Neuropsychological Predictors of Risk for Disordered Eating Behaviour in Preschool-Aged Children

by

Jessica Anne Grummitt

A thesis submitted in conformity with the requirements for the degree of Masters of Science

Institute of Medical Science
University of Toronto

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2016

Abstract

Background: To date, there are no longitudinal studies of neuropsychological predictors of disordered eating in healthy preschool-aged samples. The purpose of the present study is to identify early patterns of cognitive performance that predict disordered eating vulnerability later in childhood.

Methods: Healthy children were assessed at age 4 using the CANTAB Information Sampling Task, Stop Signal Task, and Spatial Working Memory test. BMI z-scores and Food Avoidance and Approach were assessed at age 4 and 6 using the CEBQ.

Results: Multiple regressions using neuropsychological performance to predict Food Avoidance, Approach, and BMI z-scores at age 4 and 6 revealed that females who made fewer errors on the SWM task showed greater Food Avoidance.

Conclusions: Taken as a whole, the results of the present study did not strongly support our hypotheses. However, the moderation effect of gender on the relationship between SWM performance and Food Avoidance in females merits further elucidation.
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Contributions

Dr. Robert D. Levitan – Involved in all aspects of the current project and edited thesis content
Patricia Szymkow – Coordinated the MAVAN project at the Hamilton site
Carmen MacPherson – Coordinated the MAVAN project at the Hamilton site
Hélène Gaudreau – Coordinated the MAVAN project at the Montreal site
Etienne Léger – Managed and disseminated CANTAB data
Brittany Horodecki – Assisted with patient visits, managing, and disseminating data
Carly McLeod – Assisted with patient visits, managing, and disseminating data
Dr. Leslie Atkinson – Member of Program Advisory Committee, edited thesis content
Dr. Lena Quilty – Member of Program Advisory Committee, edited thesis content
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<tr>
<td>ADHD</td>
<td>Attention Deficit/Hyperactivity Disorder</td>
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<td>AN</td>
<td>Anorexia nervosa</td>
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<tr>
<td>BED</td>
<td>Binge eating disorder</td>
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<tr>
<td>BLC</td>
<td>Big/Little Circle</td>
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<tr>
<td>BN</td>
<td>Bulimia nervosa</td>
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<td>CANTAB</td>
<td>Cambridge Neuropsychological Test Automated Battery</td>
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<tr>
<td>CBT</td>
<td>Cognitive behavioural therapy</td>
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<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
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<tr>
<td>CEBQ</td>
<td>Children’s Eating Behaviour Questionnaire</td>
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<tr>
<td>DEBQ</td>
<td>Dutch Eating Behaviour Questionnaire</td>
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<td>ED</td>
<td>Eating disorder</td>
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<td>EDNOS</td>
<td>Eating Disorder Not Otherwise Specified</td>
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<td>ICC</td>
<td>Intra-class correlation</td>
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<tr>
<td>IED</td>
<td>Intra/Extra Dimensional Set Shift</td>
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<tr>
<td>IOTF</td>
<td>International Obesity Task Force</td>
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<tr>
<td>IST</td>
<td>Information Sampling Task</td>
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<tr>
<td>OCD</td>
<td>Obsessive-Compulsive Disorder</td>
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<tr>
<td>RDoC</td>
<td>Research Domain Criteria</td>
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<tr>
<td>SMR</td>
<td>Standardized mortality ratio</td>
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<td>SST</td>
<td>Stop Signal Task</td>
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<tr>
<td>SWM</td>
<td>Spatial Working Memory</td>
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<tr>
<td>VSWM</td>
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1. Introduction

1.1. Introduction to Literature Review

The aim of the present study was to address a gap in the eating disorder (ED) literature regarding the role of neuropsychological impairment in disordered eating. More specifically, through the use of longitudinal data from a preschool-aged sample, our goal was to provide some clarification on whether specific patterns of neuropsychological performance precede, or are a consequence of, disordered eating behaviour. However, there is a dearth of ED research in preschool-aged samples. As a result, the literature review includes studies spanning across childhood, adolescence, and young- to middle-adulthood. Although this makes it somewhat difficult to make comparisons between studies, and to know exactly what it will mean for our own preschool-aged sample, it does provide valuable insight into the current state of the research on the issue at hand. In addition, because the present study focuses on dysregulated eating behaviour versus clinical EDs, effort has been taken to expand the literature review to include studies of community samples without formal ED diagnoses, where possible.

The first section of the literature review (section 1.2.) provides the reader with some background information on EDs and how they typically present in adolescent and adult populations. Section 1.3. focuses more specifically on eating problems, overweight, and obesity in pediatric samples who face different, but equally troubling, challenges than the adolescent and adult populations. There is also a discussion of gender differences, where data is available. EDs are diagnosed more frequently in females, and as a result, the majority of the available research comprises female samples only. Therefore, gender differences are important to consider, and represent an area requiring further exploration. Section 1.4. focuses on the measurement of eating behaviours in childhood, and is intended to provide background information on what can typically be observed in community samples, such as the one we have included in the present study. The final section of the introduction is a review of some of the
literature on neuropsychology in EDs. Specifically, we focused on neuropsychiatric patterns that have been consistently associated with either restrictive or over-/binge eating behaviours: response inhibition, impulsive decision-making, and poor visuospatial abilities. Research will be discussed that provides evidence for neuropsychological impairment as a consequence of dysregulated eating patterns, as well as those studies that indicate that a specific cognitive profile precedes disorder development.

From this literature review, a model was created that will guide the approach to the current project (see Figure 1). In this model, neuropsychological functioning serves as the predictor, and is divided into cognitive constructs that link to overeating (Food Approach) and those associated with food restriction (Food Avoidance). Namely, difficulty with response inhibition and an impulsive decision-making style are thought to predict Food Approach, while poor visuospatial abilities predict Food Avoidance. The relationship between neuropsychological factors and Food Approach is also thought to be moderated by gender. This hypothesis is supported by studies in both adult and pediatric samples that indicate a propensity for females who display impulsivity and a lowered ability to inhibit their behaviour to engage in Food Approach behaviours. This literature is discussed in more detail in section 1.5.4. However, there is a gap in the literature with respect to gender differences in visuospatial abilities as it relates to eating behaviour. This precludes specific hypotheses about the influence of gender on this relationship, which is represented in the model by the direct connection between predictor and outcome.
Based on this approach, specific research questions and hypotheses were tested in a sample of healthy preschool-aged children using a longitudinal design. Given the age of our sample, and the ability to obtain follow-up information from them as they age, this could be considered a golden opportunity to delineate the role of a potential etiological factor that has been debated in the ED community, as well as identify a target for early intervention.

1.2. Eating Disorders – Review of the Literature in Adolescents and Adults

1.2.1. Overview of Eating Disorders

EDs comprise a range of maladaptive eating behaviours that can have devastating physical, psychological, and psychosocial consequences. In 2013, the diagnostic criteria for these disorders were altered, and reflect the fact that children, adolescents, and adults can all be affected.

Anorexia nervosa (AN) is characterized by severe restriction of food intake, which may or may not be accompanied by binge eating and compensatory behaviours, as in the case of the binge/purge subtype (APA 2013). Individuals with AN are typically
significantly underweight and express an intense fear of “fatness”. AN is reported to typically manifest between 15-17 years of age, and is diagnosed more frequently in females than in males (Hoek and van Hoeken 2003). Bulimia nervosa (BN) is characterized by episodes of binge eating, after which the individual may compensate for the high caloric intake by engaging in self-induced vomiting, laxative abuse, excessive exercise, or a combination of these (APA 2013). Affected individuals tend to be normal weight. In both types of EDs, the individual expresses concern over, and is significantly influenced by their weight or shape.

A recent addition to this group of disorders is Binge Eating Disorder (BED), which has been observed clinically for many years but was only accepted as an official diagnosis in the most recent edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA 2013). Until 2013, this disorder was subsumed under the much more heterogeneous category of Eating Disorder Not Otherwise Specified (EDNOS), which is a category that includes individuals who are significantly ill but do not fulfil all the criteria for either AN or BN, as well as more mild ED presentations. BED is characterized by regular eating binges in the absence of compensatory behaviours, and often results in significant overweight and obesity in affected individuals.

While EDs can affect individuals across the lifespan, the most thoroughly studied populations are usually adolescents and adults. This might be due in part to the absence of diagnostic criteria that fully capture the typical presentation of a childhood ED, and therefore this age group is often excluded from epidemiologic and treatment research. It is important to note that the current diagnostic criteria for the three EDs discussed above are based on typical presentations in adolescents and adults, and that disordered eating can appear quite differently in younger populations.

ED presentations commonly change over time, and individuals can transition between different ED diagnoses. In a study that included two separate ED diagnostic assessments over a period of 30 months, Milos and colleagues (2005) reported that in their sample of 277 women diagnosed with EDs, more than half transitioned between diagnoses during the study. Twenty percent of their sample transitioned from AN to BN
at either or both assessment points, while 9% crossed over in the opposite direction. The majority of patients (37%), however, transitioned from an initial diagnosis of either AN or BN to EDNOS (Milos, Spindler et al. 2005). In a naturalistic, longitudinal study of AN patients enrolled in a treatment program, 29% (n=23) of those who had initially been diagnosed as restricting subtype developed binge eating within 5 years after discharge (Strober, Freeman et al. 1997). Sixteen of these patients went on to meet criteria for BN. Crossover in the other direction (from BN to AN) is less common, but does occur (Eddy, Dorer et al. 2008). Tozzi and colleagues (2005) found that 27% of their sample of BN patients developed AN binge eating/purging subtype, and this crossover occurred within the first 5 years of the illness for the majority of the sample. However, a review found a lower crossover rate of 0-7% (Keel and Mitchell 1997). Diagnostic crossover can also occur within ED subtypes. In a study of AN, 62% of individuals who had been diagnosed as AN restricting at intake to an ED program transitioned to AN binge/purge subtype during follow-up (Eddy, Keel et al. 2002). This might be indicative of a shared vulnerability for disordered eating between diagnostic groups, as well as a tendency toward binge eating among older populations.

1.2.2. **Physiological, Psychological, and Socioeconomic Impact**

The serious morbidity and mortality associated with EDs has long been established. In fact, mortality rates in AN are higher among young and middle-aged adults than in any other psychiatric disorder (Arcelus, Mitchell et al. 2011, Jáuregui-Garrido and Jáuregui-Lobera 2012). A large study by Fichter and Quadflieg (2016) reported standardized mortality ratios (SMR) for AN, BN, BED, and EDNOS to be 5.35, 1.49, 1.5, and 2.39, respectively, and noted that the SMR for AN was greater than five times the mortality in the general population. Patients with AN are more likely to make a suicide attempt, attempts in this population tend to be more serious, and the individual has a higher expectation of dying as a result of the attempt (Jáuregui-Garrido and Jáuregui-Lobera 2012).
However, these numbers jump significantly when considering mortality in adolescents and young adults aged 15-24. The SMR for EDs in this age group is reported to be 7.8 (Hoang, Goldacre et al. 2014). This same study calculated SMRs for other psychiatric disorders, and found that the SMR for ED was only exceeded by the ratio for schizophrenia (SMR = 10.2) in the same age group. When considering young to middle-aged adults (aged 25-44), the SMR for EDs exceeds that of all other psychiatric disorders (Hoang, Goldacre et al. 2014). In AN, BN, and EDNOS, SMRs are 11.5, 4.1, and 1.4, respectively. However, it is important to note that there is some difficulty in defining EDNOS, making reviews of the literature for this population less clear (Arcelus, Mitchell et al. 2011).

According to a meta-analysis by Arcelus and colleagues (2011) of 36 studies of mortality in EDs, the annual mortality rate in AN was 5.1 per 1000 person years, 1.3 of which were a result of suicide. For BN this rate was 1.74, but increased to 2.22 in females. In EDNOS, the mortality rate is 3.31 per 1000 person years.

Chronic, untreated EDs are often accompanied by medical and psychiatric consequences, which are frequently irreversible even if the ED has resolved. Further, the longer EDs such as AN persist without effective intervention, the more intractable the symptoms become and the less likely are the chances of recovery (Von Holle, Pinheiro et al. 2008). The medical complications that can result from a long-term ED are numerous, and include (but are not limited to) hypothyroidism, dental problems, impaired kidney function, and osteoporosis (Mehler, Cleary et al. 2011, Dickstein, Franco et al. 2014). The effects can be particularly devastating for those whose ED symptoms onset early in life, during peak times of bone density accrual. Failure to meet the body’s nutritional needs during these peak periods can place the individual at significant risk of developing osteopenia (Biller, Saxe et al. 1989, Soyka, Misra et al. 2002, Dickstein, Franco et al. 2014). This risk is especially salient for children, who have yet to reach adult levels of bone mass and are in fact losing bone mass during critical periods of development, making them especially vulnerable to the development of skeletal disease (Turner, Bulsara et al. 2001). In addition, prolonged malnutrition can predispose
an individual to a host of cardiac complications, which in some cases result in sudden cardiac death (Dickstein, Franco et al. 2014). In adolescents, these complications can be evident in the early stages of AN (Mont, Castro et al. 2003). In fact, the majority of “sudden deaths” (defined as an unexpected fatality without an obvious cause) in EDs are due to cardiac complications (Jáuregui-Garrido and Jáuregui-Lobera 2012). Even once these patients have sought treatment they are not yet out of danger, as cardiac failure can occur during refeeding, as a result of hypophosphatemia (Jáuregui-Garrido and Jáuregui-Lobera 2012).

Children with EDs are similarly affected, and may actually face increased risk because they are still developing while their nutritional intake is compromised. Growth delay can in fact be the first sign that an ED is impacting development in pre-pubertal children, and can result in permanent short stature (Nicholls et al., 2011; Katzman, 2005). Further, boys are more vulnerable to the negative consequences that AN can have on development because both puberty and peak height velocity is reached later than in girls (Nicholls et al., 2011). Early-onset EDs in children and young adolescents have been associated with bradycardia, hypotension, hypothermia, hypokalemia, and hypophosphatemia (Madden et al., 2009; Peebles et al., 2010; Nicholls et al., 2011). In a sample of 5-13-year-olds with early-onset EDs, Madden and colleagues (2009) reported incidences of hypothermia, hypotension, and bradycardia among their sample. Importantly, they also noted that although 61% of their sample exhibited potentially life-threatening complications, only 51% met the weight criterion for AN. Functional and structural cardiac abnormalities can be evident early on in the illness in adolescents, but can be reversible if intervention is provided swiftly (Katzman, 2005). Finally, a very common and early physical consequence of AN in adolescence is the observation of structural and functional brain abnormalities (Katzman, 2005). The long-term impact of these abnormalities can be quite disruptive to the overall development of the adolescent, due to the considerable amount of change that the brain is still undergoing at this stage in the life cycle.
In addition to the devastating effects that chronic, untreated EDs can have on the body, the affected individual can also experience pronounced impairment in their psychological health. In an investigation of psychosocial impairment in a sample of 552 female in- or outpatients with an ED, Reas and colleagues (2016) found that patients reported significantly greater impairment (m = 32.50) than a healthy community sample (m = 5.17), and were well above the cut-off score of 16. Further, compared to healthy controls, patients with subthreshold, as well as those with clinical levels of ED symptoms, reported significantly worse quality of life in terms of mental functioning (Ackard, Richter et al. 2014). In a large community sample assessing ED behaviours without a clinical diagnosis, those who engaged in regular binge eating reported significantly lower quality of life in both physical and mental functioning than did healthy individuals (Hay 2003). Those who engaged in extreme weight control behaviours (conceptualized as strict dieting or fasting) also reported significantly lower mental functioning, as well as higher levels of bodily pain, difficulties in social functioning, and lower vitality (Hay 2003).

EDs have been found to have a high level of comorbidity with several psychiatric disorders, including Obsessive-Compulsive Disorder (OCD; Crow, Agras et al. 2013), anxiety disorders (Kaye, Bulik et al. 2004), and personality disorders (Wilfley, Friedman et al. 2000). Vrabel and colleagues (2010) found that at admission, 39% of ED patients met diagnostic criteria for Avoidant Personality Disorder, 18% for Obsessive-Compulsive Personality Disorder, 17% for Borderline Personality Disorder, and 15% for Paranoid Personality Disorder. The rest of their sample were spread among personality diagnoses from clusters A, B, and C. Obsessive-compulsive personality traits have been reported to be a likely predisposing factor to EDs (Lilenfeld, Wonderlich et al. 2006).

Comorbidity has also been frequently reported with neuropsychiatric disorders that usually onset in childhood. In an adult sample of female ED patients diagnosed with either AN or BN, 33% (all with AN) had an autism spectrum disorder, 17% (all with AN binge/purge subtype) had Attention Deficit/Hyperactivity Disorder (ADHD), and 27% had a chronic tic disorder (Wentz, Lacey et al. 2005). A review of comorbidity between ADHD
and EDs found that the rate of BN diagnosed in individuals with ADHD ranged from 1-12%, in comparison with 0-2% in healthy controls (Nazar, Pinna et al. 2008).

Measelle and colleagues (2006) reported that in adolescent girls aged 12-15, depression levels at baseline predicted increased ED symptoms 5 years later, but that the reverse (ED symptoms predicting later depression) was not true. Levels of depression have been found to be higher in those who have been identified as at risk of developing an ED (Fragkos and Frangos 2013). A comorbid diagnosis of Major Depression appears to be especially common in those with BED, with the lifetime prevalence rate reported to be as high as 51% (Yanovski, Nelson et al. 1993).

Comorbid depression also appears to play a significant role as a moderator of both treatment outcome and susceptibility to ED risk factors. For instance, Rodgers and colleagues (2010) found that depression moderated the impact that peer and media-related evaluations of appearance had on ED symptoms. Interestingly, this relationship was significantly stronger for boys than for girls. Wilksch and Wade (2014) found that depression symptoms moderated the reduction of many disordered eating behaviours for those who received an ED prevention program, such that those who reported low levels of depression retained the benefits 2.5 years after participating in comparison with those who reported more severe depression symptoms. Depression has also been found to predict a poor prognosis in those whose ED onsets before the age of 11 (Bryant-Waugh, Knibbs et al. 1988).

In spite of all of the impairment associated with EDs, those with disordered eating symptoms rarely seek treatment. In a sample of females with variants of BN and BED, the majority of which did not meet diagnostic criteria for either, only 37.5% had sought a clinician’s advice related to eating or weight (Mond, Myers et al. 2010). Of these individuals, only 12.5% had spoken to a mental health specialist about their concerns. Participants who had sought help for ED-related concerns tended to be older, have higher BMIs, and reported higher levels of impairment in physical functioning, reflecting the possibility that those whose disorders have persisted for a longer period of time might be more likely to seek help (Mond, Myers et al. 2010). However, 83.3% of the
sample had sought help for a general mental health concern independent of the disordered eating symptoms, which might reflect either poor insight in reference to their ED symptoms, or an unwillingness to address these symptoms specifically.

Due to the intractable nature of EDs, they place a significant economic burden on the healthcare system, requiring a high number of resources and extended hospital stays. The economic burden associated with BED has been investigated to a significantly lesser extent than either AN or BN. However, a recent review of the literature reported that the average healthcare costs per patient with BED ranged from $2372 - $3731 (Ágh, Kovács et al. 2015). In addition, it has been estimated that the average healthcare expenditure in Canada is 36.5% higher for obese women with BED than for healthy women (Grenon, Tasca et al. 2010). It appears that many of the individuals requiring costly and extended hospital care may be young. The likelihood of a child or adolescent with AN needing an admission to an inpatient program is 50% or more, and the average length of stay is 6 months (Barton and Nicholls 2008).

If an individual is fortunate enough not to require ongoing medical care as a result of their ED, treating the ED itself can still be quite costly. Crow and colleagues (2013) compared the cost of a cognitive behavioural therapy program in combination with antidepressant treatment against a stepped care sequence of treatment beginning with less costly/intensive therapies progressing to more expensive/intensive therapies to treat BN. They found that the stepped care program was significantly more cost-effective. However, both programs proved to be fairly expensive, with the stepped care program costing $12,146 (USD) and the cognitive behavioural therapy program costing $20,317 (USD) per patient.

It is important to note that the associated costs do not seem to differ between those with diagnosable BN and those reporting subthreshold ED symptoms (Schmidt, Lee et al. 2008). In an investigation of AN inpatients, Hjern and colleagues (2006) found that 21.4% of patients could not support themselves independently 9-14 years after their hospital admission. This was predicted by psychiatric comorbidity as well as a long duration of hospital stay.
1.2.3. Detection of Eating Disorders – Diagnostic and Treatment Challenges

Detecting EDs effectively can be problematic, and not all assessment methods are created equal. In a comparison of self-report versus clinician-administered measures, Fairburn and Beglin (1994) found a statistically and clinically significant difference in the detection of binge eating, with higher rates obtained from a self-report measure. The authors surmised that the patient-completed questionnaire overestimated the incidence of bingeing due to difficulties in defining clinically meaningful binge eating. It appears that ED identification based on self-report is not enough to obtain an accurate diagnosis, especially in the case of more difficult to define behaviours such as binge eating. A large discrepancy was found between a clinician-administered ED interview and the self-report version of that interview, and that obese children and adolescents had a difficult time identifying binge eating episodes when they were not clearly defined by an experienced clinician (Decaluwé and Braet 2004). Based on these findings, the authors concluded that clinical interviews are necessary in order to make an accurate diagnosis.

