant matches some of the characteristics of an infant whose mother has reported using methamphetamines during her pregnancy. For instance, your baby was born at the same gestational age and has the same ethnic background.

WHAT DOES THE STUDY INVOLVE?

If you agree to take part, we will ask you to bring your child to our research centre for two further visits when your child is 4 ½ and 5 ½ years of age. At these visits we will interview you and observe your child completing further tests to determine their readiness for school. Our research centre is located at the University of Auckland across from the Starship Children’s Hospital on Grafton Road. *If you do not have transport, we will arrange and pay for a taxi for each visit or provide you with petrol vouchers of \$20.00 for each visit.*

The following is an outline of what will be included in the interviews and the measures we will be using to look at your child’s development.

Comparison Group Participant Information

WHEN YOUR CHILD IS 4 ½ AND 5 ½ YEARS OF AGE:

1. At the 4½ and 5 ½ year visit, you will be interviewed about your lifestyle including your drug use, your living conditions and your relationship with your child. We will also ask you questions about what resources are available to you to help you take care of your child and other family members. Additionally, health and nutrition issues related to your child will be investigated. Each visit will take approximately 2-3 hours. Tea or coffee and a snack for you and your child will be arranged.
2. Your child's emotional, behavioural, learning skills and physical development will be measured to determine whether he/she is prepared for formal school entry at 4 ½ and how he/she is settling in to the school environment at 5 ½ years. In addition, your child will be videotaped while he/she is carrying out a number of tasks that will test his/her problem solving abilities. Similar to the visit at 24-months, at the 4 ½ year visit we will ask if we can collect two saliva samples from your child. One will be taken at the beginning of the assessment and one after your child has completed the developmental tests. At 4½ years we would also like to seek permission to collect a sample of your saliva as well. These samples will be tested for cortisol, a substance in your body that has been associated with stress. You may remember, that the collection procedure involves taking a cotton swab and collecting a little saliva from you and your child's mouths. The change in cortisol can tell us about individual differences in how adults and children react physically to challenging situations such as being in a strange environment, or learning new tasks. These samples will be sent to the United States. After these tests are carried out the samples will be destroyed.
3. At the 4 ½ year visit we will also be asking if we can use a further cotton swab of saliva from you and your child's mouth to collect genetic material. Research has shown that stressful experiences in life can affect our behaviour and health through turning on and turning off certain genes. When this occurs there may be markers left in specific genes. Determining which genes may be affected by life experiences may help us in developing treatments to counteract these effects. We will test the saliva we collect to determine whether certain genes have been affected by different life experiences such as stress. These tests will be carried out in NZ. When they are complete the samples will be destroyed. The samples of saliva we collect will only have a code number associated with them so that they can never be associated with you or your child.
4. A vision test will also be included at 4 ½ years. The vision testing for this study will last approximately 45 minutes during which time we will test your child's ability to see objects in the distance, to use both eyes together as a team and to judge the direction of movements of dots on a screen using a special computer programme. We will also be videotaping your child's eye movements to help us judge how well they are performing on these tests. Frequent breaks will be offered to your child as necessary.
5. When your child is 5 ½ years of age we will also ask you if we can write to your child's teacher to ask him/her to fill out two questionnaires about your child's learning and behaviour in the classroom. We will not tell the teacher anything about your child, other than he/she is involved in a lifestyle study investigating the growth and development of NZ children exposed to a variety of risk factors that may or may not include things like low income, restricted resources, family mental illness, and tobacco, alcohol and/or drug use.

Comparison Group Participant Information

BENEFITS

You and your child will receive no direct benefit from this study. Your child's development will be monitored closely by study personnel. If you or members of our team have concerns about your child's development, appropriate referrals will be made. In addition, the results of this study will help us understand how lifestyle and environment during and after pregnancy affects school readiness and health. Should we find any problems with your child's vision you will receive a referral for further eye testing.

INCONVENIENCES OR RISKS

Some of the questions we ask are of a personal and sensitive nature. You may feel uncomfortable when answering these questions and may choose not to answer any of the questions we ask.