However, clinician-administered interviews are associated with a number of challenges and disadvantages, especially when used to assess young children. For instance, most structured diagnostic interviews require the individual to recall events over a period of months. Children sometimes find it difficult to accurately remember the chronology of events, which can be critical information in making a diagnosis (Bryant-Waugh, Cooper et al. 1996).

Effective treatment of EDs can also pose several challenges. There is no psychiatric medication that has been recommended as a first-line treatment for either AN or BN (Barton and Nicholls 2008). Antidepressants have been prescribed for BN in young people, but there is no evidence base for this. Further complicating things, while medications can be effective in the treatment of disorders that are commonly comorbid with EDs (e.g. depression, OCD), there are strong recommendations against using these
drugs in young people until they are within a healthy weight range due to cardiac risks (Barton and Nicholls 2008).

However, there are significant barriers to the advancement of treatment efficacy research in the EDs. While randomized, controlled trials are widely considered the “gold standard” of clinical psychiatric research, Halmi (2008) notes the difficulty in conducting these types of studies in AN, specifically. For various reasons, these patients are challenging to recruit and often have a high dropout rate, resulting in a biased sample of study completers. Instead, Halmi calls for greater efforts being directed toward prevention and early intervention in the underage AN population.

1.3. Pediatric Eating Disorders and Obesity

1.3.1. Description and Prevalence

While EDs are commonly considered to be a problem of adolescence, incidence rates are rising among children between the ages of 5-12 years old (Norris, Bonds et al. 2011). There has also been an increase in ED-related hospitalizations in children under the age of 12 (Rosen and Adolescence 2010). Little, however, is known about EDs in children, as the research in this area is fairly limited. In Canada, the incidence of early-onset restrictive disorders in 5-12-year-olds is reported to be 2.6 cases per 100,000 person years, which is twice the rate of type 2 diabetes mellitus cases diagnosed in children under 18 (Pinhas, Morris et al. 2011). To date, disordered eating behaviour has not been investigated in children as young as 4 years old.

When an ED has been detected in pre-pubertal or premenarcheal children, or in an individual under the age of 14, it is classified as an early-onset ED (van Noort, Pfeiffer et al. 2016). Prevalence of early-onset AN is estimated to be between 0.6-0.84% (Råstam, Gillberg et al. 1989, Råstam, Täljemark et al. 2013). In a study investigating early-onset EDs in 101 5-13-year-old children, Madden and colleagues (2009) found that only 37% of their sample met full DSM-IV criteria for AN. On the other end of the spectrum, 6% of
obese 9-16-year-olds met diagnostic criteria for BED and 14% exhibited subthreshold symptoms (Cebolla, Perpiñá et al. 2012).

A recent systematic review of 44 studies of early-onset disordered eating reported an age range of 6-12 years old, and only one study included 6-year-olds (Larsen, Strandberg-Larsen et al. 2015). The DSM-IV criterion that menarche be absent for at least 3 consecutive cycles has prevented many pre-pubertal children who experienced significant dysfunctional eating behaviour from receiving a diagnosis. Therefore, pediatric populations tend to exhibit a predominance of subthreshold ED symptoms, resulting in children being excluded from most research (Walker, Watson et al. 2014). For instance, approximately 40-60% of children who exhibit disordered eating are diagnosed with EDNOS (Nicholls, Chater et al. 2000, Peebles, Wilson et al. 2006, Kurz, van Dyck et al. 2015).

However, criteria for receiving the label of EDNOS are not well defined, resulting in a very heterogeneous group of patients who both narrowly miss AN and BN diagnoses as well as more mild presentations (Fairburn and Bohn 2005). Perhaps in part due to the lack of clear criteria, there is a significant dearth of systematic studies of effective treatment for EDNOS, further ensuring progression and chronicity of the disorder (Fairburn and Bohn 2005). Equally troubling, many insurance providers will deny coverage of treatment for patients who do not meet full criteria for either AN and BN, significantly contributing to the challenges that EDNOS populations face in receiving treatment (Herzog, Hopkins et al. 1993). The findings of Madden and colleagues (2009) serve to further highlight the critical nature of this issue. They reported that when adult criteria are applied, the majority of their pediatric sample did not meet criteria for AN. However, 61% of their sample still experienced life-threatening complications of malnutrition. Thus, it is important to note that children who experience subthreshold ED symptoms often suffer similar physical and psychological outcomes to those who fulfill the diagnostic criteria (Chamay-Weber, Narring et al. 2005, Eddy, Celio Doyle et al. 2008).
1.3.2. Diagnostic Challenges in Pediatric Eating Disorders

It has been argued that children may not possess sufficient cognitive skills to endorse the “core” symptoms of ED psychopathology, as adolescents do; namely, fear of fatness and preoccupation with weight and shape (Walker, Watson et al. 2014). Further, Bravender and colleagues (2010) recommend that diagnostic criteria that require abstract reasoning not be applied to children or adolescents. Skills such as abstract reasoning and consequential thinking would be required for the shape and weight concern central to ED psychopathology, and these domains are underdeveloped in most children (Rosso, Young et al. 2004, Walker, Watson et al. 2014). Therefore, this symptom is often absent in young children (Campbell and Peebles 2014). Alternatively, if this key symptom is present, children may lack the ability to reflect on or vocalize these concerns. Further, children are typically watched more closely by adults, and therefore have less of an opportunity to engage in typical ED-related behaviours (e.g. binging, purging, excessive exercise, etc.; (Walker, Watson et al. 2014). They also lack the financial means to obtain laxatives or food supplies for a binge, and more importantly, may not possess the higher-order reasoning skills to equate compensatory behaviours with weight loss or thin-ideal attainment (Walker, Watson et al. 2014).

In addition to the absence of what are considered the core ED symptoms in children, it is typical to observe disordered eating more frequently in males than females in young populations (Peebles, Wilson et al. 2006). It may also be more realistic to expect a failure to attain expected weight and height milestones rather than to observe a rapid weight loss or compensatory behaviours (Peebles, Wilson et al. 2006). Until the publication of DSM-5 in 2013, the weight requirement to receive a diagnosis of AN was less than 85% of expected weight, or failure to gain weight during a period of growth leading to a weight that is 85% less than expected. However, the newest version of the DSM does allow for some differences in presentation when it comes to children, defining “significantly low weight” as weight that is less than what would be minimally expected (APA 2013). In fact, many children with EDs will not lose sufficient weight to
fall within a diagnostic category (Rosen 2003). However, it should be cautioned that in
the case of children, any weight loss is cause for concern in light of the fact that at this
point in the lifecycle, growth and weight gain are the norm (Rosen 2003). Further,
because children have a lower percentage of total body fat than post-pubertal
adolescents, they will deteriorate at a more rapid rate as a result of weight loss,
requiring more intensive intervention more quickly (Irwin 1984).

Several researchers have questioned the appropriateness of using the current adult
diagnostic standards to diagnose childhood EDs (Jaffe and Singer 1989, Bryant-Waugh
and Lask 1995, Nicholls, Chater et al. 2000, Bravender, Bryant-Waugh et al. 2010). They
have argued that the belief system of the patient and their reasons for avoiding food are
not a suitable basis on which to base a diagnostic decision. More specifically, avoidance
of food should be the key criterion, regardless of whether it results from a fear of
fatness, choking, vomiting, etc. Pinpointing the nature of the patient’s fear driving the
ED behaviours appears to be unique to EDs, whereas other psychiatric diagnoses (e.g.
OCD) are labeled as such based on the behaviours resulting from the patients’ individual
fears.

Bryant-Waugh and Lask (1995) have suggested that rather than applying adult ED
diagnostic criteria to children, childhood onset EDs should be defined as “a disorder of
childhood in which there is an excessive preoccupation with weight or shape, and/or
food intake, and accompanied by grossly inadequate, irregular or chaotic food intake”.
Jaffe and Singer (1989) described eight patients who had been referred to their ED
service, and presented with a similar cluster of symptoms: slow eating/refusal to eat,
pre-pubertal onset, and failure to meet adult diagnostic criteria. The authors argued
that this presentation is more representative of childhood onset EDs, and serve as
evidence for widening or altering the current diagnostic criteria.

Nicholls and colleagues (2000) have responded to this issue by proposing a set of
criteria developed specifically for a pediatric population – The Great Ormond Street
criteria. This is a set of criteria for six eating-related disorders seen in child populations.
Two of the Great Ormond Street disorders could be described as “classic” EDs (AN and
BN), while the remaining four are more recent additions to the ED literature: Food Avoidance Emotional Disorder, Selective Eating, Pervasive Refusal Syndrome, and Functional Dysphagia. However, the criteria for both AN and BN have been adjusted to be more representative of the typical presentation of these disorders in childhood. For instance, any criteria relating to BMI have been removed, as well as the amenorrhea requirement. Using these diagnostic criteria, Cooper and colleagues (2002) found that among 8-18-year-olds referred to an ED treatment service, 29% were diagnosed with Food Avoidance Emotional Disorder, 17% with Selective Eating, and 1% with Functional Dysphagia, all of which can fall under the category of “Avoidant/Restrictive Food Intake Disorder” (ARFID; APA 2013).

The DSM-5 has replaced the DSM-IV category of “Feeding Disorder of Infancy or Early Childhood” with the diagnosis of ARFID; a classification more suited to children. There were two main reasons for this change. First, the former DSM-IV category was rarely used, resulting in a dearth of knowledge on its characteristics, course, and outcome (Attia et al., 2013; Norris & Katzman, 2015). Second, the criteria linked to this category did not exclusively apply to children. For instance, adults can also restrict their food intake in a way that causes significant physiologic or psychosocial interference without meeting full criteria for an ED (Attia et al., 2013; Norris & Katzman, 2015). These disorders are now presented alongside AN and BN under the single category of “Feeding and Eating Disorders”.

ARFID is characterized by a disturbance in food intake resulting in significant weight loss, nutritional deficiency, reliance on enteral feeding or supplements, or interference with psychosocial functioning, in the absence of weight or shape concern (APA 2013). This diagnostic label can be applied to several presentations that occur in children, but have not been captured by previous ED diagnostic categories, including: lack of interest in eating/food, restriction of intake due to an aversion to some property of the food, and food avoidance based on a choking/vomiting phobia (Kurz, van Dyck et al. 2015). In applying these new criteria to pediatric and adolescent samples with EDs, researchers have found the incidence of ARFID to be 13.8% - 19% (Nicholls, Lynn et al. 2011,
Ornstein, Rosen et al. 2013, Fisher, Rosen et al. 2014). In addition, Ornstein and colleagues (2013) found that application of the revised DSM-5 criteria and inclusion of ARFID as a diagnosis reduced the incidence of EDNOS diagnoses from 62.3% to 32.6%.

The criteria for a diagnosis of AN have also been adjusted to acknowledge the somewhat atypical presentation of disordered eating in younger samples. For instance, the amenorrhea criterion is no longer required for diagnosis, in light of the fact that many females who do not endorse this symptom show the same clinical characteristics and course as those who do (Attia et al., 2013; Norris & Katzman, 2015). In addition, the expressed fear of weight gain criterion is no longer the deciding factor in making a diagnosis, and has been expanded upon to include behaviour that significantly interferes with weight gain. This is in recognition of the fact that not everyone endorses this fear, which is especially true for younger populations. However, acceptance and utilization of these new criteria has proven to be challenging. Clinicians either continue to rely on the previous diagnostic criteria or are unaware of the updated criteria/categories (Katzman et al., 2014; Norris & Katzman, 2015). In fact, a recent Canadian Paediatric Surveillance Program survey found that 63% of pediatric clinicians were unfamiliar with the diagnostic category of ARFID (Katzman et al., 2014). Further, of the clinicians who suspected a diagnosis of ARFID, 30% misdiagnosed the case. This led the authors to conclude that many clinicians would benefit from additional training on these criteria.

The absence of the expected core ED symptoms in children can lead to a significant delay in diagnosis. Fosson et al. (1987) observed that it took an average of 7.4 months between parents’ first attempt to seek advice related to eating problems and referral to a child psychiatry program. Almost 10 years later, Bryant-Waugh and colleagues (1996) concluded that the situation had not improved: In a study of 8-15-year-olds diagnosed with AN, the average delay between symptom onset and diagnosis was 12.9 months. Another study found that in a sample of children, those with an earlier age of onset (7-10 years old) experienced a delay in diagnosis twice that of children whose ED onset at 11-12 years old (Atkins and Silber 1993). Finally, in a comparison between early, intermediate, and late-onset EDs, it was found that the early-onset ED group
experienced a significantly longer delay in receiving treatment than the other two groups, with an average delay of 38.35 months (Neubauer, Weigel et al. 2014). It is fair to assume that these statistics underestimate the typical delay that most children and adolescents experience in receiving treatment, as it does not take into account the period between first onset of symptoms and parents’ attempts to address those symptoms. Bryant-Waugh and colleagues (1996) attributed this delay to the consulting physician failing to recognize that the presenting symptoms indicated an ED.

This, in turn, can predict a poorer outcome (Bryant-Waugh, Knibbs et al. 1988). A meta-analysis of predictors of mortality in EDs found that death was more likely for those who first present for treatment at an older age (Arceles, Mitchell et al. 2011, Ackard, Richter et al. 2014). Further, in the case of AN, it appears that risk of mortality increases as the disorder progresses. Those who have had AN longer than 15-30 years have an SMR of 6.6, while those whose duration of illness is between 0 and 15 years have a reduced SMR of 3.2 (Franko, Keshaviah et al. 2013). Midlife adults (≥ 40 years) with EDs also report lower physical and psychological quality of life, ineffectiveness, more interpersonal concerns, and greater psychological maladjustment than younger age groups, suggesting that this group is potentially more complex and difficult to treat (Ackard, Richter et al. 2014). Even after receiving treatment, 41% of AN patients under 18 still present with at least one Axis I diagnosis (Halvorsen, Andersen et al. 2004). Therefore, earlier and more effective screening methods that can readily identify those who are at risk before the disorder becomes a pervasive problem are sorely needed.

Once children are referred for treatment, they may not obtain as much benefit as older patients. Neubauer and colleagues (2014) found that patients diagnosed with an early-onset ED were 6.7 times more likely to be externally motivated for treatment than those with a later onset, who were more internally motivated. This might reflect poor insight with respect to the illness in younger ED patients. Alternatively, pediatric ED patients may be more likely to seek treatment as a result of parental influence, rather than having a strong desire to address the disordered eating symptoms.
Bryant-Waugh and colleagues (1992) found that only 2% of primary care physicians mentioned AN in their differential diagnosis when presented with case vignettes describing common presenting symptoms of childhood AN. When asked to rate themselves on their competence with respect to the diagnosis and treatment of childhood EDs, 89.5% of primary care physicians and 62.5% of non-ED psychologists rated their competency as low (Lafrance Robinson, Boachie et al. 2013). In addition, over 90% of the clinicians surveyed reported encountering a child or adolescent patient with an ED in their practice that they were unable to treat. The three most commonly endorsed reasons for this were lack of skills, case complexity, and lack of resources (Lafrance Robinson, Boachie et al. 2013). A large-scale study of early-onset EDs reported that 24% of the early-onset ED cases were reported by pediatricians, while the remaining 76% were reported by psychiatrists (Hudson and Court 2012). This discrepancy reflects the difference in sensitivity to the presence of a childhood ED between primary care physicians and specialists. In a sample of 880 medical residents, 70% of the sample reported receiving 5 or fewer hours of training in child and adolescent EDs (Girz, Robinson et al. 2014). Residents who received more than 10 hours of training in this area showed greater ED-specific knowledge and comfort with making an ED diagnosis than did those who received less than 5 hours. This reflects the need for more intensive training in this area to improve early detection of childhood-onset EDs in order to reduce treatment delay and illness chronicity.

1.3.3. Pediatric Overweight and Obesity

The majority of cases of childhood obesity are established by the age of 5 years old, making the preschool years a crucial time for detection of early indicators of weight issues (Gillman and Ludwig 2013). The amount of subcutaneous fat (an indicator of overweight and obesity) tends to be unstable from birth until approximately 6 years of age however, making predictions about future body composition challenging for this age group (Baumgartner and Roche 1988). Despite this, there is some evidence that children
who have an above average BMI from birth to 12 years old have a higher likelihood of becoming obese as an adult (Eriksson, Forsén et al. 2003). Further, the children who are the most overweight (e.g. have a greater amount of subcutaneous fat) after the age of 6 have a higher risk of remaining so into adulthood (Roche, Siervogel et al. 1982). In addition, childhood overweight and obesity significantly increase the odds that an individual will be overweight or obese as an adult, and experience the associated metabolic disorders (Whitaker, Wright et al. 1997, Janssen, Katzmarzyk et al. 2005, Juonala, Raitakari et al. 2006, Singh, Mulder et al. 2008). In Canada, prevalence rates of overweight among 3-19-year-olds declined from 30.7% to 27% between 2004-2013, while rates of obesity have remained stable at approximately 13% (Rodd and Sharma 2016).

Children with BMIs in the overweight and obese range tend to report higher levels of overeating than other BMI classes (Sleddens, Kremers et al. 2008, van den Berg, Pieterse et al. 2011). Children aged 6-7 with higher BMIs also report a higher frequency of obesogenic eating behaviours, such as eating in response to food cues and emotional overeating. In addition, overweight/obese children are rated as significantly less responsive to satiety than children of normal weight, indicating that heavier children are less likely to decrease their food intake despite feelings of fullness (Sleddens, Kremers et al. 2008).

Obese children also report high levels of reward responsiveness (van den Berg, Pieterse et al. 2011). Several studies have reported that obese children show greater impulsivity and lower inhibitory control than healthy controls on self-report measures (van den Berg, Pieterse et al. 2011) as well as on a variety of neuropsychological tasks (Nederkoorn, Braet et al. 2006, Braet, Claus et al. 2007, Nederkoorn, Jansen et al. 2007, Pauli-Pott, Albayrak et al. 2010). Better inhibitory control and lower responsiveness to reward is associated with lower BMI as early as age 2, whereas the opposite pattern is predictive of pediatric obesity risk at age 5.5 (Graziano, Calkins et al. 2010). Further, obese children and adolescents who showed low inhibitory control tended to lose the least amount of weight during a residential weight loss treatment program, indicating
that this particular cognitive profile might impact treatment efficacy (Nederkoorn, Braet et al. 2006). Obesity is also often comorbid with ADHD, which is characterized by a high degree of impulsivity and poor inhibition (Holtkamp, Konrad et al. 2004, Cortese, Angriman et al. 2008, Waring and Lapane 2008).

While much of the research on the relationship between neurocognition, eating behaviour, and BMI has been conducted in clinical overweight/obese samples, associations between these variables have also been drawn in healthy samples. In a sample of children aged 6-12, van den Berg and colleagues (2011) found that the positive association between both impulsivity and reward responsiveness was mediated by overeating. In other words, when eating behaviour is significantly impacted, impulsivity and sensitivity to reward may lead to a physiological outcome in the form of altered body composition. In a longitudinal study of healthy female children, impulsivity at age 10 (as assessed by a parent-report measure) significantly predicted increases in BMI from age 10 to 16, even after controlling for ethnicity, socioeconomic status, and verbal comprehension (Goldschmidt, Hipwell et al. 2015). Further to this, binge eating tendencies at age 12 were found to mediate this relationship.

Gender differences have also been observed in the association between impulsivity and overweight/obesity. Levitan and colleagues (2015) demonstrated that greater impulsivity on a go/no-go task was associated with a higher BMI in 4-year-old females, even after controlling for the effects of maternal BMI. A recent review of prevalence rates of overweight and obesity in children aged 4-14 found that prevalence was consistently higher in girls than in boys (Keane, Kearney et al. 2014). However, a study undertaken by the World Health Organization (WHO) found that gender differences in overweight and obesity prevalence rates in 6-9-year-olds fluctuate by country (Wijnhoven, van Raaij et al. 2014). For instance, in Spain boys had higher BMI z-scores at age 6 than girls, while no statistically significant gender differences were detected for children from Belgium or Slovenia. In Canada, median BMI z-scores among 3-19-year-old children tend to be higher than those of the WHO reference population (Rodd and
Sharma 2016). In addition, girls were found to have lower BMI z-scores and prevalence rates of overweight and obesity than boys in Canada between 2004-2013.

Lundeen and colleagues (2016) also found significant differences in the trajectory of overweight and obesity in a sample of South African children. In females, the incidence of overweight and obesity increased with age, while in males a decrease was observed, with the highest rates of overweight/obesity occurring prior to puberty. However, obesity at 16-18 was associated with overweight/obesity in infancy and childhood in both sexes (Lundeen, Norris et al. 2016).

It should be noted that in the pediatric literature, BMI z-score calculations and overweight/obesity classifications are based on various reference norms, including country-specific norms (van den Berg, Pieterse et al. 2011), as well as those distributed by the Centers for Disease Control and Prevention (CDC) (Kuczmarski, Ogden et al. 2002) and the WHO (de Onis, Onyango et al. 2007). This might impact the frequency of children in each BMI class in the study sample, and may limit cross-comparisons between studies. For instance, a Swedish study investigating disparities in overweight and underweight classifications between the WHO, International Obesity Task Force (IOTF; Cole, Bellizzi et al. 2000, Cole and Lobstein 2012), and two Swedish national growth references found significant variability in BMI classification of children aged 7-9 (Nilsen, Yngve et al. 2016). Depending on the growth reference used, the prevalence of thinness ranged from 7.5%-16.9% for boys and 6.9%-13.7% for girls. On the opposite end of the spectrum, the prevalence of overweight (including obesity and severe obesity) ranged from 16.5%-25.7% for boys and 18.2%–25.2% for girls (Nilsen, Yngve et al. 2016). Significant gender differences in overweight classification were also detected between growth references. This was taken into consideration when selecting a reference norm for the calculation of BMI z-scores in the present study (see section 4.2.1.).

BMI does have some notable limitations when it comes to measuring adiposity in pediatric samples. For instance, an elevated BMI does not necessarily indicate greater adiposity in a child, because it does not distinguish between fat mass and muscle mass
(Daniels, 2009). Another issue concerns the BMI cut-offs which indicate clinical overweight and obesity. Some ethnicities may be at risk for complications as a result of obesity at a lower BMI threshold, which may indicate a need for ethnicity-specific cut-offs (Daniels, 2009). Using percentile ranges to determine overweight/obesity categories poses yet another difficulty when measuring young samples. This is especially true for the “Overweight” category, which lies between the 85th and 94th BMI percentile. It is unclear whether children and adolescents in this category are truly overweight, because their increased risk of adiposity-related comorbid conditions does not tend to be great, especially when they fall in the lower end of this range (Daniels, 2009).

In clinical practice, pediatricians have been found to be better at correctly identifying obesity in adolescents versus children (Barlow et al., 2007). Overweight seems to be particularly difficult for clinicians to diagnose, with only 27% of children with a BMI in the 85th – 94th percentile being placed into the appropriate category. Further, many pediatric clinicians still rely on visual inspection to determine overweight status. However, the mean BMI of children has increased over the years, which has affected the perception of what appears to be within the normal or average range (Daniels, 2009). Correct identification of overweight and obesity in children is crucial, so that education and intervention can be initiated to slow or prevent the effects of adiposity-related health conditions.

1.4. **Food Approach and Food Avoidance Behaviour**

Dawe and Loxton (2004) propose a two factor eating behaviour classification system from which to approach EDs: Disorders which involve binge eating and those which involve food restriction. More specifically, they suggest that ED diagnosis would be better served by making a distinction between patients who experience a loss of control over eating (e.g. BN, AN binge-purge subtype, and BED) and those who obsessively control their food intake (e.g. AN restrictive subtype).
In pediatric samples, these behaviours are often measured by parental report through questionnaires. The Children’s Eating Behaviour Questionnaire (CEBQ; (Wardle, Guthrie et al. 2001) is a 35-item self-report questionnaire completed by the parent or primary caregiver that assesses different aspects of the child’s relationship with food. It was designed to measure individual differences on behaviours that contribute to both underweight and overweight, and is regarded as the most comprehensive instrument for this purpose (Carnell and Wardle 2007, Cao, Svensson et al. 2012). Examples of items include “My child enjoys eating” and “My child eats less when he/she is upset”. Six subscales are derived from this questionnaire: Satiety Responsiveness, Food Responsiveness, Slowness in Eating, Food Enjoyment, Desire for Drinks, Food Fussiness, Emotional Overeating, and Emotional Undereating. Higher scores on each of these subscales indicate a greater presence of the trait being measured. Male and female children appear to score differently on the subscales of this measure. In a sample of 6-7-year-olds, Sleddens and colleagues (2008) found that boys tended to score more highly on Food Fussiness and Emotional Overeating, while girls were rated more highly on Food Enjoyment.

Satiety Responsiveness is a measure of the individual’s responsiveness to internal cues indicating that he/she is full (Wilfley, Vannucci et al. 2010). Individuals with low or poor Satiety Responsiveness engage in what has been termed “eating in the absence of hunger”, which has been observed in children as young as 4 (Fisher 2003, Hill, Llewellyn et al. 2008). In fact, this sensitivity to internal hunger cues has been found to decrease with age, making older children more susceptible to over-consumption and obesity (Carnell and Wardle 2007, Carnell and Wardle 2008).

Food Responsiveness is a measure of how susceptible the child is to external food cues (e.g. being offered a food that they find palatable). An individual who scores highly on this behaviour will eat in response to these cues, regardless of internal hunger cues. This construct is sometimes called “external eating”, and derives from Externality Theory, which states that eating in the obese is more related to response to food cues
such as sight, smell, and taste of food, rather than the internal physiological state of hunger (Schachter 1971).

Slowness in Eating is a measure of the child’s rate of food consumption, and has been found to be significantly lower in girls with severe obesity (Gross, Fox et al. 2016). Conversely, higher scores on this scale have been associated with underweight in 2-year-olds (McCarthy, Chaoimh et al. 2015).

The Food Enjoyment subscale was designed to capture normal fluctuations in eating (Carnell and Wardle 2007).

Food Fussiness refers to the child’s tendency to be extremely particular about what they will eat (Wardle, Guthrie et al. 2001). In children, this construct has been found to be associated with lower BMI, fat mass index, and fat-free mass index, as well as an increased risk for becoming underweight (de Barse, Tiemeier et al. 2015). Further, children who exhibit this behaviour are at greater risk of developing subsequent AN (Marchi and Cohen 1990).

Desire for Drinks reflects the child’s preference for sweet drinks, usually in the absence of thirst or hunger (Sweetman, Wardle et al. 2008). Scores on this subscale have been found to be higher in children with higher BMIs (Webber, Hill et al. 2009).

Emotional Overeating measures the child’s propensity to increase their intake in response to negative life events or internal states (e.g. sadness, anger; (Wardle, Guthrie et al. 2001), while Emotional Undereating measures the opposite relationship between food intake and negative affect. The Emotional Overeating subscale has been found to be positively associated with BMI in children, whereas a negative relationship has been observed between Emotional Undereating and BMI (Viana, Sinde et al. 2008). These constructs are derived from Psychosomatic Theory (KAPLAN and KAPLAN 1957), which posits that while a typical response to negative emotions (e.g. fear, anger, stress) is loss of appetite, some individuals respond by increasing their food intake. Bruch (1964) associates this increase in food intake in response to negative affect with confusion between internal emotional states and hunger, and attributed this to early childhood experiences.
In a sample of adults, Emotional Overeating was found to be equally distributed between the AN subtypes, as well as BN (Ricca, Castellini et al. 2012). However, those with BN tended to engage in Emotional Overeating in response to depression more frequently than either of the AN subtypes. Further, Emotional Overeating was found to be differentially associated with specific ED behaviours in each of the different diagnoses: Positive correlations were found between Emotional Overeating and restraint in the AN restricting group, subjective binge episodes in the AN binge/purge subtype, and with the number of objective binge episodes in the BN group (Ricca, Castellini et al. 2012). Finally, Emotional Overeating has been found to predict subsequent binge eating in adolescent females (Stice, Presnell et al. 2002).

This construct, along with Food Responsiveness, is measured in adults by the Dutch Eating Behaviour Questionnaire (DEBQ; van Strien, Frijters et al. 1986), which is discussed in more detail in section 4.1.4. On the DEBQ, these behaviours are termed “Emotional Eating” and “External Eating”, respectively, and together measure tendency toward overeating (Ouwens, van Strien et al. 2003). A children’s version of the DEBQ (DEBQ-C; van Strien and Oosterveld 2008) has also been developed, which yields the same subscales as the adult version.

The combined overeating measure comprised of DEBQ Emotional and External Eating has been found to be significantly associated with greater consumption of palatable foods, such as ice cream and cookies (Van Strien, Cleven et al. 2000, Ouwens, van Strien et al. 2003). Individuals who report binge eating (binge/purge AN and BN) also tend to score significantly higher on these subscales than those who restrict their food intake (Vervaet, van Heeringen et al. 2004). Among obese female children and adolescents receiving a lifestyle intervention for weight change, Emotional Eating at both program start and end was found to be associated with greater weight regain in the year after completion of the program (Halberstadt, van Strien et al. 2016). Finally, in a study of overweight 7-15-year-olds and their parents, good convergence was found between parent and child ratings of emotional and external eating (Braet, Soetens et al. 2007).
During Wardle and colleagues’ (2001) initial development of the CEBQ, they identified two eating behaviour “clusters” which they felt suggested positive versus negative responsiveness to eating. These clusters have since been re-classified as “Food Approach” and “Food Avoidance”, and are hypothesized to consist of four CEBQ subscales each. The Food Responsiveness, Food Enjoyment, Desire for Drinks, and Emotional Overeating subscales form part of a Food Approach composite score that can be used to measure eating behaviours on the binge eating and obesity spectrum (Groppe and Elsner 2014, Groppe and Elsner 2015). Conversely, the Satiety Responsiveness, Slowness in Eating, Food Fussiness, and Emotional Undereating subscales comprise a Food Avoidance variable (Groppe and Elsner 2015). This differentiation closely mirrors the two factor classification approach suggested by Dawe and Loxton (2004). Previous studies have found positive correlations between the expected subscales that have been hypothesized to belong to the two factors (Wardle, Guthrie et al. 2001, Sleddens, Kremers et al. 2008, Viana, Sinde et al. 2008, Webber, Hill et al. 2009, Svensson, Lundborg et al. 2011).

Young children who score highly on Food Approach have a higher risk of overweight/obesity, while children who are high on Food Avoidance exhibit a higher risk of low fat free mass and of becoming underweight (de Barse, Tiemeier et al. 2015, McCarthy, Chaoimh et al. 2015). Braungart-Rieker and colleagues (2014) found that higher levels of mother-rated impulsivity in 3-6-year-old children were associated with Food Approach behaviour. However, while this two-factor system is appealing intuitively, it has yet to be validated statistically.

1.5. Neuropsychological Functioning in Eating Disorders

1.5.1. Neuropsychological Impairment – Antecedent or Outcome of Disordered Eating?

The first 5 years of life are a critical period in the development of executive function (Garon, Bryson et al. 2008). However, this can be significantly impacted in chronic EDs, which in turn can lead to a significantly decreased ability to make decisions,
control emotions, and regulate appetite (Dickstein, Franco et al. 2014). In children, cognitive deficits can go undetected if the individual is high-functioning and the deficit is mild (Lena, Fiocco et al. 2004). If not addressed, these impairments can have negative impacts not only on scholastic achievement, but also on the child’s self-esteem, social functioning, mood, and coping abilities (Peck 1981, Cohen 1985, Fox and Mahoney 1998).

Adolescent inpatients with AN were found to have deficits in total grey and white matter volumes in comparison to healthy individuals (Katzman, Lambe et al. 1996). Another study found reduced grey matter volume in a sample of children and adolescents with AN, which was negatively associated with their performance on a task of visuospatial ability (Castro-Fornieles, Bargalló et al. 2009). These deficits often do not return to normal levels, even after weight restoration (Roberto, Mayer et al. 2011). Bravender and colleagues (2010) have highlighted the potentially devastating impact that childhood onset EDs can have on future neural development. They argue that malnutrition that occurs prior to the critical period of neural remodeling (dendrite pruning and myelination) during adolescence can have permanent negative effects on the child’s decision-making and emotional control, leading to a host of serious difficulties down the line. Further, the brain consumes approximately 20% of the body’s total calorie intake, making it particularly vulnerable to extreme restriction in food intake (Treasure and Russell 2011). This restriction also significantly interferes with the neural circuitry that regulates appetite, further compounding disordered eating behaviour and possibly making recovery more difficult (Treasure and Russell 2011).

Neuropsychological impairment can also impact ED treatment efficacy. The cognitive rigidity often evident in those with acute AN can hinder their ability to engage fully in structured therapies centring on altering cognitions (e.g. cognitive behavioural therapy; Tchanturia, Anderluh et al. 2004). Individuals in a starvation state often lack insight into the severity of their illness, and as a result, lack the motivation to follow a treatment protocol (Dickstein, Franco et al. 2014). In a sample of female AN patients admitted to an inpatient treatment program, 45% were found to be cognitively impaired on
admission, and 35% remained so at discharge (Hamsher, Halmi et al. 1981). Further, 71% of those who showed impairment at discharge had poor outcome, in comparison with 29% of those with average neuropsychological functioning.

It is clear that cognitive deficits can perpetuate and exacerbate the symptoms of EDs (Tchanturia, Morris et al. 2002, Tchanturia, Anderluh et al. 2004). It has also been suggested that neuropsychological deficits precede and underlie EDs (Lena, Fiocco et al. 2004). However, it is often unclear whether a specific pattern of neuropsychological performance represents a predisposition which puts an individual at risk for developing an ED, or if it is the result of a protracted and severe illness. (Matsumoto, Hirano et al. 2015).

Studies of ED patients and their healthy siblings provide some support for the former. In a study of female AN patients and their unaffected sisters, Tenconi and colleagues (2010) found that not only did patients show impaired neuropsychological performance, but their healthy sisters also performed significantly worse than controls on measures of set-shifting, central coherence, and visuospatial ability. Holliday and colleagues (2005) assessed set-shifting in women reporting lifetime AN (binge-purge or restrictive subtype), their healthy sisters, and healthy unrelated women using the CatBat task (Tchanturia, Morris et al. 2002) and the Haptic Illusion task (Uznadze 1966). Healthy sisters of women with AN performed similarly to their affected sibling, and took significantly longer than controls to make the required shift in the task. From this, the authors concluded that impaired set-shifting is a trait characteristic of individuals who are at risk for, and subsequently develop AN.

In a study of young children (approximately 2.5 years of age) of mothers who either had a perinatal diagnosis of an ED or healthy mothers, it was found that children of ED mothers showed delays on indexes of mental and psychomotor development (Sadeh-Sharvit, Levy-Shiff et al. 2016). Specifically, children of mothers with EDs showed delays in verbal and motor skills, working memory, and responsiveness to social cues. Further, maternal ED symptom severity significantly predicted delays in the children’s neurodevelopmental functioning, while maternal mood and anxiety did not. Koubaa and
colleagues (2013) also found neurodevelopmental delays in language skills among a sample of 5-year-olds of mothers with an ED. In addition, children of ED mothers who exhibited neurodevelopmental delays also had a reduced cranial circumference at birth. For children of mothers with BN in particular, reduced head circumference was associated with delays in planning/organizing, social, and language skills (Koubaa, Hällström et al. 2013). Some researchers attribute the delays observed in children of mothers with EDs to the inadequate nutrition during prenatal development as a result of the ED (Zerwas, Von Holle et al. 2012, Easter, Naumann et al. 2013). However, others suggest that this may be the result of an inherited vulnerability for EDs (Trace, Baker et al. 2013, Sadeh-Sharvit, Levy-Shiff et al. 2016).

If specific patterns of neuropsychological functioning do in fact precede the onset of disordered eating behaviour, this may help to explain the high rate of symptom severity changes and relapse that has been observed in these disorders (Lena, Fiocco et al. 2004). Treating the ED symptoms alone may not be enough to promote remission; the neuropsychological impairment must be addressed in the treatment paradigm as well (Lena, Fiocco et al. 2004). Specific clusters of neuropsychological deficits are thought to exist together at certain degrees of severity in a vulnerable individual, and together they impede self-esteem development, assimilation of the body image changes that take place during puberty, identity formation, interpersonal relationships, and autonomy (Lena, Fiocco et al. 2004). This combination of setbacks is thought to set the stage for ED development.

1.5.2. Neuropsychological Impairment in Restrictive Eating Disorders

Support for the assertion that specific patterns of neuropsychological functioning precede the onset of disordered eating is derived from the Cognitive-Interpersonal Maintenance Model of AN, proposed by Schmidt and Treasure (2006). While the authors emphasize that this particular model is concerned primarily with how AN is perpetuated versus causal factors, we argue that it also has implications for the
development of restrictive-type disordered eating. The model posits that both intra- and interpersonal factors are responsible for the maintenance of AN, including obsessive-compulsive and perfectionistic personality traits and avoidance of strong negative emotions, as well as the unintentional reinforcement by others in the affected individual’s immediate circle. More specifically, the disordered eating behaviour is reinforced in highly perfectionistic and obsessive individuals by providing them with a way to avoid experiencing negative emotions associated with feelings of failure. By refusing foods that have been deemed “forbidden”, the individual can both avoid the emotional distress they would feel if they made what would be perceived as a mistake and consumed one of these foods, as well as the unpleasant physiological sensations that can occur when an individual eats while in a starvation state (e.g. nausea, bloating; Schmidt and Treasure 2006). In addition, members of the affected individual’s immediate circle may unintentionally reinforce the AN symptoms by making positive comments about weight loss in the early stages of the illness, and by paying extra attention to and showing concern for the individual in the later stages, leading the individual to feel that their AN symptoms make them special, and that they contribute positively to their well-being (Schmidt and Treasure 2006).

While the primary purpose of this model is to account for the formation of pro-anorexia beliefs and other factors that serve to maintain the disorder, it has some significant implications for formation of restrictive eating behaviour as well. The authors suggest that this cascade of events takes place in individuals who are perfectionistic and obsessive to begin with. This implies a predisposition for AN in those who display obsessive-compulsive personality traits, and the cognitive style that accompanies these traits.

In fact, visuospatial working memory (VSWM), which is defined as the ability to perceive spatial relationships among objects and to retrieve these relationships in the short-term (Baddeley and Hitch 1974), is impaired in individuals with OCD. Purcell and colleagues (1998) administered the Spatial Working Memory (SWM) task from the Cambridge Neuropsychological Test Automated Battery (CANTAB; Sahakian and Owen
1992), and found that the OCD group made significantly more errors than did healthy controls as the difficulty of the task increased. The type of error that they made (called Between-Search Errors) was indicative of a failure to maintain in working memory a visual representation of the arrangement of the objects that they were working with. This is a key feature of visuospatial cognitive abilities. Impairments in this ability are thought to underlie the difficulty individuals with AN experience in accurately evaluating their own body shape and weight (Phillipou, Gurvich et al. 2015). Urgesi and colleagues (2014) reported that those with AN may possess deficits in configural processing that are related to their obsessive concern about body shape and weight, and their tendency to overly focus on the details of what they are perceiving.

However, the literature on VSWM performance in AN has been mixed. A study of 25 female inpatients with AN found no impairment in performance when compared with healthy controls (Fowler, Blackwell et al. 2006). However, another study of adult female AN patients revealed that the patient group had significantly poorer VSWM performance than healthy controls (Phillipou, Gurvich et al. 2015). In a sample of adolescents with acute AN, 30% of the sample was found to be impaired on tasks of visuospatial abilities (Andrés-Perpiña, Lozano-Serra et al. 2011).

The majority of the literature in this area has featured samples made up of mostly, if not entirely, female AN patients. However, in a study of adult males with EDs (the majority of whom were diagnosed with AN), Goddard and colleagues (2014) found that the visuospatial abilities of males with an ED were comparable to the healthy control sample. Interestingly, the authors had initially hypothesized that the performance of eating-disordered males in their sample would be superior to that of healthy controls, given that males in the general population show enhanced performance in this domain in comparison with females (Collins and Kimura 1997, Vecchi and Girelli 1998, Weiss, Kemmler et al. 2003), and that ED patients show a greater affinity for detail processing than healthy controls (Lopez, Tchanturia et al. 2008, Lopez, Tchanturia et al. 2008, Harrison, Tchanturia et al. 2011).
However, in healthy preadolescent samples gender differences in visuospatial abilities are inconsistent. For example, Kaplan and Weisberg (1987) found that visuospatial skills differed between girls and boys depending on age (8- vs. 10-year-olds) and the task that was administered. In a sample of 6-13-year-olds, boys were found to have faster reaction times while girls showed greater accuracy on a task of VSWM (Vuontela, Steenari et al. 2003). In addition, gender differences were most pronounced in the youngest age groups (6-8 years). Levine and colleagues (1999) concluded that superior male performance emerges as early as 4½. However, Young and Wilson (1994) did not detect any gender differences in their sample of 5-11-year-olds.