There are no other discomforts or dangers to you or your child.

PARTICIPATION

Your participation in this study is entirely voluntary (your choice), you do not have to take part if you do not wish. If you agree to take part in the study you are free to withdraw at any time without giving a reason and this will not affect your health care or support you may be receiving through other social services now or in the future.

If for some reason, you are unable to come to our development centre, we are asking your permission to allow us to ask questions of whoever is the primary person who is caring for your child at the time.

If you have any queries or concerns regarding your rights as a participant in this research study, you can contact an independent Health and Disability Advocate. This is a free service provided under the Health and Disability Commissioner Act:

Telephone (NZ wide): 0800 555 050
Free Fax (NZ wide): 0800 2787 7678 (0800 2 SUPPORT)
Email: Advocacy@hdc.org.nz

COMPENSATION

In the unlikely event of a physical injury as a result of your participation in this study, you may be covered by ACC under the Injury Prevention, Rehabilitation and Compensation Act. ACC cover is not automatic and your case will need to be assessed by ACC according to the provisions of the 2002 Injury Prevention Rehabilitation and Compensation Act. If your claim is accepted by ACC, you still might not get any compensation. This depends on a number of factors such as whether you are an earner or non-earner. ACC usually provides only partial reimbursement of costs and expenses and there may be no lump sum compensation payable. There is no cover for mental injury unless it is a result of physical injury. If you have ACC cover, generally this will affect your right to sue the investigators.

Comparison Group Participant Information

CONFIDENTIALITY

All information you give us will be treated in the strictest confidence. No material which could personally identify you will be used in any reports on this study. All interviews, audiotapes and videotapes will be assigned a code number. The developmental psychologists that assess your infant will not know whether or not you have used drugs during pregnancy and will also only be able to identify you through your code number, your infant's date of birth and your first names. These codes and the names associated with them will be stored separately on external drives and locked in separate cabinets.

No information collected in this study will be placed in your or your baby's hospital or medical records. The study will have a comprehensive security system, with all information you provide being stored anonymously on computer files. Access to these files will be confined to study investigators.

Although we will make every effort to protect your privacy, if one of our researchers should find that your child is at risk physically or developmentally we will refer you to the study psychologist, your General Practitioner or appropriate social services and this will be discussed with you.

IF YOU WANT TO KNOW MORE

If you want to know more about the study (either now or at a later date) please feel free to contact:

Dr Trezia Wouldes, Developmental Psychologist, Department of Psychological Medicine, University of Auckland, Direct Dial 923 6221.

Dr Nicola Anstice, Optometrist, Department of Optometry and Vision Science, University of Auckland, Direct Dial 923 2956.

Dr Ben Thompson, Optometrist, Department of Optometry and Vision Science, University of Auckland, Direct Dial: 923 6020.

We are committed to treating all our study participants in a fair and ethical manner. This study has received ethical approval from the Northern X Regional Ethics Committee.

Finally, we would like to thank you for considering assisting us with this research.

Appendix C

Executive Function Task Score sheets

Study ID:	Birth Date:
Examiner's No.	Date of Assessment:

Bear/Dragon Executive Function Task

Introduction to Task

I've got some puppets to show you, this one is the naughty dragon, and this one is the nice bear (show the puppets and allow child to say hello and touch them).

Now we are going to play a silly game with them. When the nice bear tells you to do something you should do it, but if the naughty dragon tells you to do something, you're not going to do it or listen to him because he is naughty. Let's practice before we play the game.