Obsessive-compulsive personality traits have also been associated with weak central coherence in AN patients (Roberts, Tchanturia et al. 2013), which is defined as the tendency for an individual to overly focus on details while simultaneously failing to integrate these details to create a meaningful bigger picture (Frith 2003, Happe and Booth 2008). Cognitive rigidity is also highly associated with obsessive-compulsive traits, and is believed to be another predisposing factor for ED (Treasure and Schmidt 2013). These traits are manifest in the many obsessive behaviours that those with AN engage in, such as fixation on, and preoccupation with food and weight, as well as highly ritualized eating and mealtime behaviours (e.g. counting calories, frequent weighing; (Brockmeyer, Ingenerf et al. 2014). This pattern of behaviours is theorized to be a symptomatic expression of a cognitive profile characterized by inflexibility and obsessive-compulsive temperament.

These underlying cognitive deficits are apparent in tasks of mental flexibility that require a shift in cognitive set (Zakzanis, Campbell et al. 2010). Tchanturia and colleagues (2004) applied factor analysis to a variety of tasks requiring cognitive flexibility, and identified four distinct domains. They then discovered differential patterns of abnormality for patients with AN versus those with BN. Specifically, those diagnosed with AN exhibited difficulties with simple alternation (or switching between mental sets) and perceptual shift. Patients with BN also displayed difficulties with perceptual shift, but experienced significant difficulty with mental flexibility as well.
(Tchanturia, Anderluh et al. 2004). Interestingly, the authors found that these deficits were unrelated to obsessionality, depression, and anxiety in both patient groups. However, no differences in set-shifting ability were detected in overweight women with BED or subthreshold BED in comparison with those without (Manasse, Forman et al. 2015).

Similar performance has also been observed between patients diagnosed with either subtype of AN, BN, and their healthy sisters on a measure of visuospatial ability and central coherence, and differed significantly from that of healthy controls (Rozenstein, Latzer et al. 2011, Roberts, Tchanturia et al. 2013). In another study examining underlying components of cognitive and social-emotional functioning in ED patients (AN and BN), AN-recovered individuals, and healthy controls, both the recovered group and the acute groups similarly endorsed a fragmented perseverative cognitive style (reflecting a combination of weak central coherence and cognitive inflexibility) and social-emotional difficulties (Harrison, Tchanturia et al. 2012). Finally, no association between neuropsychological performance and BMI was found in a sample of women receiving inpatient treatment for AN (Bayless, Kanz et al. 2002). Thus, degree of neuropsychiatric impairment does not appear to fluctuate with BMI, indicating that impaired cognitive functioning is not simply a result of an acute ED.

Some have hypothesized that individuals with AN have an underlying alteration in their processing of rewards, which is the driving force behind the extreme dietary restriction that is characteristic of this disorder (Kidd and Steinglass 2012). A proposed mechanism responsible for this altered reward processing is impaired feedback-based learning, which influences how an individual responds to positive and negative feedback (Kidd and Steinglass 2012). In support of this, several studies have found that when provided with feedback on their performance during a cognitive task, individuals in the acute phase of AN fail to learn the optimal response strategy in order to maximize the rewards obtained (Cavedini, Bassi et al. 2004, Brogan, Hevey et al. 2010, Abbate-Daga, Buzzichelli et al. 2011).
In order to understand the role neuropsychological variables might play in the development of AN, Kothari and colleagues (2014) identified children of mothers with EDs, who were then classified as at risk of developing an ED. They were tested with the Griffiths Developmental Scales (Griffiths 1954) at 18 months, and were tested again at 4 years with the Wechsler Preschool and Primary Scale of Intelligence – Revised (Wechsler 1989). The Griffiths scales (0-2 year version) assess typical areas of early childhood development: locomotor skills, social skills, language, eye-hand coordination, and cognitive performance. The scales are designed to track development trends that are significant for intelligence. The Wechsler scales provide a similar measurement for an older age group. Using these measures as their primary outcomes, Kothari and colleagues (2014) found that in comparison with children of healthy mothers, children of women who reported lifetime AN showed lower scores in social understanding, visual-motor abilities, planning, and abstract reasoning, which is a component of cognitive flexibility. However, it is not reported whether the at-risk group deviated significantly from the norms for the tests, and whether they could be classified as having a neuropsychological deficit in any of these areas.

In a study of 9-14-year-olds with early-onset AN, no significant differences were detected between patients and controls or between the early-onset AN group and an adolescent AN group on tests of cognitive flexibility, inhibition, planning, central coherence, visuospatial memory, or recognition (van Noort, Pfeiffer et al. 2016). However, cognitive flexibility was found to improve less with age in the AN group than in the healthy control group, suggesting that the development of this ability is slowed in individuals with AN.

In a recent paper by Talbot and colleagues (2015), the authors called into question the classification of cognitive deficits as an endophenotype of EDs, as well as the Cognitive-Interpersonal Maintenance Model of AN (Schmidt and Treasure 2006). In accordance with the model, Talbot and colleagues (2015) compared the performance of AN patients (acutely ill, weight recovered, and fully recovered) to healthy controls on measures of set-shifting and central coherence. Surprisingly, the only differences in
cognitive abilities were observed between recovered AN patients and controls on the set-shifting task. However, there were several notable limitations of this study, including small sample sizes, and the failure to differentiate between sub-types of AN.

Other researchers have concluded that the neuropsychological deficits that have been associated with EDs are a state rather than a trait characteristic, based on the observation that these impairments are not present in recovered ED patients to the same extent as those in the acute phase of the illness. For instance, individuals who were considered recovered from AN (defined as maintenance of a healthy BMI and abstinence from ED behaviours for at least 1 year) showed significantly fewer set-shifting difficulties than those with an acute ED (Roberts, Tchanturia et al. 2010). Further, healthy sisters of affected individuals did not show set-shifting difficulties to the same degree as their siblings in this study. Several studies have also demonstrated that while cognitive performance is not at peak levels in individuals in the acute phase of an ED, performance returns to normal once the ED goes into remission, which have led many to conclude that the cognitive profile that accompanies EDs is a direct result of disordered eating behaviours (Lauer, Gorzewski et al. 1999, Bodell, Keel et al. 2014).

However, as Lena and colleagues (2004) point out, the study conducted by Lauer et al (1999) did not include a healthy control group, preventing the authors from determining that neuropsychological functioning did in fact return to premorbid levels. The authors go on to note that many of the previous literature on associations between neuropsychological impairment and EDs did not attempt to draw an explicit link between the two, but instead explained the relationship as the cognitive deficit being a result of the acute starvation phase. Further, while several researchers have concluded that these effects can simply be reversed with structured therapy and re-feeding (Szmukler, Andrewes et al. 1992, Lauer, Gorzewski et al. 1999), others have shown that cognitive deficits persist even after treatment in areas such as somatosensory integration processing (Grunwald, Ettrich et al. 2001), reaction time, motor control/speed, immediate recall (Green, Elliman et al. 1996), visuospatial ability, and memory (Kingston, Szmukler et al. 1996).
In fact, there is a great deal of inconsistency between the methodologies employed in studies of cognitive functioning in EDs (Zakzanis, Campbell et al. 2010). Variability exists between studies on measures of illness severity (acute, recovered, long-term recovered), whether the study differentiated between AN diagnostic subtypes (binge/purge, restrictive), and whether a comorbid disorder was assessed or controlled for. Importantly, there is also a great deal of variability in the neuropsychological tests used to assess a specific construct, and when the same tests are used, there is variability in what types of outcomes are reported (Zakzanis, Campbell et al. 2010). In addition, it is impossible to rule out the effects of starvation in studies that include acutely ill AN patients without true premorbid measurements of cognitive functioning.

1.5.3. Neuropsychological Impairment in Binge Eating and Overweight/Obesity

Interest in neuropsychological impairment as a possible precursor to EDs began with several case studies examining the connection between pre-existing ADHD and EDs (Schweickert, Strober et al. 1997, Lena, Chidambaram et al. 2001). In an early case study of BN in a 25-year-old, Schweickert and colleagues (1997) reported a connection between pre-existing attention deficits and EDs. Specifically, the subject of this case was diagnosed with ADHD at age 7, which was followed by a diagnosis of BN at age 13. Methylphenidate was initiated, which ameliorated both the symptoms of ADHD and the bingeing episodes. Further, the patient attributed the attenuation of the BN symptoms to the improved concentration and decreased restlessness and distractibility that she was experiencing as a result of the methylphenidate. The authors went so far as to suggest that the BN symptoms were actually a compensatory mechanism to help alleviate the frustration and anxiety associated with the inattention and disorganization that results from untreated ADHD (Schweickert, Strober et al. 1997).

According to a 2010 review by Zakzanis and colleagues, impaired decision-making is observed in EDs, and in BN in particular. Boeka and Lokken (2006) compared
20 women with BN to 20 women with minimal to no BN symptoms on the Iowa Gambling Task (Bechara, Damasio et al. 1994). The Iowa Gambling Task was initially developed to study decision-making in individuals with ventromedial lesions in the prefrontal cortex (Bechara, Damasio et al. 1994). It is a computer-administered task in which the subject is presented with four decks of cards, labelled A, B, C, and D. Decks A and B are considered to be disadvantageous decks, while C and D are advantageous; the subject will lose fewer points in the long-term by selecting from the advantageous decks. Women with BN tended to select from the disadvantageous decks more frequently than healthy controls, suggesting a preference for a greater immediate reward and a disregard for risk (Boeka and Lokken 2006). These results held true even when age, education, verbal ability, and depression scores were controlled for.

Matsumoto and colleagues (2015) investigated Iowa Gambling Task performance in females who had either BN or AN, in comparison with healthy controls. The results demonstrated that both the ED groups failed to demonstrate advantageous decision-making until the end of the task. However, in the final block of the task, a significant impairment in performance was only observed in the BN group. Another study using the Iowa Gambling Task in AN, BN, and healthy controls assessed whether these groups were differentially sensitive to the feedback received from the software program on their decisions during completion of the task, as well as monetary losses incurred (Chan, Ahn et al. 2014). BN subjects were significantly more sensitive to decision-related feedback, and less loss averse than both the AN and healthy control groups. More specifically, BN subjects appeared to be more sensitive to feedback related to decisions resulting in gains.

Some researchers have theorized that the decision-making that BN patients demonstrate on neuropsychological tests underlie their disordered eating behaviours (Boeka and Lokken 2006, Matsumoto, Hirano et al. 2015). For instance, the tendency to favour a greater immediate reward while simultaneously ignoring long-term negative consequences parallels the compulsion to binge eat and purge to manage negative affect, despite awareness of the significant health consequences. This theory could also
be applied to individuals with BED, who have also been shown to demonstrate poorer performance on decision-making tasks than both healthy controls and patients with AN (Aloi, Rania et al. 2015). As in BN, individuals with BED tend to make riskier decisions, which is reflective of a tendency to ignore feedback that encourages the sacrificing of short-term reward for long-term gains. Greater impulsivity has also been found among individuals with an ED diagnosis who also engage in gambling behaviour (von Ranson, Wallace et al. 2013).

Reinforcement Sensitivity Theory (Pickering, Diaz et al. 1995) provides a framework for understanding the role that reward responsiveness plays in the relationship between neuropsychological functioning and bulimic behaviour. The theory is based on Gray’s work (Gray 1970, Gray and McNaughton 2000), which posits that two separate dimensions of motivation and personality drive behaviour: Impulsivity and anxiety. Impulsivity is related to individual differences in responsiveness to rewarding stimuli, and is mediated by the Behavioural Activation System, which regulates responses to appetitive stimuli. In contrast, anxiety is associated with sensitivity to punishment, and is mediated by the Behavioural Inhibition System, which is responsible for inhibition in the face of perceived punishment and aversive stimuli. Individual differences in each of these systems are responsible for the differential patterns of behaviour that can be observed when individuals are faced with rewarding or aversive stimuli (e.g. poor response inhibition when presented with the possibility of obtaining a reward). Individuals who are high on the Behavioural Activation System are more likely to display approach behaviour and positive affect in situations when a reward is imminent (Carver and White 1994). Sensitivity to reward has been found to play a role in several behaviours that are characterized by poor inhibition and impulsivity, such as gambling (Brevers, Koritzky et al. 2014, Gaher, Hahn et al. 2015, Wardell, Quilty et al. 2015) and substance abuse (Genovese and Wallace 2007, Smerdon and Francis 2011, Heinrich, Müller et al. 2016). It has also been found to impact decision-making in children with ADHD (Masunami, Okazaki et al. 2009). Extending these principles to disordered eating behaviour, an individual prone to high impulsivity and poor response inhibition would
also be highly sensitive to the Behavioural Activation System, resulting in an increase in Food Approach behaviour when presented with the possibility of a palatable food (reward).

In line with this, Dawe and Loxton (2004) note that impaired inhibitory control and reward sensitivity are separate components of impulsivity, and both are associated with bulimic behaviours. In addition to scoring higher than healthy controls on a rating scale of impulsivity, women with BN were found to sort cards more quickly during a reward trial of a behavioural measure of reward reactivity (Kane, Loxton et al. 2004). This led the authors to conclude that the tendency to be preferentially drawn to rewarding stimuli may predispose an individual to develop binge eating behaviour. Further support of this was provided by Farmer and colleagues (2001) who demonstrated a positive association between reward sensitivity behaviour and frequency of binge/purge behaviour in a sample of women with EDs.

Impulsivity has been repeatedly associated with EDs in the literature, and in EDs featuring bingeing behaviour in particular (Waxman 2009). This construct has been measured in two ways in the ED literature: Ability to inhibit an automatic response, and the speed at which the individual makes a response (latency (Zakzanis, Campbell et al. 2010). In a study of females with either AN binge/purge subtype, AN restricting subtype, or BN, individuals with an ED diagnosis were found to differ significantly from healthy controls on the cognitive dimension of impulsivity (ability to maintain focused attention; (Rosval, Steiger et al. 2006). Interestingly, participants whose disorders were characterized by bingeing (e.g. BN and AN binge/purge subtype) scored significantly higher on measures of motoric impulsivity (or the inability to inhibit reckless actions), stimulus seeking, and made more commission errors (low response inhibition) on a go/no-go task. Based on this, the authors concluded that while individuals with EDs (regardless of diagnosis) struggle with various aspects of impulsivity, the adoption of a risk-taking attitude might be unique to disorders characterized by BN-type behaviours (Rosval, Steiger et al. 2006). This makes sense intuitively when we consider that the hallmarks of behavioural inhibition are over-control, passivity, and restricted affect,
which closely describes the typical presentation of an individual with restrictive-type AN (Wierenga, Ely et al. 2014). Whereas disorders characterized by binge eating are often associated with limited impulse control and a disregard for averse future consequences (Wierenga, Ely et al. 2014). In support of this, Bruce and colleagues (2003) found that among BN patients grouped by presence of laxative abuse, those who abused laxatives made significantly more commission errors on a go/no-go task during the punishment condition, indicating that this group had greater difficulty inhibiting their behaviour, even when faced with a perceived threat.

1.5.4. Gender Differences in Neuropsychological Functioning and Eating Behaviours

Gender differences have been observed in samples of healthy children with respect to neuropsychological performance and eating behaviours indicative of Food Approach or Food Avoidance. In a sample of 1657 6-11-year-olds, Groppe and Elsner (2014) found a relationship between what they referred to as “cool executive functioning” (comprised of attention shifting, updating, and inhibition) and the Desire for Drinks and Food Responsiveness subscales of the CEBQ, as well as the Restrained Eating subscale of the DEBQ. This association was only observed in females, however. In an extension of this work, Groppe and Elsner (2015) examined whether hot and cool executive function could predict either Food Approach or Food Avoidance. In this study, Food Approach was comprised of the Food Enjoyment, Food Responsiveness, Desire for Drinks, and Emotional Overeating subscales of the CEBQ, in combination with the External Eating and Restrained Eating subscales of the DEBQ-C. Food Avoidance consisted of the Satiety Responsiveness, Slowness in Eating, Food Fussiness, and Emotional Undereating subscales of the CEBQ. In girls, lower cool executive functioning (conceptualized in the same way as discussed above) predicted an increase in both Food Enjoyment and Food Responsiveness one year later, while a decreased ability for affective decision-making, as measured by an age-appropriate version of the Iowa Gambling Task (Crone and van der Molen 2004) predicted increased Satiety
Responsiveness and Slowness in Eating. In boys, only Food Responsiveness was predicted by a decreased ability for affective decision-making.

Summary of Prior Literature and Rationale for the Current Project

Once established, EDs are highly intractable illnesses with severe physiological, psychological, and socio-economic consequences for individuals, families, and society as a whole. Given this reality, identifying children at higher risk for EDs, and implementing preventative strategies as early as possible, is a high priority. Neuropsychological functioning has been consistently associated with various ED manifestations in children, adolescents, and adults. Individuals with a Food Approach style (e.g. binge eating and subsequent overweight and obesity) display difficulties with inhibition and impulsivity, while those with a Food Avoidance style (e.g. restricting food intake and low body weight) struggle with tasks requiring visuospatial abilities. Deficits in these areas are thought to underlie the pathological behaviours associated with EDs, and may help to explain why individuals are able to maintain such extreme behaviours despite knowing their disastrous consequences, contributing to treatment-resistance and high relapse rates. Neuropsychological screening represents an accessible and non-invasive method for assessing the cognitive functioning of an individual, and may provide clues to an individual’s underlying risk for developing an ED. However, to date there have been no longitudinal studies exploring the relationship between neuropsychological functioning and disordered eating behaviours in preschool-aged children. Studies of this type are sorely needed in order to clarify whether the cognitive deficits observed in those with EDs are simply a consequence of the illness, or if they do in fact precede the illness and represent a serious risk factor.
2. Research Questions and Study Hypotheses

2.1. Research Questions and Rationale

1. Can objective measures of neuropsychological functioning in preschoolers predict the onset of eating patterns that are associated with EDs and obesity?
2. Does gender moderate the relationship between neuropsychological functioning and eating behaviour in preschoolers?

Rationale

There are no longitudinal studies of neuropsychological functioning as a predictor of disordered eating behaviours starting in the preschool years. The aim of the current project was to address this issue in a longitudinal study of healthy preschool-aged children in Canada. The primary hypotheses were as follows:

2.2. Study Hypotheses

2.2.1. Hypothesis 1: Low response inhibition at age 4 as assessed by a computer-based go/no-go task predicts Food Approach behaviour and high BMI in girls at age 6.

Rationale: A number of studies have demonstrated consistent links between response inhibition and binge eating behaviour (Bruce, Koerner et al. 2003, Rosval, Steiger et al. 2006, Svaldi, Naumann et al. 2014, Manasse, Goldstein et al. 2016), as reviewed above. Gender differences have also been observed in pediatric samples, indicating that female children who show poor response inhibition engage in more Food Approach behaviours (Groppe and Elsner 2014, Groppe and Elsner 2015). Further, high scores on aspects of Food Approach behaviour have been associated with a higher BMI in the pediatric literature (Viana, Sinde et al. 2008, Webber, Hill et al. 2009, de Barse, Tiemeier et al. 2015, McCarthy, Chaoimh et al. 2015).
2.2.2. **Hypothesis 2:** Risky/impulsive decision-making behaviour at age 4 as assessed by a computer-based information sampling task predicts Food Approach behaviour and high BMI in girls at age 6.

**Rationale:** Reward-based and impulsive decision-making has been associated in the literature with eating behaviours consistent with Food Approach and high BMI (Boeka and Lokken 2006, Chan, Ahn et al. 2014, Aloi, Rania et al. 2015, Matsumoto, Hirano et al. 2015). While most of these studies have been conducted with female samples, there is evidence of gender differences in the relationship between impulsivity and BMI in 4-year-olds (Levitan, Rivera et al. 2015). Specifically, female children who displayed higher levels of impulsivity were found to have higher BMIs.

2.2.3. **Hypothesis 3:** A high error rate on a computer-based spatial working memory task at age 4 predicts Food Avoidance behaviour and low BMI at age 6.

**Rationale:** A link has been demonstrated in the literature between impaired performance on tasks requiring visuospatial skills and aspects of Food Avoidance behaviour, such as restricting food intake and underweight (Andrés-Perpiña, Lozano-Serra et al. 2011, Zuchova, Kubena et al. 2013, Phillipou, Gurvich et al. 2015, Weider, Indredavik et al. 2015). However, because comparisons have not been made between males and females in the literature with respect to this cognitive domain, no predictions can be made regarding gender differences.
3. Methods

3.1. Overall Research Strategy

The goal of the present study was to determine whether neuropsychological performance could predict patterns of eating behaviour associated with EDs in preschool-aged children. This necessitated the selection of independent and dependent variables that were reliable and relevant to the study hypotheses. Independent variables were considered to be suitable if they were cognitive tests that had both demonstrated associations with EDs in the literature, and were appropriate for use with pediatric samples. The Maternal Adversity, Vulnerability, and Neurodevelopment (MAVAN) project (discussed in more detail in section 3.4.1.), from which the sample for the present study was taken, included a battery of 7 CANTAB tests that each generate numerous outcome measures. In order to minimize the problem of making multiple comparisons, the possible predictors needed to be limited to only those that were most relevant and reliable. Therefore, the selected test outcomes needed to meet the following criteria: 1) administered at age 4, 2) demonstrated an association with disordered eating in the literature, and 3) showed acceptable stability across the ages of 4, 5, and 6, as determined by an intra-class correlation (ICC) coefficient of >.4 (Field 2009).

With these criteria in mind, the following tests were selected from the larger battery included in the MAVAN study: Big/Little Circle (BLC), Intra/Extra Dimensional Set Shift (IED), Information Sampling Task (IST), Stop Signal Task (SST), and Spatial Working Memory (SWM). Each of these tasks is described in detail below. The BLC task, being a fairly simple measure of learning and reversal, was included to provide a gauge for whether children as young as 4 can understand the instructions and respond appropriately using the touchscreen technology. The remaining tasks measure the domains of cognitive flexibility, decision-making, inhibition, and visuospatial working memory, respectively, which have been repeatedly associated with disordered eating in the literature (Harrison, Tchanturia et al. 2012; Aloï, Rania et al. 2015; Matsumoto,
Hirano et al. 2015; Groppe & Elsner, 2014; Phillipou, Gurvich et al. 2015). Several scores from each test were examined, equalling 12 outcomes in total. More details on these outcomes are provided below. ICCs were then performed on each outcome using the age 4, 5, and 6 time-points. This provided an indication of whether the child’s performance was stable over time. Any ICC coefficient that was >.4 was considered acceptable, and was considered to be a candidate independent variable (Field 2009).

The next step was to reduce the number of dependent variables, in order to simplify the testing of our hypotheses. For the present study, the CEBQ was selected as the main measure of eating behaviour in our sample. Several researchers have noted that the eight subscales of the CEBQ can be intuitively divided into those addressing Food Approach versus Food Avoidance behaviours (Wardle, Guthrie et al. 2001, Sleddens, Kremers et al. 2008, Viana, Sinde et al. 2008, Svensson, Lundborg et al. 2011). Therefore, it was decided to perform a factor analysis on the eight CEBQ subscales at both the age 4 and age 6 time-points. The purpose of this was to distill the eight different subscales into two latent factors that represent two ends of the disordered eating spectrum. The factor structures at the age 4 and 6 time-points were then compared using a congruence coefficient to determine the stability of the factors, which would provide further confirmation that they are in fact detecting the presence of different latent eating behaviours.

The next sections describe the recruitment and characteristics of the study sample, as well as the general study protocol for the MAVAN project. This is followed by a more detailed description of the specific study procedures and statistical analyses.

3.2. General Methods

3.2.1. Study Participants

Participants were obtained from the MAVAN project. This study is described in detail elsewhere (O’Donnell, Gaudreau et al. 2014). MAVAN is a longitudinal, cohort project that has been in operation since 2003, with the original purpose of examining
the effects of fetal adversity on development in the postnatal environment. Emphasis was put on the measurement of maternal-child interactions. Paternal interactions were not captured due to funding constraints.

Healthy pregnant females who achieved full term were recruited from obstetric clinics at two major Canadian hospitals. The sample also included two “high risk” subsamples of mothers who were either recruited from a low-income area, or who reported significant symptoms of depression or anxiety at their first study visit (12-23 weeks gestation). Eligible participants were 18 years or older, and fluent in English or French. Women could not be included if: they experienced serious obstetric complications during pregnancy or delivery, their child was born at an extremely low weight, was premature ($\leq 37$ weeks), or had any congenital diseases. In addition, potential participants were excluded if they had a history of bipolar disorder or psychosis or if they reported drug/alcohol abuse within 6 months prior to screening.

Mothers and their offspring were assessed twice during the prenatal period beginning at 13 to 20 weeks gestation, at birth, 3 months, 6 months, 12 months, 18 months, 2 years, and annually thereafter. When possible, study visits were conducted at the study site. However, if mother-child dyads were unable to travel to the hospital for a particular visit, every effort was made to collect most or all of the measures at the participants’ home. For the purposes of the present study, we will be focusing on the 4 – 6 year time points. Ethics approval for this study was obtained from the Research Ethics Boards at both the Douglas Mental Health University Institute, and St. Joseph’s Hospital (Hamilton, Ontario).

### 3.2.2. Data Acquisition Protocol

Child birth weights were obtained directly from the birthing unit records. At 4 years (+/- 6 months), children and their mothers were asked to attend their annual study visit at the study centre. The child was first asked to complete the CANTAB battery (CANTABeclipse™, Cambridge Cognition Ltd.). The tests were completed in a quiet room,
using a touch-screen laptop. Children were seated at a desk for the duration of the test battery. All potential distractions were either removed from the testing room, or covered in order to limit the amount of extraneous visual stimuli the child was exposed to during testing. The mother was not present during testing, but a research assistant was available to supervise the entire session, as suggested by the testing manual (Cognition 2011). Prior to beginning the computerized tests, the research assistant asked the child to select which hand they would prefer to use for responding, and explained that the index finger of this hand must be used for the entire session. The research assistant then read from a standardized script that explained the rules of the test, which is provided by the test battery manufacturer (Cognition 2011).

The present study is comprised of a sub-sample of data from the larger project. Therefore, the neuropsychological test battery administered during the study visit contains some tests that will not be discussed in detail (see section 5.2.). The tests were administered in the following order: Motor Screening, BLC, IED (followed by a break), IST, SST, SWM. During testing, research assistants were instructed to only provide one prompt to continue per test. In some cases, tests were discontinued early if the child refused to continue. Following this, weight and height of the children and their mothers was measured.

The mothers then completed the CEBQ on behalf of their child. In cases where the mother was unable to return to the site to complete the visit, the CEBQ was mailed to the participants’ home with return postage provided. If items were identified as missing once the CEBQ was received by study staff, efforts were made to follow-up with the mother by telephone in order to complete the missing item(s). Mothers were also asked to complete the Center for Epidemiologic Studies Depression measure (CES-D; Radloff 1977), and their weight and height were measured at this visit. One year later, the mothers were asked to complete the DEBQ to measure maternal eating behaviour at their child’s age 5 visit.

If a mother-child pair was unable to attend the visit at the study site, measures were completed during a home visit. Every effort was made to maintain the same level
of standardization of administration during these modified visits. However, testing in a more unpredictable environment presents numerous challenges which cannot always be controlled. For instance, the number of distractions (e.g. clutter in the testing area, interruptions by a younger sibling) was significantly higher during these visits.

Children and their mothers returned to the study site two years later for their age 6 (+/− 6 months) visit. They were again measured for weight and height, and the CEBQ was completed by the mother at this visit. The same data completion methods (described above) were applied at this visit.

3.3. Selection of Age Range for Study

For the present study, we chose to focus on the ages of 4 and 6 for several reasons. Age 4 was selected as a baseline in part because this is the youngest age at which the CANTAB battery has been administered in the literature (Luciana and Nelson 2002). In accordance with this, age 4 was the earliest point at which CANTAB data were available in the present study. This was also a desirable baseline because the earliest age at which EDs have been diagnosed in the literature is 5 years old (Norris, Bonds et al. 2011). Therefore, it could be assumed that the children in our sample were relatively free of disordered eating at this time-point, making it possible to investigate neuropsychological functioning in the absence of the effects of prolonged dysregulated eating behaviour. While a structured ED assessment was not administered to our pediatric sample, scores on each of the eight CEBQ subscales obtained from our sample at age 4 are comparable to those reported by Wardle and colleagues (2001) in their community sample of 4-year-olds. Based on this, we concluded that our sample was within normal limits in terms of their eating behaviours, and were not extremely dysregulated in any of the aspects of Food Approach or Food Avoidance.

Age 6 was chosen as the follow-up time-point because, as mentioned previously, disordered eating behaviour meeting diagnostic criteria has been detected at this age in the literature (Norris, Bonds et al. 2011, Pinhas, Morris et al. 2011, Larsen, Strandberg-
Eating behaviours which have been linked to the future development of EDs also emerge at this age, such as loss of control eating (Morgan, Yanovski et al. 2002, Tanofsky-Kraff, Yanovski et al. 2004, Tanofsky-Kraff, Faden et al. 2005), eating in the absence of hunger (Fisher and Birch 2002, Birch, Fisher et al. 2003), and picky eating (Jacobi, Agras et al. 2003). In addition, this appears to be a critical time-point in terms of adiposity. Several studies have noted that children who are heaviest after the age of 6 carry a higher risk of remaining so into adulthood (Roche, Siervogel et al. 1982, Eriksson, Forsén et al. 2001). Therefore, this appears to be a target age for intervention in terms of obesity prevention.

3.4. Potential Covariates

3.4.1. Child Birth Weight Percentile

High birth weight has been identified as a risk factor for obesity later in childhood and adulthood (Parsons, Power et al. 1999, Reilly, Armstrong et al. 2005, Dubois and Girard 2006, Oldroyd, Renzaho et al. 2011, Li, Liu et al. 2014, Qiao, Ma et al. 2015). In a large Swedish epidemiological study, higher birth weight for gestational age also predicted future BN in females (Goodman, Heshmati et al. 2014). Conversely, the prevalence of picky eating was almost three times higher among children who were low birth weight (> 2500 g) at ages 2.5, 3.5, and 4.5 (Dubois, Farmer et al. 2007), and low birth weight was identified as one of the risk factors for persistent picky eating at age 6 (Cardona Cano, Tiemeier et al. 2015). Picky or fussy eating has been associated with greater risk of underweight (de Barse, Tiemeier et al. 2015) and development of AN later in life (Marchi and Cohen 1990), and is a characteristic of ARFID (Fisher, Rosen et al. 2014).
3.4.2. Maternal Depression

Maternal depression has been found to influence children’s eating behaviour. Among a sample of low-income mothers, those reporting high levels of depressive symptoms were more likely to pressure their children to eat and were overall less responsive in their child’s feeding practices (Goulding, Rosenblum et al. 2014). Mothers who report higher levels of depression also showed higher rates of negative parenting (which is conceptualized as the combination of high levels of authoritarianism and permissiveness), which in turn predicted greater impulsivity in children aged 3-6 (Braungart-Rieker, Moore et al. 2014). Maternal depression thus warranted consideration in the present study.

3.4.3. Maternal BMI

Maternal BMI has been found to be a significant predictor of childhood overweight and obesity in both genders, as well as disordered eating behaviours in girls (Berkowitz, Moore et al. 2010, Gonçalves, Silva et al. 2012, Levitan, Rivera et al. 2015). In addition, parental obesity more than doubles the risk of adulthood obesity in children under the age of 10 (Whitaker, Wright et al. 1997). This is especially relevant for the present sample, in which 50.9% of the mothers had BMIs in the overweight or obese range (≥ 25 kg/m²) (1998). In addition, because one of the main outcomes of interest in the present study is based on the mother’s report of her child’s eating behaviour, the mother’s own weight and shape might influence their perception and reporting of their child’s eating behaviours.

3.4.4. Maternal Eating Behaviour

Maternal eating behaviour has been found to predict disordered eating in preadolescent girls (Gonçalves, Silva et al. 2012). In a sample of mothers and their 2-
year-old children, maternal dietary restraint was found to predict an increase in the child’s BMI z-score over the course of 1 year (Rodgers, Paxton et al. 2013). This dietary restraint behaviour has also been found to be associated with the mothers’ monitoring of their female children’s eating behaviour, independent of the child’s weight (Tiggemann and Lowes 2002). Maternal emotional eating has also been found to mediate the relationship between maternal BMI and emotional eating in their 3-6-year-old sons (Jahnke and Warschburger 2008).

4. Measures

4.1. Maternal Measures

4.1.1. Maternal Depression

The CES-D (Radloff 1977) was given to mothers when their children were 4 years old. This measure was developed to detect depressive symptoms in the general population, rather than for diagnosis or assessment of treatment efficacy. The CES-D is a 20-item self-report measure that rates symptoms of depression over the past week. Items are rated on a 4-point Likert scale (“Rarely or none of the time” to “Most or all of the time”), with higher scores indicating a greater presence of that particular symptom. Scores range from 0 to 60. Scores of ≥ 16 are indicative of “possible depression”, and scores of ≥ 23 are categorized as “probable depression”. The English version of this questionnaire has been found to have high internal consistency, as well as acceptable test-retest reliability and concurrent validity (Radloff 1977). This measure has also been translated to French (Fuhrer and Rouillon 1989), and adapted for use with a Quebecois population (Delisle, Kwakkenbos et al. 2014).

4.1.2. Maternal BMI

The mother’s weight (measured to the nearest 0.1 kg) and height was measured at the study site at each visit, using the same scale that was used to measure the
children (TANITA BF625, Arlington Heights, IL). BMI (kg/m²) was calculated for the age 4 and 6 visits. In some cases, the mother’s weight was unavailable at the study visit, either because the mother was pregnant at the time of the visit or she refused to be weighed. To compensate for this and to maximize the amount of available data, a BMI value for the mother was taken from another visit. For instance, if the value was missing for the age 4 visit then data from the age 6 visit was used, and vice versa. When data from both visits were used, an average of the values was taken. If there was a large discrepancy in maternal BMI measures across visits, the data were excluded (e.g. if the mother was pregnant at both visits) because it was deemed unrepresentative of that individual’s typical body mass. BMI data were missing for 32 mothers.

4.1.3. Socioeconomic Status

Socioeconomic status (SES) was calculated from a composite of maternal education and income. Low/high sub-groupings for maternal education and income were first established based on Canadian norms (StatisticsCanada 2005, StatisticsCanada 2011), and were then combined to create three categories: Low SES & Low Education, Low SES & High Education or High SES & Low Education, and High SES & High Education. A mother was considered to be in the “low” income category when their total family income after tax was < $21,359; high income was considered to be > $21,358 after taxes (StatisticsCanada 2005). Maternal education was classified as “low” if they did not obtain a high school degree (StatisticsCanada 2011).

4.1.4. Maternal Eating Behaviour

Maternal eating behaviour was assessed with the DEBQ (van Strien, Frijters et al. 1986, van Strien 2002). The DEBQ is a 33-item self-report measure of eating behaviours that are typically related to overweight and obesity. Items are scored on a 5-point Likert scale ranging from 1 (“Seldom”) to 5 (“Very often”). The questionnaire yields three
subscales: Restrained Eating, Emotional Eating, and External Eating. The Restrained Eating subscale measures wilful efforts to restrict food intake, such as dieting, in an effort to control body weight, and is based on Polivy and Herman’s Restraint Theory (1985). This theory posits that restrained eating contributes to overeating when the resolve of the individual to restrict their food intake breaks down, and results in overeating (Polivy and Herman 1985). This construct is measured by items such as “Do you deliberately eat less in order not to become heavier?”. Emotional Eating is conceptualized as eating in response to negative affect, and is assessed by questions such as “Do you have the desire to eat when you are irritated?”. This subscale can be further divided into Eating in Response to Diffuse Emotions and Eating in Response to Clearly Labelled Emotions. “Diffuse emotions” refers to feeling lonely, sluggish, or bored; examples of “clearly labelled emotions” are feelings of anger or sadness (van Strien, Frijters et al. 1986). External Eating is defined as eating in response to food cues, such as the sight, smell, or taste of a palatable food. Examples of items comprising this subscale include “Do you eat more than usual when you see others eating?”. In the present study, we used only the Emotional Eating subscale as a covariate, because it comprises both types of emotional eating assessed by the DEBQ.

The authors of the DEBQ have demonstrated that it has high internal consistency and factorial validity (van Strien, Frijters et al. 1986). It has also been shown to successfully identify the very different eating styles of healthy individuals, those participating in a weight loss program, and patients with ED diagnoses (Wardle 1987). A French (France) version of the DEBQ has also been validated in a population of healthy and obese individuals (Lluch, Kahn et al. 1996, Brunault, Rabemampianina et al. 2015).

4.2. Child Measures

4.2.1. Adiposity

The child’s birth weight in grams was obtained from their medical record. Weights were then converted to percentiles based on their gestational age at birth.
Birth weights of the children in the MAVAN sample fell within the normal range, based on Canadian norms (Kramer, Platt et al. 2001).

At the 4 and 6 year visits, the weight and height of the child was collected. Body weight, without shoes and in light clothing, was measured to the nearest 0.1 kg using a digital floor scale (TANITA BF625, Arlington Heights, IL). Standing height was measured (without shoes) to the nearest 0.1 cm using a stadiometer (Perspective Enterprises, PE-AIM-101, Portage, MI). Based on these measurements, BMI (kg/m²) and BMI z-scores were calculated for both time-points using the WHO guidelines (WHO 2006, de Onis, Onyango et al. 2007), as recommended by Nilsen and colleagues (2016). The WHO growth reference cut-offs are lower than those of the IOTF, another international growth reference based on a different normative group, resulting in lower levels of misclassification of children who are deviating from typical growth trajectories (Nilsen, Yngve et al. 2016).

Between 1997 and 2003, the WHO undertook the Multicentre Growth Reference Study to address issues raised in 1993 regarding the representativeness of the anthropometric references that had been in use since the late 1970s (WHO 2006). The study included healthy breastfed infants of non-smoking mothers from diverse ethnic and cultural backgrounds, with the express purpose of establishing a reference group who were likely to achieve their full growth potential due to the favourable conditions in which they were being raised. The resulting references are appropriate for use with children up to the age of 5. For children 5 and over, a gap was identified in the previously recommended BMI-for-age references, which only began at 9 years of age (Must, Dallal et al. 1991). This led to the development of a single international growth reference for children and adolescents between the ages of 5 and 19 (de Onis, Onyango et al. 2007). However, rather than undertaking a multicentre study, which would be difficult with this older age group due to challenges with controlling their environment, growth references were constructed from the original 1977 sample supplemented with data from the 2006 Multicentre Growth Reference Study sample to facilitate a smooth
transition at 5 years (de Onis, Onyango et al. 2007). It is from these two reference samples that the BMI-for-age z-scores were calculated for the present study.

4.2.2. *Children’s Eating Behaviour Questionnaire (CEBQ)*

The CEBQ is described in detail in section 1.4. Items are scored on a 5-point Likert scale ranging from 1 (“Never”) to 5 (“Always“). For the present study, the questionnaire was translated into French for administration to the French-Canadian portion of the sample. Order of items was kept consistent across the two versions.

All of the subscales show good test-retest reliability, with the exception of the Emotional Over- and Undereating scales, which show moderate reliability (Wardle, Guthrie et al. 2001). Further, reliability was not observed to increase with age (e.g. no differences between children aged 4 and under, aged 5, and aged 6 and older; (Wardle, Guthrie et al. 2001). The CEBQ also shows good internal reliability (Cronbach’s alphas between 0.70 and 0.87 on all eight subscales; (Domoff, Miller et al. 2015) in a low-income sample. In addition, all of the subscales (with the exception of Desire for Drinks) have been found to be significantly related to child BMI in the expected direction: Positive associations were found between BMI on the Food Responsiveness, Food Enjoyment, and Emotional Overeating scales, while negative correlations were observed for the Satiety Responsiveness, Slowness in Eating, Food Fussiness, and Emotional Undereating scales (Domoff, Miller et al. 2015). The “obesogenic” subscales (e.g. Food Enjoyment and Food Responsiveness) also show good validity in comparison with several laboratory-based behavioural measures of eating (Carnell and Wardle 2007). In addition, in comparison with a laboratory-based behavioural measure of eating that is administered at a single time-point, parents have almost constant opportunities to observe their child’s eating, particularly when they are in the preschool years. Thus, they are in a particularly superior position to report accurately on their child’s eating behaviours (Carnell and Wardle 2007).
4.2.3. Cambridge Neuropsychological Test Automated Battery (CANTAB)

The CANTAB (Cambridge Cognition Ltd.) was originally designed for the purpose of assessing elderly participants who were showing signs of cognitive decline as a result of any of the various subtypes of dementia (Luciana and Nelson 2002). The tests that comprise the CANTAB battery were based on experimental tasks that were currently being used for brain-to-behaviour assessment, sometimes in rodent models (Luciana and Nelson 2002). These tests were then adapted for easy administration to human subjects with neurological issues, psychiatric disorders, or both. The CANTAB offers several advantages, including the use of non-verbal stimuli and responses, which allows for use with language-impaired and international populations (Sahakian and Owen 1992). Further, the battery is comprehensive enough to allow for a performance profile to be derived for a particular patient group (Sahakian and Owen 1992). Construct validity of the CANTAB battery has been demonstrated in samples of patients with neurological lesions (Owen, Downes et al. 1990, Owen, Morris et al. 1996) and healthy volunteers (Morris, Ahmed et al. 1993, Elliott, Sahakian et al. 1997). In addition, all of the tests are demonstrated on the computer and require the participant to complete a practice trial prior to testing, making the battery a suitable choice for young samples whose language proficiency is still developing (Luciana and Nelson 2002). In fact, no differences in performance were found between children for whom English was a second language in comparison with those who spoke English as their primary language (Luciana and Nelson 2002).
5. **Selection of CANTAB Tests for Use in the Present Study**

5.1. *CANTAB Use in Pediatric Samples*

The CANTAB has been increasingly used in the assessment of child and adolescent samples since the late 1990s. In an effort to clarify interpretation of findings and describe normative performance in a pediatric sample, Luciana and Nelson (2002) conducted a descriptive study of 4-12-year-olds using a subset of the CANTAB battery. Prior to this, baseline data of healthy children had not been collected, nor were the CANTAB reference norms suitable for comparison with a pediatric population.