Practice Trials

In the practice trials each puppet asks child to do an action and assessor provides feedback each time and corrects any mistakes. Each child is given six practice trials regardless of performance during these trials. If child hesitates, in the practice trials the assessor can prompt with: *What action should you do?*

Example of positive feedback: *Well done, you remembered the rule!*

Example of corrective feedback: *Oops, you forgot that if the naughty dragon tells you something you are not supposed to do it, remember? Let's try again.*

PRACTICE TRIALS						
Practice Trial No.	Puppet used	Puppet Instruction	Correct Response	Did child do correct action? (Circle)		
				Y	N	
1	Bear	"Clap your hands."	Child claps hands	Y	N	
2	Dragon	"Close your eyes."	No response	Y	N	
3	Bear	"Put your hands on your head."	Child puts both hands on head	Y	N	
4	Dragon	"Touch your nose."	No response	Y	N	
5	Bear	"Stick out your tongue."	Child sticks out tongue	Y	N	
6	Dragon	"Touch your mouth."	No response	Y	N	

Test Trials

In the test trials no feedback or prompts are provided by the assessor. If child makes a mistake do not stop or correct him/her. If child makes no response, wait 5 seconds and then continue with the game.

TEST TRIALS									
Test Trial No.	Puppet used	Puppet Instruction	Correct Response	Did child do correct action? (Circle)		Request Score (0-3) (Circle the score)			
				Y	N	0	1	2	3
1	Bear	"Touch your nose."	Child touches nose	Y	N	0	1	2	3
2	Bear	"Clap your hands."	Child claps hands	Y	N	0	1	2	3
3	Dragon	"Put your hands on your head."	No response	Y	N	0	1	2	3
4	Bear	"Close your eyes."	Child closes eyes	Y	N	0	1	2	3
5	Dragon	"Stick out your tongue."	No response	Y	N	0	1	2	3
6	Dragon	"Touch your mouth."	No response	Y	N	0	1	2	3
7	Dragon	"Touch your ears."	No response	Y	N	0	1	2	3
8	Bear	"Touch your shoulders."	Child touches shoulders	Y	N	0	1	2	3
9	Dragon	"Clap your hands."	No response	Y	N	0	1	2	3
10	Bear	"Put your hands on your head".	Child puts both hands on head	Y	N	0	1	2	3
11	Dragon	"Touch your nose."	No response	Y	N	0	1	2	3
12	Bear	"Stick out your tongue."	Child sticks out tongue	Y	N	0	1	2	3

Total Bear Score (activation)*	
Total Dragon Score (inhibition)*	

* Best possible performance on this task would be a total score of 18 for Bear trials, and total score of 0 for Dragon trials. This would mean the child was correctly carrying out *all* of the Bear actions and correctly inhibiting *all* the Dragon actions.

Puppet Request Score per trial	
0=no action completed at all, no response	2=fully completed wrong action (i.e. did something different than what the puppet had requested)
1=partially completed action requested by the puppet	3=fully completed action requested by puppet

Notes:

Study ID:	Birth Date:
Examiner's No.	Date of Assessment:

Day/Night Executive Function Task

Introduction to Task

I've got some pictures to show you, this one is of the day, and this one is of the night. Now we are going to play a silly game. When you see this picture (point to the night card) I want you to say "day". (Ask child to repeat "day"). When you see this picture (point to the day card) I want you to say "night". (Ask child to repeat "night"). Let's practice before we play the game.

Practice Trials

In the practice trials show the child the picture cards again, if child hesitates to respond, ask what you have to say for each one. Provide feedback each time and if necessary, correct any mistakes. If child doesn't respond at all, or says he/she doesn't know the answer, provide the correct response and explain why.

Example of positive feedback: *Well done, you got it right, you remembered the rule!*

Example of corrective feedback: *Oops, you forgot the rule that if you see the day card, you have to say "night". When you see the night card, you have to say "day". Let's try it again.*

Each child is given six practice trials regardless of performance during the trials.

PRACTICE TRIALS					
Practice Trial No.	Test Card Used	Correct Response	Did child respond correctly? (Circle)		
			Y	N	
1	Day	Night	Y	N	
2	Night	Day	Y	N	
3	Day	Night	Y	N	
4	Night	Day	Y	N	
5	Day	Night	Y	N	
6	Night	Day	Y	N	

Test Trials

Do not provide any feedback or correction during the test trials. If the child self-corrects, this counts as a correct response, but should be noted by writing '**SC**' next to trial in the correct response column. No response/Don't Knows both count as incorrect and are recorded by circling '**NR**' or '**DK**'.

If needed, prompt with: *What do you say for this one? Or: Look at the picture, what do you say?*

Cards are presented in a pseudorandom fixed order.

TEST TRIALS								
Test Trial No.	Test Card Used	Correct Response	No Response or Don't Know (circle 'NR' or 'DK')		Did child respond correctly? (Circle)		Score (0 or 1) (Circle the score)	
			NR	DK	Y	N	0	1
1	Night	Day	NR	DK	Y	N	0	1
2	Day	Night	NR	DK	Y	N	0	1
3	Day	Night	NR	DK	Y	N	0	1
4	Night	Day	NR	DK	Y	N	0	1
5	Day	Night	NR	DK	Y	N	0	1
6	Night	Day	NR	DK	Y	N	0	1
7	Night	Day	NR	DK	Y	N	0	1
8	Day	Night	NR	DK	Y	N	0	1
9	Day	Night	NR	DK	Y	N	0	1
10	Night	Day	NR	DK	Y	N	0	1
11	Day	Night	NR	DK	Y	N	0	1
12	Night	Day	NR	DK	Y	N	0	1
13	Night	Day	NR	DK	Y	N	0	1
14	Day	Night	NR	DK	Y	N	0	1
15	Night	Day	NR	DK	Y	N	0	1
16	Day	Night	NR	DK	Y	N	0	1
Total Score (out of 16)			Total No. of trials with No Response/Don't Knows					
Percent Accuracy			*No. of trials child used <i>different</i> vocab to describe picture					
Total No. of self-corrections (SC)								

Score per trial

0 = incorrect response, or no response 1= correct response

*Record here how often child uses alternative words to mean same thing during test trials, e.g. if child says "morning" instead of "day", or "moon" in the place of "night". Only record this when the answer would have been correct, for example, if the correct answer was to say "day" for the night picture card, and the child had said "sun" it would be recorded here.

Notes:

Study ID:	Birth Date:
Examiner's No.	Date of Assessment:

Gift Delay (wrap) Executive Function Task

Introduction to Task

Now I have a present for you to say thank you for all the games you've been playing with us today. You've worked so hard and done really well. (Assessor goes to retrieve gift)

*Oops! I forgot to wrap it up. I'm going to wrap it now, so let's turn your chair around so you can't see me do it, as I don't want to spoil the surprise. ***Now, don't look until I say you can.***

Task

Child sits in chair with his/her back to the table. Assessor wraps the gift noisily over 60 seconds. Once wrapping has begun, no prompts, reinforcement or reminders are provided for the child. If he/she turns around or speaks, do not remind or instruct the child to stop peeking/talking or to go back to seat.

***Timing of the child's resistance to peeking begins once assessor has finished speaking the final part of the introduction to task (see text underlined and in bold italics above).**

Results	
Latency before first peek occurred (in seconds)	
No. of total peeks per session (in 60 seconds)	

Peek Resistance Score per individual peek	Peek 1		Peek 7	
	Peek 2		Peek 8	
	Peek 3		Peek 9	
	Peek 4		Peek 10	
	Peek 5		Peek 11	
	Peek 6		Peek 12	

Peek Resistance Score (0, 1 or 2)	
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Peek Resistance Score	
2 = no peeking occurred at all	0 = mostly full torso turns in order to peek, getting out of chair to come and look, standing on chair to look over assessor etc.
1 = peeking occurred but it was mostly only over the shoulder head turns and quite subtle movements	