Although it is possible to test children as young as 4 using the CANTAB tests, there is a question of whether scores obtained with this age group are reliable and valid. In addition, the literature on test-retest reliability of the CANTAB tests in pediatric samples is extremely limited, with only two studies conducted to date (Luciana and Nelson 2002, Syväoja, Tammelin et al. 2015). In a sample of fifth graders, moderate to good stability one year later was found for CANTAB tests of visual memory and attention, as well as moderate stability for two tests of executive function (Syväoja, Tammelin et al. 2015). However, tests of visuospatial recognition memory and planning/organization showed poor stability in this sample. One explanation provided for this low level of reliability between annual assessments is that performance on tests of executive function improve dramatically when an optimal strategy is discovered and employed, but fails to improve when a completion strategy is not found (Syväoja, Tammelin et al. 2015). However, this is problematic when testing young children, who may not yet be cognitively developed enough to detect and employ effective strategies (Andersen, Visser et al. 2014, Qin, Cho et al. 2014, Mayor-Dubois, Zesiger et al. 2016).

Test administration difficulties have also been reported in the literature, including issues with the touch-screen technology. Often, 4-year-old children do not touch the screen hard enough for their first response to register, which results in a lag in response time that can be misleading, especially when the primary variable of interest is response latency. In fact, due to this testing issue, Luciana and Nelson (2002) called all
of their response latency data obtained from 4-year-olds into question when interpreting their results. They also noted that this age group had difficulty with the SWM task, and attributed it to the length and increasing difficulty of the task. Children at this age may lack the stamina to complete the more cognitively demanding tasks, especially if these tasks are administered toward the end of the testing session. Administration has been reported to become easier at ages 5 and 6 (Luciana and Nelson 2002).

Luciana and Nelson (2002) provide norms for 4-12-year-old children on some of the tests that assess cognitive constructs that have been associated with EDs in the literature. However, the SST and the IST, tasks targeting inhibition and decision-making, were not included in their study. These constructs have been repeatedly associated with EDs, and evidence exists that impaired performance in these domains precedes, and perhaps contributes to, ED development (Boeka and Lokken 2006, Rosval, Steiger et al. 2006, Waxman 2009, Zakzanis, Campbell et al. 2010, Groppe and Elsner 2014, Groppe and Elsner 2015, Matsumoto, Hirano et al. 2015). In order to elucidate any issues that may render these tests inappropriate for use with children, and to address any questions about the validity of the neuropsychological predictors employed in the present study, we conducted additional reliability tests (Grummitt, Gaudreau et al. 2015). In addition, Syväoja and colleagues (2015) concluded that the psychometric properties of previously validated tests do not always hold up when they are converted into a computerized format, as is the case with many of the CANTAB tests, necessitating confirmation of the reliability of the tests you wish to use with the specific population that you are interested in testing prior to use. Therefore, it was important that the feasibility and validity of administering these tests in a sample of 4-year-olds was evaluated, in order to confidently include these measures in the main analyses.
5.2. **Stability of the CANTAB in the Current Pediatric Population**

5.2.1. **Method**

The sample for this analysis consisted of 312 children from the MAVAN project who had completed the same CANTAB tests at ages 4, 5, and 6. The children completed the CANTAB tests as part of their annual visits at the study site. Inclusion criteria, participant recruitment, and details on test administration can be found in section 3.4. The following tests were completed (in this order) during the visit: BLC, IED, IST, SST, and SWM. These tests were chosen for the current study because they 1) tap into dimensions of neuropsychological functioning that have been linked to ED pathology in older age groups and 2) were consistently administered at ages 4, 5, and 6, allowing for assessment of reliability at all three time-points. The battery took a total of 52 minutes to complete, if the participant completed all trials of all tests.

**Big/Little Circle**

The BLC is a test of comprehension, learning, and reversal, and is designed to train participants on the learning and reversing of a rule (Cognition 2011). The task consists of 40 trials, split into two phases of 20 each. During the first phase, the respondent is presented with a small and a large circle, and is instructed to touch the smaller circle. During the second phase, the stimuli are the same, but the correct response is to touch the larger circle. The outcome measures include: response latency on correct responses, total trials completed, total correct responses, percentage of correct responses, and total errors. The outcome that we were more interested in establishing reliability for was percentage of correct responses.

**Intra-Extra Dimensional Set Shift**

This test gauges the respondent’s mental flexibility by assessing their ability to switch from one set of rules to another. The IED is analogous to the Wisconsin Card Sorting Test (Grant and Berg 1948, Heaton, Chelune et al. 1993), and requires the
respondent to learn a rule for making a correct response (i.e. touch the purple triangle). An “intra-dimensional shift” occurs when a participant who has been trained to respond to a stimulus belonging to a particular category (e.g. shape) must then apply that rule to a new stimulus belonging to that same category (Sahakian and Owen 1992). An “extra-dimensional shift” requires the participant to transfer responding from the previously learned category to a new category (e.g. lines; Sahakian and Owen 1992). Initially, simple discrimination and reversal learning are assessed through presentation of only two categories of stimuli (shapes and lines). After six correct responses, the intra-dimensional shift occurs and the respondent must learn the new rule. Finally, the extra-dimensional shift occurs, requiring the participant to shift their responding to a new (and previously irrelevant) category of stimuli (Sahakian and Owen 1992). The participant receives feedback on the correctness of their responses from the computer throughout, facilitating rule learning. There are nine stages in the test, which gradually increase in difficulty. The test will automatically terminate if the respondent fails to learn the rule after 50 trials within a given stage. For the current analysis we examined the outcome of Stages Completed.

**Information Sampling Task**

This task is designed to assess decision-making abilities as well as impulsivity (Cognition 2011). Respondents are presented with a 5 x 5 grid of grey squares, below which are 2 panels, each in a different colour. They can turn over the grey squares to discover which colour is on the other side by touching the screen. Their task is to correctly guess which colour the majority of the squares are by turning over squares and making a decision based on the information available. Participants are instructed that they can win points by correctly guessing the colour. The respondent makes their final colour choice by touching the panel below the grid that corresponds to the colour the participant guesses is in the majority. Once a choice is made, the remaining grey squares turn over to reveal their colours, and the participant receives feedback on whether or not their choice was correct. The square colours change from trial to trial.
There are two phases of this task: The Fixed Win condition and the Decreasing Win condition. In the Fixed Win condition, respondents are awarded 100 points based on their ability to correctly identify which colour was in the majority, regardless of the number of squares they turn over. In the Decreasing Win condition, the total number of points that can be gained starts at 250, and decreases by 10 for every square turned over. The number of points lost for an incorrect colour decision is 100 in both conditions. Outcomes are calculated for each condition and include latency, errors, mean boxes opened, total correct, and probability of a correct decision. For the present analysis, we included Mean Colour Decision Latency and Mean Number of Boxes Opened Per Trial in both the Fixed and Decreasing Win conditions.

*Stop Signal Task*

This is a go/no-go task which measures both the respondent’s reaction time as well as their ability to inhibit their responses (Cognition 2011). The task consists of two parts: a practice round that does not include any no-go trials, and a go/no-go condition. During the practice round, respondents are presented with a blank screen on which an arrow appears (the go stimulus) that either points to the left or to the right. Respondents are instructed to select the correct direction in which the arrow is pointing as quickly as possible by pressing the corresponding arrow on the press pad. Practice consists of one block of 16 trials. Next, the go/no-go round begins, in which the response rules are the same, except when a tone sounds (the stop signal) after the arrow has appeared on the screen. When this occurs, respondents are instructed not to press any buttons on the press pad. This occurs approximately once every four trials. The delay between the arrow appearing and the tone varies from trial to trial.

The SST produces 5 outcomes: Direction Errors on Stop Trials, Direction Errors on Go Trials, Proportion of Successful Stops, Stop Signal Delay, and Stop Signal Reaction Time. We examined Proportion of Successful Stops and Stop Signal Reaction Time for the present analysis. These measures were calculated for the last 20 sub-blocks of the test.
Spatial Working Memory

This is a test of the respondent’s ability to remember the arrangement of items on the screen in space, as well as their interactions with those items (Cognition 2011). It is adapted from the radial arm maze task used with rodent samples (Olton 1987). A blue coin is hidden in one of the boxes on the screen, and the respondent’s task is to find the coin and place it into a column at the side of the screen, while avoiding re-checking boxes that they have already opened. The respondent must also avoid re-checking boxes in which a coin was previously found, as a coin will not be hidden there again in subsequent trials. The number of boxes presented on the screen gradually increases, until a maximum of 8 boxes is reached. The colour and position of the boxes changes from trial to trial. There are 24 outcome measures for this task, which include latencies, various types of errors, and a search strategy score. In our reliability assessment, we examined Total Errors in the 4 box condition as well as the Strategy score. Although not originally calculated for the initial publication (Grummitt, Gaudreau et al. 2015), the Between-Search Errors in the 4 box condition was an outcome of interest for the present study, and was also examined.

5.2.2. Statistical Analyses

ICCs were performed between the three time-points (4, 5, and 6 years of age) for each of the 5 tests, corresponding to 12 outcome measures of interest. All analyses were carried out using the Statistical Package for the Social Sciences, version 20 (SPSS v20, IBM Corp.).

5.2.3. Results

Average ICCs and mean scores for each CANTAB outcome measure can be seen in Table 1. In accordance with Field (2009), ICCs of >.4 were considered to show adequate agreement. The ICCs showed moderate to substantial agreement for BLC
Percentage Correct, IST Mean Colour Decision Latency-Fixed Win Condition, IST Mean Number Of Boxes Opened Per Trial-Decreasing Win Condition, SST Stop Signal Reaction Time, SST Proportion of Successful Stops, SWM Total Errors-4 Boxes, and SWM Between-Search Errors-4 Boxes. ICCs for IED Stages Completed, IST Mean Colour Decision Latency-Decreasing Win Condition, IST Mean Number Of Boxes Opened Per Trial-Fixed Win Condition, and SWM Strategy were poor.

Table 1  Means, Average ICCs, 95% Confidence Interval range, and p-values for all CANTAB tests between ages 4, 5, and 6

<table>
<thead>
<tr>
<th>CANTAB Test Outcome</th>
<th>Mean</th>
<th>Average ICC</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLC Percentage Correct</td>
<td>97.76</td>
<td>.67</td>
<td>.54 – .77</td>
<td>***&lt;.01</td>
</tr>
<tr>
<td>IED Stages Completed</td>
<td>6.77</td>
<td>.21</td>
<td>-.11 – .45</td>
<td>.09</td>
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<tr>
<td>IST Mean Colour Decision Latency – Fixed Win Condition</td>
<td>31382.65</td>
<td>.55</td>
<td>.36 – .69</td>
<td>***&lt;.01</td>
</tr>
<tr>
<td>IST Mean Colour Decision Latency – Decreasing Win Condition</td>
<td>32390.67</td>
<td>.02</td>
<td>-.42 – .33</td>
<td>.46</td>
</tr>
<tr>
<td>IST Mean Boxes Opened – Fixed Win Condition</td>
<td>21.17</td>
<td>.16</td>
<td>-.19 – .42</td>
<td>.17</td>
</tr>
<tr>
<td>IST Mean Boxes Opened – Decreasing Win Condition</td>
<td>18.72</td>
<td>.53</td>
<td>.32 – .68</td>
<td>***&lt;.01</td>
</tr>
<tr>
<td>SST Proportion of Successful Stops</td>
<td>.63</td>
<td>.62</td>
<td>.45 – .74</td>
<td>***&lt;.01</td>
</tr>
<tr>
<td>SST Stop Signal Reaction Time</td>
<td>597.95</td>
<td>.42</td>
<td>.18 – .60</td>
<td>**&lt;.01</td>
</tr>
<tr>
<td>SWM Total Errors (4 boxes)</td>
<td>4.78</td>
<td>.58</td>
<td>.41 – .71</td>
<td>***&lt;.01</td>
</tr>
<tr>
<td>SWM Strategy</td>
<td>12.99</td>
<td>.06</td>
<td>-.33 – .35</td>
<td>.36</td>
</tr>
<tr>
<td>SWM Between-Search Errors (4 boxes)</td>
<td>4.60</td>
<td>.60</td>
<td>.43 – .72</td>
<td>***&lt;.01</td>
</tr>
</tbody>
</table>

*** p < .001; ** p < .01; *p < .05
5.2.4. Summary of Intra-Class Correlation Coefficients

Some CANTAB measures are appropriate for repeated administrations with children as young as 4 to assess learning and reversal (BLC), impulsivity and inhibition (SST), and some aspects of decision-making (IST) and spatial working memory (SWM). However, cognitive flexibility (as measured by the IED) and strategy use in the SWM task were not reliable in children between the ages of 4, 5, and 6. This is in keeping with the findings of Luciana and Nelson (2002), who concluded that children do not typically reach adult levels of performance on these tasks until the age of 7.

At this stage of development, children may not yet be cognitively sophisticated enough to fully employ these skills. In a comparison of CANTAB performance between 4-8-year-olds and adults, Luciana and Nelson (1998) found that 4-year-olds tended to exhibit the lowest levels of performance. This led them to conclude that this age group exhibit less efficient responses to sensory stimuli, and have underdeveloped sequencing and recognition memory abilities. This could potentially result from functional immaturity in anterior or posterior cortical, thalamic, or striatal structures, or underdeveloped interconnections between these structures.

The measures that were chosen for the present study were those that showed adequate stability across ages 4, 5, and 6 and were appropriate for use with a 4-year-old sample. While the results show that several of the outcome measures from each of the CANTAB tests examined obtained adequate levels of test/retest reliability, only a subset were selected for the main analyses. The IST Mean Number of Boxes Opened Per Trial – Decreasing Win Condition was chosen as the measure of decision-making for the present study because it required the respondent to make a trade-off between accuracy and reward. It was hypothesized that children who were highly reward sensitive would choose to open fewer boxes, even when they did not have enough information to know whether or not their colour selection was going to be correct. This pattern of responding on this outcome measure of the IST has been found in a sample of young cannabis users (Solowij, Jones et al. 2012). This type of response style would also be consistent with the
decision-making displayed by individuals who engage in binge eating in the adult literature (Boeka and Lokken 2006, Alo, Rania et al. 2015, Matsumoto, Hirano et al. 2015).

The Proportion of Successful Stops (obtained by dividing the number of times the respondent inhibited their response successfully by the total number of stop signals) was chosen as the SST outcome of interest for a number of reasons. Response inhibition was of particular interest in the present study, given its association with binge eating in the literature (Rosval, Steiger et al. 2006, Zakzanis, Campbell et al. 2010). This measure is entirely dependent on the child’s ability to inhibit their response (e.g. refrain from pressing a button when they hear a tone). Given the age of the sample, this outcome presented the most simplistic and straightforward measure of response inhibition. This measure has also been used in the literature to assess inhibition in a number of different populations, including bipolar disorder, Parkinson’s disease, posttraumatic stress disorder, and adolescent obesity (Kulendran, Vlaev et al. 2014, Olff, Polak et al. 2014, Stefanova, Ječmenica Lukić et al. 2014, Farahmand, Tehrani-Doost et al. 2015).

Finally, the Between-Search Errors in the 4 box condition of the SWM was chosen for the main analyses. Between-Search Errors have been referred to as “forgetting errors” in the literature (Luciana and Nelson 2002), and are recorded when a respondent revisits a box in which they previously found a token. Scores on this measure are sensitive to samples who experience difficulty maintaining visuospatial information in short-term memory, such as ADHD (Fried, Hirshfeld-Becker et al. 2015), OCD (Purcell, Maruff et al. 1998), and autism (Goldberg, Mostofsky et al. 2005). This outcome measure was of particular interest because it requires the respondent to perceive and maintain the spatial relationships between the boxes in order to avoid making this type of error. Therefore, a high number of errors on this measure would indicate reduced VSWM abilities, which have been demonstrated in EDs characterized by restriction of food intake (Kingston, Szmukler et al. 1996, Andrés-Perpiña, Lozano-Serra et al. 2011, Rozenstein, Latzer et al. 2011, Roberts, Tchanturia et al. 2013, Phillipou, Gurvich et al. 2015). The 4 box condition was selected with the young age of
the sample in mind, being the easiest level administered in the MAVAN study and the only level at which the sample was able to complete all trials.

For the ease of the reader, from this point forward IST Mean Number of Boxes Opened Per Trial-Decreasing Win Condition will be referred to as “ISTA”, SST Proportion of Successful Stops will be referred to as “SST”, and SWM Between-Search Errors-4 Boxes will be referred to as “SWM”.

6. **Statistical Analyses**

All analyses were performed using the Statistical Package for the Social Sciences version 22 (SPSS v22; IBM Corp.).

6.1. **Methodological Considerations**

To reduce the number of linear regressions required to test our hypotheses, it was decided that a factor analysis would be performed on the eight subscales of the CEBQ to test for the presence of the underlying proposed Food Approach and Food Avoidance factors. These factors would then be entered into the multiple linear regressions as dependent variables.

Pearson’s correlations were performed on the eight subscales of the CEBQ at ages 4 and 6 to observe the strength of the associations between the Food Approach and Food Avoidance facets of eating behaviour, as well as to ascertain the level of multicollinearity between these subscales. In order to identify latent variables related to different ED presentations (e.g. AN, BN, BED), two separate factor analyses were performed at age 4 and 6 on the 8 subscales of the CEBQ. A direct oblimin rotation was used, as the subscales were hypothesized to be measuring different aspects of the same underlying component (eating behaviour). In addition to employing the Kaiser criterion, which states that only factors with eigenvalues greater than one should be retained, a parallel analysis was also conducted. Factor loadings of >.30 were interpreted (Field 2009). Tucker’s congruence coefficient (Tucker 1951) was calculated to compare factor scores between ages 4 and 6. Coefficients above .85 were considered to have high congruence, and coefficients above .95 were indicative of equivalent factors (Lorenzo-Seva and ten Berge 2006).
6.2. Testing of Hypotheses 1-4

Prior to conducting the multiple linear regressions, normality of the predictors, covariates, and outcomes was assessed. Normal distributions and skewness values less than 1/-1 were observed for all outcomes (Food Avoidance, Food Approach, and BMI z-scores) and CANTAB predictors, with the exception of the IST. Examination of the histogram for this variable revealed that approximately 45% of the sample (n=125) opened all 25 boxes on each trial of the test, resulting in a negative skew of -1.43. However, as noted by Brooks and colleagues (2009), many distributions of neuropsychological test scores deviate from the expected normal distribution in healthy samples. Further, significant skew can sometimes be observed in samples that differ in some way from the general population sample on which the data was normed (e.g. in pediatric vs. adult samples). In addition, it must be taken into account that when considering neuropsychological data, the ability being tested may simply not be normally distributed in the general population (Brooks, Strauss et al. 2009). Normative data for preschool-aged children does not exist for the IST, making it impossible to conclude whether or not this distribution of performance is normal for this age group. Therefore, it was decided that transformations of this variable would not be performed to compensate for non-normality. However, the special considerations applied to neuropsychological data were not relevant to maternal BMI and CES-D scores, which were found to have positive skews of 1.35 and 1.60, respectively. Thus, these variables were transformed using the base-10 logarithm.

Missing CEBQ items were then dealt with according to the method used by Webber and colleagues (2009). According to these guidelines, when items are missing, subscale scores can still be calculated if 75% of the items comprising that subscale are completed, except in the case of the Desire for Drinks subscale on which 67% of items must be completed. The sum of the scores was then divided by the adjusted number of items completed for that subscale to obtain the adjusted subscale mean.
Next, the independent variables (SST, IST, and SWM) and covariates (birth size percentile, maternal BMI, maternal CES-D scores, and maternal DEBQ Emotional Eating) were centred for inclusion in the multiple regression analysis. To do this, the grand mean for each variable was subtracted by the individual participant scores on that variable (Holmbeck 2002, Field 2009). The child gender variable was then dummy coded, creating two new dummy variables. In the first variable, males were categorized as 0 and females were categorized as 1 (making males the reference group for this variable), and the reverse categorization was used for the second dummy variable. Next, gender interaction terms were calculated by multiplying each centred CANTAB test score first by dummy gender variable 1, and then by dummy gender variable 2, resulting in 6 new interaction terms. This was done in order to facilitate simple slopes analysis in the event that a significant two-way interaction was found (Holmbeck 2002).