Appendix D

Photographs of Executive Function Task Stimuli

1. *Bear/Dragon* task stimuli: photographs of puppets

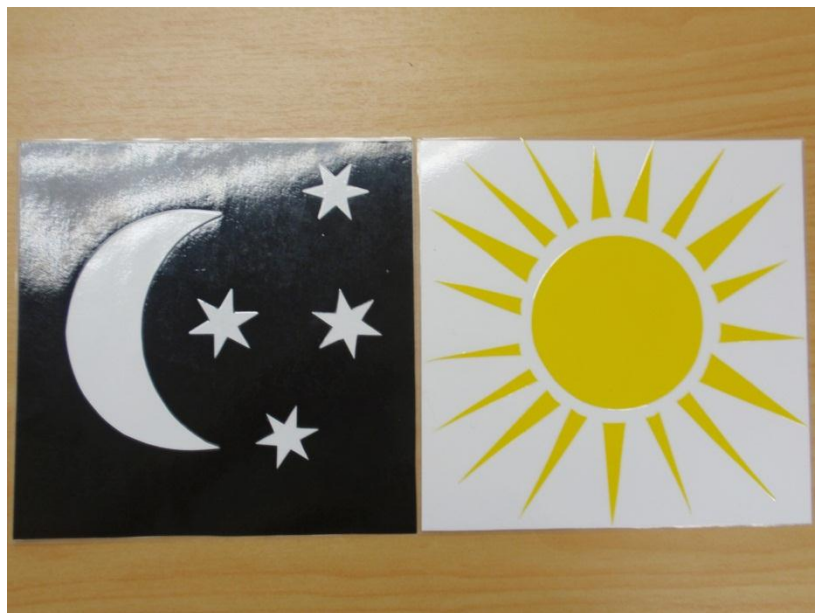
The “naughty” dragon puppet



The “nice” bear puppet



2. *Day/Night* task stimuli: photograph of picture cards used for pretest trials



3. *Day/Night* task stimuli: photographs of flip book of pictures used for test trials



Appendix E

Verbal Instructions for Administering the *BRIEF-P* to Mothers/Caregivers

We find that talking to parents about their child's behaviour and problem-solving skills is a very good way of finding out what happens in the home. We really appreciate your help with this as it enables us to fully understand your child's development and will provide us with a more complete picture. This questionnaire allows us to document your observations of your child's behaviour at home and how he/she interacts with family members and friends.

While many of these behaviours are very typical for preschool-aged children, I would like to know how often your child has had a problem with each of these behaviours over the past 6 months. If the specific behaviour has *never* been a problem in the last 6 months then please answer *never* (N), if it has *sometimes* been a problem then answer *sometimes* (S), and if the behaviour has *often* been a problem answer *often* (O).

If you have any questions or concerns as we do the questionnaire together please don't hesitate to ask me.

Appendix F

Behaviour Rating Form of Children during Executive Function Tasks

Study ID:	Birth Date:
Examiner's No.	Date of Assessment:

Behaviour Rating Scale – Executive Function Tasks

<i>Bear/Dragon</i> EF Task	
1)Number of times refused to go further during task	
2)Number of times out-of-seat	
3) Number of physical avoidance behaviours	
4)Number of verbal attempts to distract examiner	
5)Number of times off-task	
Total Task Score	
<i>Day/Night</i> EF Task	
1)Number of times refused to go further during task	
2)Number of times out-of-seat	
3) Number of physical avoidance behaviours	
4)Number of verbal attempts to distract examiner	
5)Number of times off-task	
Total Task Score	
<i>Gift Delay (wrap)</i> EF Task	
1)Number of times refused to go further during task	
2)Number of times out- of-seat	
3) Number of physical avoidance behaviours	
4)Number of verbal attempts to distract examiner	
5)Number of times off-task	
Total Task Score	
Total Score for <i>all three</i> EF tasks	

Motivation/interest in Executive Function Tasks				
Always	Mostly	Some	None	
Rapport/Interaction with examiner				
Very Good	Good	Some	Very Little/none	
Affect during EF testing				
Over-stimulated/agitated	Happy	Anxious	Sad	
Support required during EF testing: Parent/caregiver or family/whanau member				
None	Occasional	½ of the time	Continual	
Additional Support or requirements during EF testing				
Held a toy of comfort item during EF tasks			Yes	No
Required more tangible reinforcers other than the sticker certificate/star chart: Details of reinforcer(s): No. required _____			Yes	No
Required lollies as reinforcers to complete EF tasks: No. required _____			Yes	No
Additional reinforcers given? Provide details:			Yes	No
General Comments about behaviour:				

Appendix G

Operational Definitions of Child Behaviours for EF Tasks

Before recording instances of specific child behaviours during the EF tasks, it was first essential to accurately define the nature of each behaviour in order to measure it effectively and objectively. Definitions of these behaviours were then shared with raters for interobserver purposes. For this thesis study, the operational definitions of child behaviours were as follows:

Operational Definitions of Behaviour for EF Rating Scale
<p>1) Refusal to go further during task:</p> <p>Refusal to continue with an EF task was defined as the child refusing to complete the requested activity. This included the child simply leaving the table or testing room. Verbal refusals were also counted as long as they were accompanied by a physical action e.g. pushing away the EF task stimuli, getting out of chair, walking away, or leaving the room. For instance, the child's use of phrases such as: <i>I want to stop, I've had enough, I'm tired, Can I go now? Can we finish? Are we finished? I'm going now.</i> etc. were not counted as refusals unless the child actually refused to do the requested activity after making the statement. In instances where the child refused to do a task but was able to be motivated to continue by further incentives (e.g. lollies or more stickers), the refusal was still counted and the additional reinforcer reported on the behaviour rating form.</p>
<p>2) Out-of-seat behaviour:</p> <p>An out-of-seat behaviour was recorded when the child left his/her assigned chair without permission from the assessor or another adult (e.g. parent/family member). The behaviour was only recorded if the distance from the student to the vacated chair exceeded approximately 30cm. Sitting behaviour which involved the contact of a</p>

child's leg or foot with the chair was not considered to be out-of-seat (e.g. when a child sat up on his/her legs or knees, leaned to the side but was still mostly on chair). The behaviour was also not considered out-of-seat if a child was responding to an adult's request or instruction, was having a snack/drink, or was visiting the restroom. Out-of-seat behaviour was also not recorded when the student quickly picked up an item (i.e. EF task stimuli) which had fallen on the floor as long as this occurred within the specified 30cm area. Slipping off the chair accidentally was not recorded as out-of-seat. If a child was out-of-seat for a prolonged time (i.e. more than 1 min.) then this was recorded as one single out-of-seat behaviour but it was noted as prolonged (with approximate duration) on the rating form.

3) Physical avoidance behaviours:

Physical avoidance behaviours were considered to be any physical response a child made which suggested avoidance of completing the task. Examples include: turning head away from examiner or stimuli, pushing away the stimuli with hand/foot, turning around in seat, flopping head down onto table, shaking head to signal "no", closing eyes, hiding face etc.

4) Verbal attempts to distract examiner

Verbal attempts to distract the examiner were defined as any verbal child response which detracted from EF task administration. These were considered to be conversations the child initiated focused on non-related topics, including questions or comments which had no relevance to the activity taking place. Requests to use the restroom were not counted, however asking for food/drink was considered as an attempt to distract the examiner since a snack was given to each child prior to the start of the tasks.

5) Off-task behaviour

Off-task behaviour was defined as any inappropriate verbal or physical response which had no relevance to the EF task, suggested the child was not adequately engaged in the activity, and also was not covered by any of the previously described categories (above). Examples of off-task behaviour include: kicking the chair/table or throwing/flicking task items.