Multiple linear regressions were performed on centred continuous independent variables using the Enter method (Holmbeck 2002). Each regression contained two blocks with different predictors: Block 1) centred CANTAB test score(s) and one dummy-coded gender variable (for consistency, the dummy-coded gender variable in which males were the reference group was always used); Block 2) CANTAB score(s) X child gender interaction term(s). Block 2 allowed for the assessment of moderational effects of child gender on any of the relationships between neuropsychological performance and the outcomes of interest.
7. **Results**

7.1. **Description of Study Sample**

Characteristics of the children and mothers in our sample are presented in Tables 2 and 3, respectively. A total of 702 children were recruited to the larger MAVAN project. At the time of the present study, 282 children had complete CANTAB test data at 4 years old, of which, 272 children were included in the final analyses (123 females, 149 males). Seven children were identified by their pediatrician or a specialist as having an attentional or neurological issue that could interfere with neuropsychological testing, and were thus removed from the sample: 4 children had ADHD, 2 were diagnosed with autism, and 1 child had epilepsy. An additional 3 children dropped out of the study after their age 4 visit.

Chi-square analyses revealed that the distributions between the sites did not differ for child gender (see Table 2). Mean birth weight (in grams) differed significantly between the study sites, with children in Hamilton being heavier, on average, at birth than children in Montreal. There were no extremely low birth weight children (e.g. <1500 g) in the sample. At age 4, 68.4% of the children in our sample had a BMI z-score in the average range, 21% were at risk of overweight, 3.7% were overweight, and 1.8% were obese. Data were missing for 14 children. At age 6, these proportions changed somewhat, with increases in the number of overweight and obese children. Proportions between the various BMI categories did not differ significantly between study sites at either age 4 or age 6 (see Table 2).

The total number of mothers in our sample was 242. Forty-eight children in the sample were younger siblings of children who had already been recruited to the study. For this reason, in some cases the total amount of maternal data collected exceeds the total number of mothers in the sample. Mothers at the Montreal study site were, on average, younger than Hamilton mothers at the time of their child’s birth (29 vs. 31; see Table 3). Maternal BMI at age 4 and age 6 were found to be highly correlated (r=.89, p<.01), and were thus averaged to be used as a single covariate, as discussed in section
4.1.2. No significant differences were found between Montreal and Hamilton with respect to maternal BMI, with both sites falling within the overweight range (BMI ≥ 25 kg/m²; (1998), or the distributions of education, income, and SES.

8.8% of the sample was classified as below the low income cut-off of <$21,359 after tax (StatisticsCanada 2005), which is a smaller proportion than what is typically found in the general population (StatisticsCanada 2009); see Table 3. The remaining 69.6% were considered high income (>$21,358 after tax). Eight mothers did not know their household income and 1 refused to answer. Income data were missing for 50 participants.

In terms of maternal education, 6.3% of the sample had a high school diploma or less (n=17), 5.1% had partially completed a community college program (n=14), 27.9% had completed community college or part of a University degree (n=76), and 45.2% had a University degree (n=123). Education information was missing for 42 participants. Our sample contained a lower number of individuals with less than 10 years of education than what is typically reported for the provinces of Ontario and Quebec, which is approximately 12% (StatisticsCanada 2011). For the combined SES variable, 2.6% of mothers (n=7) had both low education and low income, 15.4% had either low education and high income or high education and low income (n=42), and 61.4% had both high education and high income (n=167). Data were missing for 56 participants. On average, the present sample appears to be well educated and have a higher annual income than what is typically observed in the general population.

7.2. **Baseline Comparisons**

More of the participants were from the Montreal (58.5%, n=159) than the Hamilton site (41.5%, n=113). However, this is to be expected because the Montreal site began recruitment approximately 1.5 years before the Hamilton site. Therefore more Montreal children have reached the age 6 time-point and have complete data. Baseline
comparisons of descriptive variables between the sites were conducted in order to confirm that the two study sites contained similar distributions.

Mean scores on each of the predictor variables (IST, SST, and SWM) were compared between the sites. No significant differences were observed between Hamilton and Montreal for any of the CANTAB scores (see Table 2). Five children in the sample were identified as having completed the CANTAB tests during a home visit. However, no significant differences were found between participants who had completed the tests at home versus at the study site on the SST, the IST, or the SWM. Therefore, it was decided to include these five participants in the final analyses.

Montreal mothers did not differ from those in Hamilton on any of the key covariates (maternal BMI, CES-D scores, DEBQ Emotional Eating scores; see Table 3). Maternal scores on the CES-D were within the average range (<16; (Radloff 1977), indicating that on average, the mothers in our sample did not endorse a high number of depressive symptoms. Approximately 15.8% of mothers scored at or above the 95th percentile on the Emotional Eating subscale of the DEBQ (van Strien 2002).
Table 2  Descriptive statistics and between site comparisons for children in Montreal, Hamilton, and the combined study sample

<table>
<thead>
<tr>
<th></th>
<th>Montreal (N= 159)</th>
<th>Hamilton (N= 113)</th>
<th>Total Sample (N=272)</th>
<th>t</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females - N (%)</td>
<td>73 (45.9)</td>
<td>50 (44.2)</td>
<td>123 (45.2)</td>
<td>-</td>
<td>.07</td>
<td>1</td>
<td>.79</td>
</tr>
<tr>
<td>Males - N (%)</td>
<td>86 (54.1)</td>
<td>63 (55.8)</td>
<td>149 (54.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Birth Weight (in grams)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (±SD)</td>
<td>3281.19 (±437.21)</td>
<td>3536.11 (±472.05)</td>
<td>3387.10 (±468.38)</td>
<td>-4.58</td>
<td>-</td>
<td>270</td>
<td>&lt;.01</td>
</tr>
<tr>
<td><strong>BMI z-score – Age 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (±SD)</td>
<td>.53 (±1.00)</td>
<td>0.57 (±1.08)</td>
<td>0.54 (±1.03)</td>
<td>-.34</td>
<td>-</td>
<td>259</td>
<td>.73</td>
</tr>
<tr>
<td><strong>BMI z-score – Age 6</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mean (±SD)</td>
<td>0.38 (±1.14)</td>
<td>0.33 (±1.03)</td>
<td>0.36 (±1.10)</td>
<td>.34</td>
<td>-</td>
<td>201</td>
<td>.73</td>
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<tr>
<td><strong>BMI Classification – Age 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obese - N (%)</td>
<td>1 (0.6)</td>
<td>4 (3.5)</td>
<td>5 (1.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight - N (%)</td>
<td>4 (2.5)</td>
<td>6 (5.3)</td>
<td>10 (3.7)</td>
<td></td>
<td></td>
<td></td>
<td>.10</td>
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<tr>
<td>Risk of Overweight - N (%)</td>
<td>38 (23.9)</td>
<td>19 (16.8)</td>
<td>57 (21)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Average - N (%)</td>
<td>103 (64.8)</td>
<td>83 (73.5)</td>
<td>186 (68.4)</td>
<td></td>
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<td><strong>BMI Classification – Age 6</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Obese - N (%)</td>
<td>10 (6.3)</td>
<td>6 (5.3)</td>
<td>16 (5.9)</td>
<td></td>
<td></td>
<td></td>
<td>.73</td>
</tr>
<tr>
<td>Overweight - N (%)</td>
<td>24 (15.1)</td>
<td>13 (11.5)</td>
<td>37 (13.6)</td>
<td></td>
<td></td>
<td></td>
<td>.62</td>
</tr>
<tr>
<td>Average - N (%)</td>
<td>86 (54.1)</td>
<td>62 (54.9)</td>
<td>148 (54.4)</td>
<td></td>
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<tr>
<td><strong>SST</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean (±SD)</td>
<td>.70 (±.15)</td>
<td>.71 (±.15)</td>
<td>.70 (±.15)</td>
<td>-.91</td>
<td>-</td>
<td>270</td>
<td>.37</td>
</tr>
<tr>
<td><strong>IST</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (±SD)</td>
<td>20.71 (±7.94)</td>
<td>18.94 (±7.93)</td>
<td>19.98 (±7.97)</td>
<td>1.81</td>
<td>-</td>
<td>270</td>
<td>.07</td>
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<tr>
<td><strong>SWM</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (±SD)</td>
<td>5.84 (±3.15)</td>
<td>5.81 (±3.26)</td>
<td>5.83 (±3.19)</td>
<td>.07</td>
<td>-</td>
<td>270</td>
<td>.94</td>
</tr>
</tbody>
</table>
Table 3  Descriptive statistics for mothers in Montreal, Hamilton, and the combined study sample

<table>
<thead>
<tr>
<th></th>
<th>Montreal (N=121)</th>
<th>Hamilton (N=103)</th>
<th>Total Sample (N=224)</th>
<th>t</th>
<th>χ²</th>
<th>df</th>
<th>p-value</th>
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<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mean (±SD)</td>
<td>29.78 (±4.30)</td>
<td>31.34 (±4.82)</td>
<td>30.39 (±4.57)</td>
<td>-2.70</td>
<td>254</td>
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<td>&lt;.01</td>
</tr>
<tr>
<td><strong>BMI - Averaged</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean (±SD)</td>
<td>27.24 (±6.54)</td>
<td>28.18 (±7.03)</td>
<td>27.66 (±6.77)</td>
<td>-1.07</td>
<td>240</td>
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<td>.28</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school or less - N (%)</td>
<td>10 (6.3)</td>
<td>7 (6.2)</td>
<td>17 (6.3)</td>
<td></td>
<td>3</td>
<td>.53</td>
<td></td>
</tr>
<tr>
<td>Some college - N (%)</td>
<td>7 (4.4)</td>
<td>7 (6.2)</td>
<td>14 (5.1)</td>
<td></td>
<td>2.24</td>
<td>3</td>
<td>.53</td>
</tr>
<tr>
<td>College diploma - N (%)</td>
<td>38 (23.9)</td>
<td>38 (33.6)</td>
<td>76 (27.9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University degree - N (%)</td>
<td>74 (46.5)</td>
<td>49 (43.4)</td>
<td>123 (45.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (&lt;$21,359) - N (%)</td>
<td>14 (8.8)</td>
<td>10 (8.8)</td>
<td>24 (8.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High (&gt;=$21,358) - N (%)</td>
<td>103 (64.8)</td>
<td>87 (77.0)</td>
<td>190 (69.9)</td>
<td></td>
<td>.15</td>
<td>1</td>
<td>.70</td>
</tr>
<tr>
<td><strong>SES</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Income/Low Education</td>
<td>5 (3.1)</td>
<td>2 (1.8)</td>
<td>7 (2.6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Inc/High Ed OR High Inc/Low Ed</td>
<td>24 (15.1)</td>
<td>18 (15.9)</td>
<td>42 (15.4)</td>
<td></td>
<td>.92</td>
<td>2</td>
<td>.63</td>
</tr>
<tr>
<td>High Income/High Education</td>
<td>90 (56.6)</td>
<td>77 (68.1)</td>
<td>167 (61.4)</td>
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<td></td>
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<tr>
<td><strong>CES-D Score</strong></td>
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<td></td>
</tr>
<tr>
<td>Mean (±SD)</td>
<td>10.12 (±8.30)</td>
<td>9.69 (±9.66)</td>
<td>9.94 (±8.89)</td>
<td>.38</td>
<td>259</td>
<td></td>
<td>.70</td>
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<tr>
<td><strong>DEBQ Emotional Eating</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean (±SD)</td>
<td>2.43 (±1.03)</td>
<td>2.50 (±1.05)</td>
<td>2.46 (±1.04)</td>
<td>-.48</td>
<td>213</td>
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<td>.63</td>
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</table>
7.3. Associations between Covariates, Eating Behaviour, and Child BMI

Pearson correlations were conducted between the key covariates (child birth size percentile, maternal BMI, CES-D scores, and DEBQ Emotional Eating scores), the predictors (CANTAB scores; see Table 4), and the outcomes of interest (see Table 5) in order to determine whether they might play a role in the relationship between neuropsychological performance and disordered eating in our sample. Correlation size interpretations were based on Cohen’s (1988) guidelines, which suggest that correlations between 0.5 and 1.0 are considered to be large, 0.3 and 0.5 to be medium, and 0.1 to 0.3 to be small.

Between the covariates and the eating outcomes, all correlations were in the small range, with the exception of maternal BMI for which a medium correlation was observed with child BMI z-scores at age 4 and 6 (see Table 5). None of the covariates correlated significantly with any of the CANTAB scores (see Table 4). It should be noted that a small negative correlation between the IST and SWM was the only significant association observed between the CANTAB scores. This indicates that there is very little multicollinearity between these measures, which further validates their selection as predictors for the present study.

Small to medium correlations were observed between the Food Avoidance and Food Approach factors (with the exception of Food Approach at age 4) and child BMI z-scores at both time-points (see Table 5). Further, these correlations were in the expected directions: negative correlations were observed between Food Avoidance and BMI z-scores, while positive associations were found between Food Approach and BMI z-scores. Therefore, maternal ratings of child eating behaviour appear to be related to physical outcomes of over- and under-eating in our sample. This partially mitigates concerns about whether mothers’ perceptions of their child’s eating behaviours are accurate and representative. Further investigations of the reliability of maternal reports on the CEBQ were undertaken by conducting Pearson correlations on the same subscales between time-points (see Table 6). All associations were positive and above .5, indicating a large amount of agreement between age 4 and 6 maternal ratings of child eating behaviour.
Table 4  Pearson correlations between covariates and CANTAB SST, IST, and SWM scores

<table>
<thead>
<tr>
<th></th>
<th>Child Birth Size %</th>
<th>Maternal BMI</th>
<th>CES-D</th>
<th>DEBQ Emotional Eating</th>
<th>SST</th>
<th>IST</th>
<th>SWM</th>
</tr>
</thead>
<tbody>
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<td>Child Birth Size %</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal BMI</td>
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<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CES-D</td>
<td>.07</td>
<td>*.14</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEBQ Emotional Eating</td>
<td>.05</td>
<td>***.27</td>
<td>*.17</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SST</td>
<td>.04</td>
<td>.02</td>
<td>.06</td>
<td>.01</td>
<td>1.00</td>
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<td></td>
</tr>
<tr>
<td>IST</td>
<td>-.004</td>
<td>.12</td>
<td>-.02</td>
<td>.06</td>
<td>-.07</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>SWM</td>
<td>.07</td>
<td>.03</td>
<td>.03</td>
<td>.004</td>
<td>.02</td>
<td>*-.13</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*** p < .001; ** p < .01; * p < .05
<table>
<thead>
<tr>
<th></th>
<th>Child Birth Size %</th>
<th>Maternal BMI</th>
<th>CES-D</th>
<th>DEBQ Emotional Eating</th>
<th>Food Avoidance (age 4)</th>
<th>Food Approach (age 4)</th>
<th>Food Avoidance (age 6)</th>
<th>Food Approach (age 6)</th>
<th>BMI z-score (age 4)</th>
<th>BMI z-score (age 6)</th>
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</thead>
<tbody>
<tr>
<td>Child Birth Size %</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Maternal BMI</td>
<td></td>
<td>.09</td>
<td>1.00</td>
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<tr>
<td>CES-D</td>
<td>.07</td>
<td>*.14</td>
<td>1.00</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>DEBQ Emotional Eating</td>
<td></td>
<td></td>
<td></td>
<td>***.27</td>
<td>* .17</td>
<td>1.00</td>
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<td></td>
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<tr>
<td>Food Avoidance (age 4)</td>
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<td>-.03</td>
<td></td>
<td>.13</td>
<td>.10</td>
<td>1.00</td>
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<td></td>
</tr>
<tr>
<td>Food Approach (age 4)</td>
<td></td>
<td>.08</td>
<td>.12</td>
<td>* .18</td>
<td>* .19</td>
<td>.01</td>
<td>1.00</td>
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</tr>
<tr>
<td>Food Avoidance (age 6)</td>
<td></td>
<td>.02</td>
<td>-.05</td>
<td></td>
<td>.13</td>
<td>.12</td>
<td>***.68</td>
<td>-.10</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Food Approach (age 6)</td>
<td></td>
<td>-.04</td>
<td>* .20</td>
<td></td>
<td>*.17</td>
<td>.15</td>
<td>-.02</td>
<td>***.64</td>
<td>-.14</td>
<td>1.00</td>
</tr>
<tr>
<td>BMI z-score (age 4)</td>
<td>**.16</td>
<td>***.32</td>
<td>.04</td>
<td></td>
<td>* -.17</td>
<td>.13</td>
<td>**-.20</td>
<td>**.23</td>
<td>**.30</td>
<td>**.77</td>
</tr>
<tr>
<td>BMI z-score (age 6)</td>
<td>.10</td>
<td>***.34</td>
<td>*.14</td>
<td>-.04</td>
<td>* -.18</td>
<td>.14</td>
<td>**-.23</td>
<td>***.30</td>
<td>**.77</td>
<td>1.00</td>
</tr>
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</table>

*** p < .001; ** p < .01; * p < .05
Table 6  Pearson correlations of CEBQ subscales between ages 4 and 6

<table>
<thead>
<tr>
<th>CEBQ Subscales – Age 4</th>
<th>SR</th>
<th>SE</th>
<th>FF</th>
<th>FR</th>
<th>FE</th>
<th>DD</th>
<th>EUE</th>
<th>EOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satiety Responsiveness (SR)</td>
<td>***.56</td>
<td>***.30</td>
<td>***.35</td>
<td>**-.22</td>
<td>***-.41</td>
<td>-.03</td>
<td>***.29</td>
<td>-.05</td>
</tr>
<tr>
<td>Slowness in Eating (SE)</td>
<td>***.29</td>
<td>***.55</td>
<td>*.21</td>
<td>-.06</td>
<td>***-.30</td>
<td>.05</td>
<td>***.33</td>
<td>-.01</td>
</tr>
<tr>
<td>Food Fussiness (FF)</td>
<td>***.31</td>
<td>*.18</td>
<td>***.73</td>
<td>-.13</td>
<td>***-.49</td>
<td>.04</td>
<td>.12</td>
<td>-.08</td>
</tr>
<tr>
<td>Food Responsiveness (FR)</td>
<td>-.15</td>
<td>.02</td>
<td>-.06</td>
<td>***.65</td>
<td>***.31</td>
<td>***.28</td>
<td>.06</td>
<td>***.45</td>
</tr>
<tr>
<td>Food Enjoyment (FE)</td>
<td>***-.34</td>
<td>**-.23</td>
<td>***-.37</td>
<td>***.33</td>
<td>***.68</td>
<td>.03</td>
<td>-.05</td>
<td>.11</td>
</tr>
<tr>
<td>Desire to Drink (DD)</td>
<td>-.01</td>
<td>.08</td>
<td>.12</td>
<td>***.27</td>
<td>.002</td>
<td>***.73</td>
<td>**.21</td>
<td>**.21</td>
</tr>
<tr>
<td>Emotional Undereating (EUE)</td>
<td>*.18</td>
<td>**.21</td>
<td>*.16</td>
<td>-.08</td>
<td>-.10</td>
<td>.02</td>
<td>***.58</td>
<td>.06</td>
</tr>
<tr>
<td>Emotional Overeating (EOE)</td>
<td>-.12</td>
<td>.03</td>
<td>.03</td>
<td>***.39</td>
<td>*.19</td>
<td>.09</td>
<td>**.23</td>
<td>***.58</td>
</tr>
</tbody>
</table>

*** p <.001; ** p <.01; *p <.05; Cells highlighted in yellow indicate correlations of the same subscale between age 4 and 6
7.4. Associations between CEBQ Food Approach and Food Avoidance Subscales

Pearson correlations of the eight CEBQ subscales at ages 4 and 6 can be seen in Table 7 and Table 8, respectively. None of the subscales correlated at 0.90 or above, indicating that multicollinearity was not an issue for any of the chosen variables. It was concluded that all subscales could be retained for the factor analysis.

At age 4, correlations between the Food Avoidance subscales were positive and in the small to medium range (see Table 7). For the Food Approach subscales, a large correlation was observed between Food Responsiveness – Emotional Overeating, while the remaining correlations were in the small to medium range.