Operational Definitions of Behaviour for *Gift Delay (wrap)* EF Task**Operational definition of peeking behaviour:**

Peeking behaviour for the *Gift Delay (wrap)* EF task was defined as any physical attempt the child made to see the present during the wrapping process while seated with his/her back to the examiner in the chair. This included turning around either completely (i.e. full torso) or partially, or else just turning the head over the shoulder enough to attempt to see the present. Only peeks occurring within the 60 second wrapping period were counted. Child behaviour which was aimed at seeing the gift but may not have actually resulted in seeing it, was still scored as peeking as the intention was there. Each individual peeking behaviour was further classified into one of two groups: subtle peeking or full peeking. Subtle peeking was assigned when the peek was mostly an over the shoulder head turn and was associated with a subtle or small movement. Full peeking was used to describe blatant, full torso turns in order to see the gift, and larger movements like getting out of chair to come over to the table and look, or standing up on the chair to look over the examiner. In instances where the child peeked for a prolonged period and/or never returned to the assigned chair, this was counted as one “full peek” but its duration was recorded on the score sheet.

It is important to note that the timing of the wrapping process and of each child’s latency to first peek (in seconds) did not begin until the examiner finished saying these words “*Now, don’t look until I say you can.*” Once wrapping had begun, no prompts, reinforcement or reminders were provided for the child. If he/she turned around or spoke, the examiner did not stop wrapping and did not remind or instruct the child to stop peeking/talking or tell him/her to go back to the seat.

Operational Definitions of Behaviours for the *Bear/Dragon* EF Task

Operational definitions of behaviours exhibited in response to puppet instructions

All behaviours scored for the *Bear/Dragon* EF task related to physical movements made by the child. Therefore following a puppet instruction was operationally defined as the child exhibiting a physical response only. Any verbal responses made during testing were neither scored nor attended to by the assessor. If the child did not respond to each puppet's request within 5 seconds of presenting the instruction, the next trial started. Therefore the requested behaviours had to be performed by the child within a window of approximately 5 seconds.

Definitions of Puppet Request Scores

0=no action completed at all, no physical response

This score was given if the child made no physical movement at all after presentation of the stimulus (i.e. puppet instruction).

1=partially completed action requested by the puppet

This score was assigned if the child completed a *partially* correct physical action after presentation of the stimulus. E.g. If the puppet instructed the child to “*touch your ears*” and only one hand was raised to touch one ear. Any instruction that was not fully completed was considered as *partially* completed in this scoring system.

2=fully completed wrong action

This score was allocated if the child completed a full physical action after presentation of the stimulus, but it was not the action requested by the puppet. E.g. if the puppet instructed the child to “*touch your nose*” and the child touched his/her mouth instead.

3=fully completed action requested by puppet

This score was assigned if the child completed a full, correct physical action after presentation of the stimulus.

Appendix H

Setting of the Executive Function Assessments

1. Photograph of the testing room



2. Partially hidden camera in the testing room



3. DVD recording device and scoring/observation room



Appendix I

Additional tables comparing the results of EF tasks from this study with those reported in the review by Carlson (2005).

Table 1. Percentage passing executive function tasks for the young 4 age group (48-53 months) compared with results from Carlson (2005).

			Data from Carlson (2005)	Data from this Thesis study		
EF Task	Pass Criteria	Pass Criteria as %	Young age 4 group (48-53 mths)	Total Cohort (48-53 mths) (n=6)	Experimental (exposed) group (48-53mths) (n=2)	Control group (48-53mths) (n=4)
<i>Bear/Dragon</i>	5/6 trials	80	88	100	100	100
<i>Day/Night</i>	12/16 trials	75	48	50	50	50
<i>Gift Delay (Wrap)</i>	No peek occurred	—	53	50	50	50

Table 2. Percentage passing executive function tasks for the young 5 age group (60-65 months) compared with results from Carlson (2005). The number of children aged 60-65 months in each group in my thesis is provided in parenthesis

			Data from Carlson (2005)	Data from this Thesis study		
EF Task	Pass Criteria	Pass Criteria as %	Young age 5 group (60-65 mths)	Total Cohort (60-65 mths) (n=4)	Experimental (exposed) group (60-65mths) (n=2)	Control group (60-65mths) (n=2)
<i>Bear/Dragon</i>	5/6 trials	80	100	100	100	100
<i>Day/Night</i>	12/16 trials	75	N/A	50	0	100
<i>Gift Delay (Wrap)</i>	No peek occurred	—	74	75	100	50