Correlations between the Food Avoidance subscales at age 6 were again within the small to medium range, reflecting similar relationships between individual subscales to what was observed at age 4 (see Table 8). For the Food Approach subscales, the same correlations found to be in the large range at age 4 were of similar size at age 6, while the remaining subscales correlated in the small to medium range. In addition, a significant (p<.01) positive correlation was observed between Emotional Overeating – Emotional Undereating at both ages 4 and 6. It is also worth noting that at both age 4 and 6, the Desire for Drinks subscale consistently demonstrated small correlations with the other subscales within the same proposed factor (Food Approach), with the exception of Food Responsiveness.
Table 7  Pearson’s correlations between CEBQ subscales at age 4 (N=197)

<table>
<thead>
<tr>
<th>Subscale</th>
<th>SR</th>
<th>SE</th>
<th>FF</th>
<th>FR</th>
<th>FE</th>
<th>DD</th>
<th>EUE</th>
<th>EOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satiety Responsiveness (SR)</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slowness in Eating (SE)</td>
<td>.49</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Food Fussiness (FF)</td>
<td>.45</td>
<td>.30</td>
<td>1.00</td>
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<td></td>
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</tr>
<tr>
<td>Food Responsiveness (FR)</td>
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<td>-.07</td>
<td>-.15</td>
<td>1.00</td>
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</tr>
<tr>
<td>Food Enjoyment (FE)</td>
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<td>-.40</td>
<td>-.56</td>
<td>.47</td>
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<tr>
<td>Desire for Drinks (DD)</td>
<td>.02</td>
<td>.10</td>
<td>.10</td>
<td>.28</td>
<td>-.03</td>
<td>1.00</td>
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<td></td>
</tr>
<tr>
<td>Emotional Undereating (EUE)</td>
<td>.36</td>
<td>.29</td>
<td>.30</td>
<td>.04</td>
<td>-.10</td>
<td>.08</td>
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<tr>
<td>Emotional Overeating (EOE)</td>
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<td>.06</td>
<td>.11</td>
<td>.50</td>
<td>.09</td>
<td>.22</td>
<td>.31</td>
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</tbody>
</table>

Blue indicates the inter-correlations between the Food Approach subscales; Yellow indicates the inter-correlations between the Food Avoidance subscales.
Table 8  Pearson’s correlations between CEBQ subscales at age 6 (N=178)

<table>
<thead>
<tr>
<th></th>
<th>SR</th>
<th>SE</th>
<th>FF</th>
<th>FR</th>
<th>FE</th>
<th>DD</th>
<th>EUE</th>
<th>EOE</th>
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<td>(SR)</td>
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<td>Slowness in Eating</td>
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<tr>
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<tr>
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<tr>
<td>(FR)</td>
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<td>-.59</td>
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<td>(FE)</td>
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<td>Desire for Drinks</td>
<td>.05</td>
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<td>.06</td>
<td>.35</td>
<td>.06</td>
<td>1.00</td>
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<td>(DD)</td>
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<tr>
<td>Emotional Undereating</td>
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<td>(EUE)</td>
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<tr>
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<td>-.11</td>
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<td>.27</td>
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</tbody>
</table>

Blue indicates the inter-correlations between the Food Approach subscales; Yellow indicates the inter-correlations between the Food Avoidance subscales.
7.5. **CEBQ Food Approach and Food Avoidance Factors**

In the present study, 75 children (27%) had at least one missing CEBQ subscale at age 4, and 94 children (34%) had at least one missing CEBQ subscale at age 6. Missing cases were excluded from the analyses using listwise deletion and factor scores were therefore not computed for these children.

The Kaiser-Meyer-Olkin tests of sampling adequacy indicated that matrices at both age 4 and age 6 were adequate, with values of .67 and .61, respectively (Kaiser 1974, Field 2009). Bartlett’s test also indicated no issues of sphericity at age 4 ($\chi^2(28)=435.09, p<.01$) or age 6 ($\chi^2(28)=460.24, p<.01$). It was concluded that it was appropriate to proceed with factor analysis, and that the factors that resulted from the analysis could be considered reliable.

Application of the Kaiser criterion for eigenvalues, as well as examination of the scree plot, revealed a two-factor structure for the eight CEBQ subscales at age 4 (see Table 9). This was further confirmed by the parallel analysis, which yielded two factors for which eigenvalues were not less than or equal to the parallel average random eigenvalues (Hayton et al., 2004). Satiety Responsiveness, Slowness in Eating, Food Fussiness, lack of Food Enjoyment, and Emotional Undereating loaded highly on Factor 1. While Satiety Responsiveness and Emotional Undereating reflect normal physiological processes, the high loading of Food Fussiness and indifference to food exhibited by a high negative loading of Food Enjoyment were more indicative of a restrictive eating style. Therefore, it was concluded that this factor represented Food Avoidance. Factor 2 consisted of Food Responsiveness, Desire to Drink, and Emotional Overeating, and represented a Food Approach factor.

A similar two-factor structure was obtained at age 6 (see Table 9). However, the factor loadings for Factor 1 (the proposed Food Avoidance factor) were in the reverse direction than they had been at age 4. These values were multiplied by -1 for ease of comparisons between factor structures. In addition, the factor loading for Emotional Undereating was >.30 on both factors at age 6 (.32 on Factor 1 and .31 on Factor 2), precluding the conclusion that this subscale loaded more highly on one factor over the other.
The Food Avoidance and Food Approach factors (with the exception of Food Approach at age 4) correlated significantly with child BMI z-scores at both age 4 and 6 in the expected direction (see Table 5). This provides evidence that these factor scores are measuring the proposed underlying eating behaviour components. Tucker’s coefficients of congruence were .97 between age 4 and 6 for Factor 1, and .99 for Factor 2, indicating that the factor structure is stable, and can be considered identical according to the guidelines established by Lorenzo-Seva and ten Berge (2006).

Table 9  Factor loadings of CEBQ subscales at age 4 and 6

<table>
<thead>
<tr>
<th>CEBQ Subscale</th>
<th>Age 4 (N=197)</th>
<th>Age 6 (N=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor 1</td>
<td>Factor 2</td>
</tr>
<tr>
<td>Satiety Responsiveness</td>
<td>.77</td>
<td>-.02</td>
</tr>
<tr>
<td>Slowness in Eating</td>
<td>.59</td>
<td>.06</td>
</tr>
<tr>
<td>Food Fussiness</td>
<td>.64</td>
<td>.05</td>
</tr>
<tr>
<td>Food Responsiveness</td>
<td>-.35</td>
<td>.81</td>
</tr>
<tr>
<td>Food Enjoyment</td>
<td>-.75</td>
<td>.32</td>
</tr>
<tr>
<td>Desire for Drinks</td>
<td>.06</td>
<td>.33</td>
</tr>
<tr>
<td>Emotional Undereating</td>
<td>.40</td>
<td>.29</td>
</tr>
<tr>
<td>Emotional Overeating</td>
<td>.08</td>
<td>.67</td>
</tr>
</tbody>
</table>

Factor loadings of ≥ 0.4 are bolded
7.6. **Neuropsychological Performance and Eating Behaviour**

7.6.1. **Testing of Hypotheses 1 & 2**

**Hypothesis 1**: Low response inhibition at age 4 as assessed by a computer-based go/no-go task predicts Food Approach behaviour and high BMI in girls at age 6.

**Hypothesis 2**: Risky/impulsive decision-making behaviour at age 4 as assessed by a computer-based information sampling task predicts Food Approach behaviour and high BMI in girls at age 6.

To address hypotheses 1 and 2, four separate multiple linear regressions were performed with centred SST, IST, and child gender as predictors. ANOVA coefficients for each model, as well as $R^2$ change and F change p-values can be seen in Table 10. Separate regressions were performed on Food Approach at age 4, Food Approach at age 6, child BMI z-scores at age 4, and child BMI z-scores at age 6. Regressions were performed on age 4 variables because it would help to establish when relationships (if any) between neuropsychological predictors and disordered eating and weight outcomes first emerge.

Both the F change p-value and the overall regression model for Food Approach at age 4 was non-significant, indicating that neither IST or SST performance or gender were significantly associated with this outcome. However, a significant ANOVA coefficient was found for the first block of the regression model including child BMI z-score at age 4 as the dependent variable (see Table 10). The F change p-value for Block 2 was non-significant, indicating that gender did not moderate this relationship. Child gender was found to be significantly associated with child BMI z-scores at age 4 ($\beta=-.16, 95\% \text{ CI}=-.58 - -.08, p=.01$), such that males tended to have higher BMIs than females at this age. The coefficients for SST and IST did not reach significance. The regression was repeated, controlling for child birth size percentile, maternal BMI, maternal depression (as measured by CES-D scores), and maternal Emotional Eating (as measured by the DEBQ). Child gender remained significant ($\beta=-.17, 95\% \text{ CI}=-.64 - -.06, p<.05$), with maternal BMI also being significantly associated with child BMI z-scores at age 4 ($\beta=.38, 95\% \text{ CI}=2.68-5.90, p<.01$). Inspection of the beta value indicated that children of mothers with high BMIs also tended to have high BMIs. SST, IST, birth
weight percentile, CES-D scores, and DEBQ Emotional Eating were not significantly associated with child BMI z-scores at age 4.

Contrary to our hypotheses, neither SST nor IST were significant predictors of Food Approach behaviour or child BMI z-scores at age 6 in either gender (see Table 10).
Table 10  ANOVA coefficients, $R^2$ change, and F change p-values for multiple linear regression models between SST, IST, Food Approach and child BMI z-scores

<table>
<thead>
<tr>
<th></th>
<th>$F$</th>
<th>$df$</th>
<th>$R^2$</th>
<th>Model p-value</th>
<th>$R^2$ change</th>
<th>F change p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food Approach (age 4)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>.44</td>
<td>193</td>
<td>.01</td>
<td>.72</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Model 2</td>
<td>.81</td>
<td>191</td>
<td>.02</td>
<td>.55</td>
<td>.01</td>
<td>.26</td>
</tr>
<tr>
<td><strong>Food Approach (age 6)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>.40</td>
<td>174</td>
<td>.01</td>
<td>.75</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Model 2</td>
<td>.34</td>
<td>172</td>
<td>.01</td>
<td>.89</td>
<td>.003</td>
<td>.77</td>
</tr>
<tr>
<td><strong>Child BMI z-score (age 4)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>2.92</td>
<td>257</td>
<td>.03</td>
<td>* .04</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Model 2</td>
<td>2.38</td>
<td>255</td>
<td>.05</td>
<td>* .04</td>
<td>.01</td>
<td>.21</td>
</tr>
<tr>
<td><strong>Child BMI z-score (age 6)</strong></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
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<td>.02</td>
<td>.33</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Model 2</td>
<td>.78</td>
<td>197</td>
<td>.02</td>
<td>.57</td>
<td>.002</td>
<td>.78</td>
</tr>
</tbody>
</table>

***p<.001; **p<.01; *p<.05

1 Model including SST, IST, and child gender as predictors
2 Model including SST X gender and IST X gender interaction terms in addition to predictors in Model 1
7.6.2. Testing of Hypothesis 3

**Hypothesis 3:** A high error rate on a computer-based spatial working memory task at age 4 predicts Food Avoidance behaviour and low BMI at age 6.

Four separate multiple linear regressions were performed with SWM and child gender entered as predictors. Dependent variables for each of the analyses were as follows: Food Avoidance at age 4, Food Avoidance at age 6, child BMI z-score at age 4, and child BMI z-score at age 6. The Enter method was once again used, with the SWM X gender interaction term entered into the second block as an exploratory analysis of potential gender moderation. The fact that the majority of the literature on VSWM performance in EDs has been conducted in female samples precluded any explicit hypotheses regarding differential relationships between SWM performance and eating and weight outcomes in boys versus girls. In addition, while males display superior performance on visuospatial tasks in samples of healthy adults (Collins and Kimura 1997, Vecchi and Girelli 1998, Weiss, Kemmler et al. 2003), inconsistent gender differences have been observed in the pediatric literature (Kaplan and Weisberg 1987, Young and Wilson 1994, Levine, Huttenlocher et al. 1999, Vuontela, Steenari et al. 2003). Therefore, we felt that this was an important opportunity to assess whether gender does significantly impact this relationship.

The regression models for both Food Avoidance and child BMI z-scores at age 4 were non-significant (see Table 11). In contrast to our predictions, SWM did not significantly predict Food Avoidance behaviour or child BMI z-scores at age 6 when males and females were grouped together.

In terms of the exploratory analyses of gender moderation, gender did not significantly moderate the relationships between SWM errors and child BMI z-scores at age 4 or 6. However, inclusion of the child gender interaction term contributed a significant amount of variance when SWM was regressed on Food Avoidance at age 4, indicating the presence of a moderational effect of child gender (see Table 11). The SWM X gender interaction term ($\beta=.20$, 95% CI=.01-.16, $p<.05$) accounted for a significant amount of variance in the model. Analysis of the simple slopes of the two-way interaction between SWM and child gender revealed a significant difference for females...
Table 11  ANOVA coefficients, $R^2$ change, and F change p-values for multiple linear regression models between SWM, Food Avoidance, and child BMI z-scores

<table>
<thead>
<tr>
<th>Model</th>
<th>$F$</th>
<th>df</th>
<th>$R^2$</th>
<th>Model p-value</th>
<th>$R^2$ change</th>
<th>F change p-value</th>
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<tr>
<td>Model 1</td>
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<td>.164</td>
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<td>n/a</td>
</tr>
<tr>
<td>Model 2</td>
<td>2.72</td>
<td>193</td>
<td>.04</td>
<td>* .05</td>
<td>.02</td>
<td>* .04</td>
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<tr>
<td>Food Avoidance (age 6)</td>
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<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>.83</td>
<td>175</td>
<td>.01</td>
<td>.44</td>
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<td>n/a</td>
</tr>
<tr>
<td>Model 2</td>
<td>3.17</td>
<td>174</td>
<td>.05</td>
<td>* .03</td>
<td>.04</td>
<td>** &lt; .01</td>
</tr>
<tr>
<td>Child BMI z-score (age 4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Model 1</td>
<td>2.87</td>
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<td>n/a</td>
</tr>
<tr>
<td>Model 2</td>
<td>2.43</td>
<td>257</td>
<td>.03</td>
<td>.07</td>
<td>.01</td>
<td>.22</td>
</tr>
<tr>
<td>Child BMI z-score (age 6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>.37</td>
<td>200</td>
<td>.004</td>
<td>.69</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Model 2</td>
<td>1.45</td>
<td>199</td>
<td>.02</td>
<td>.23</td>
<td>.02</td>
<td>.06</td>
</tr>
</tbody>
</table>

***p<.001; **p<.01; *p<.05

1 Model including SWM, and child gender as predictors
2 Model including SWM X gender interaction term in addition to predictors in Model 1
(B=.06, SE=.03, β=.23, t=2.16, p<.05), but not for males. The analysis was repeated, controlling for child birth size percentile, maternal BMI, maternal CES-D score, and maternal Emotional Eating on the DEBQ. The presence of a significant moderation effect of gender on the model was again detected, based on a significant F change value in Model 2 (F change [1,150]=4.74, R² change=.03, p<.05). The SWM X gender interaction remained significant (β=-.24, 95% CI=-.17 – -.01, p<.05), with females who made fewer errors on the SWM task scoring highly on Food Avoidance at age 4 (B=.08, SE=.03, β=.29, t=2.63, p=.01; see Figure 2). None of the covariates contributed a significant amount of variance to the model.

Figure 2  Gender interaction of CANTAB SWM Between-Search Errors at age 4 and CEBQ Food Avoidance factor scores at age 4

Child gender also emerged as a significant moderator of the relationship between SWM performance and Food Avoidance at age 6 (see Table 11). A significant two-way interaction between SWM errors and child gender (β=-.29, 95% CI=-.20 – -.03, p<.01) revealed that females (B=.08, SE=.03, β=.28, t=2.66, p<.01) who made a lower number of errors on the SWM task at age 4 scored highly on
Food Avoidance at age 6 (see Figure 3). The regression was repeated to control for child birth size percentile, maternal BMI, maternal CES-D score, and maternal DEBQ Emotional Eating. Gender remained a significant moderator in the model (F change[1,130]=5.86, $R^2$ change=.04, p<.05). However, the overall model obtained a trend level of significance (F[7]=2.00, p=.06). The SWM $\times$ gender interaction term remained significant ($\beta=-.28$, 95% CI=$-.22$ – -.02, p<.05), with females who made fewer errors on the SWM task at age 4 rated as highly Food Avoidant at age 6 ($B=.09$, SE=.03, $\beta=.30$, t=2.60, p=.01).

Figure 3  Gender interaction of CANTAB SWM Between-Search Errors at age 4 and CEBQ Food Avoidance factor scores at age 6
7.6.3. **Follow-up Analyses – Removal of Nested Data**

Due to the presence of siblings in the dataset, there was some concern regarding nesting of the CEBQ data. To explore whether this significantly impacted our results, the main analyses testing hypotheses 1-3 were repeated with the 48 younger siblings removed. The regression models between IST/SST and Food Approach and BMI z-scores at ages 4 and 6 were non-significant, as in the larger sample. Further, the significant moderation effect of gender remained between SWM errors and Food Avoidance at age 4 and 6, in females only. However, although this relationship persisted at age 4 after controlling for covariates in the larger sample, this was not the case in the first-born sample.

**Summary of Key Findings**

**Hypothesis 1:** Low response inhibition at age 4 did not significantly predict Food Approach behaviour or a high BMI z-score in girls at age 6.

**Hypothesis 2:** Risky/impulsive decision-making on a task utilizing an information sampling paradigm at age 4 did not significantly predict Food Approach behaviour or high BMI z-scores in girls at age 6.

**Hypothesis 3:** A high error rate on a task of spatial working memory at age 4 did not significantly predict Food Avoidance behaviour or a low BMI z-score at age 6. However, a low rate of errors on the SWM task at age 4 was associated with high Food Avoidance at both ages 4 and 6 in girls.
8. Discussion

8.1. General Discussion of Results

The aim of the present study was to investigate whether neuropsychological performance could predict the onset of ED correlates in preschool-aged children. Specifically, it was hypothesized that poor response inhibition and reward-based decision-making would predict Food Approach behaviour and high BMI z-scores in girls, while poor visuospatial abilities would predict Food Avoidance behaviour and low BMI z-scores, as depicted in Figure 1.

Taken as a whole, the results were not supportive of the study hypotheses. Specifically, preschool-aged children’s neuropsychological performance did not predict any of the eating behaviour outcomes or BMI z-scores at age 6. However, exploratory analyses investigating the potential role of gender moderation in Hypothesis 3 revealed that gender did significantly moderate the relationship between errors made on the SWM task at age 4 and Food Avoidance behaviour at age 6 in females. Two aspects of this finding may limit its overall impact however. Firstly, this relationship was also present at age 4, precluding any conclusions about causality. Furthermore, the direction of this association was not anticipated a priori. Previous studies have demonstrated poor (Andrés-Perpiña, Lozano-Serra et al. 2011, Phillipou, Gurvich et al. 2015) or comparable visuospatial performance (Fowler, Blackwell et al. 2006) in comparison to healthy controls. However, in our dataset we found that preschool-aged females who were rated highly on Food Avoidance behaviours demonstrated superior performance on the SWM task at both ages 4 and 6.

While the association in girls between better SWM performance at age 4 and Food Avoidance at age 6 was not anticipated, it is interesting to consider these findings in the context of prior literature. For example, individuals who engage in restrictive eating behaviours also tend to exhibit high levels of obsessive and perfectionistic traits (Strober 1980, Vitousek and Manke 1994, Bastiani, Rao et al. 1995, Shafran, Cooper et al. 2002, Franco-Paredes, Mancilla-Diaz et al. 2005, Treasure and Schmidt 2013, Lang, Lopez et al. 2014). Together, these characteristics could result in a more conscientious response style, resulting in a lower error rate. This is in line with the findings of Pieters and colleagues (2007), who demonstrated that patients with the restrictive subtype of AN scored significantly higher than controls on a subscale measuring “concern over mistakes”. These same
patients also made significantly fewer errors on a speeded task of choice-reaction, which the authors interpreted as indicative of a more “controlled” response style. In a study of healthy individuals, Cuttler and Graf (2007) found that higher levels of conscientiousness predicted better memory performance on two tasks of prospective memory, defined as the ability to remember to perform a planned action.

This excessive concern over perfect performance and the avoidance of mistakes provides some support for the Cognitive-Interpersonal Maintenance Model of AN, and its potential implications for AN development as well as perpetuation (Schmidt and Treasure 2006). For instance, consuming foods that are viewed as “forbidden”, or in some cases consuming anything at all, is viewed as an error or a failure, and causes extreme negative affect and distress. Schmidt and Treasure (2006) assert that this experience of negative emotions serves to reinforce the disordered eating behaviour, resulting in the individual experiencing terror over the possibility of making a mistake. In the present sample we have observed possible evidence of this type of concern over mistakes as early as age 4, prior to the onset of clinical ED symptoms. Therefore, these cognitions may represent a predisposing, as well as a perpetuating factor of restrictive eating behaviour. It should be noted that it is difficult to assess neuropsychological performance before the age of 4, and this has not yet been attempted with the CANTAB battery. Therefore, it may not yet be possible to delineate whether specific patterns of performance in the cognitive domains investigated in the present study precede early disordered eating, and later clinical ED development.

In the present study, only the easiest level of the SWM task (the 4 box level) was assessed, due to the young age of the participants. This may partially explain why a specific sub-group of children were able to exhibit such a low error rate, and why we did not observe the increase in errors that have been found by other researchers (Purcell, Maruff et al. 1998). Anecdotally, the children also seemed to enjoy this task more and were more engaged when completing it, despite the fact that it was the final test of the battery. It must be acknowledged that the superior performance displayed by females in our sample may simply be a reflection of the appealing nature of the SWM task. Performance on this task is also stable in 4-year-olds across ages 4, 5, and 6, as reflected by the ICC of 0.6 for the SWM errors. A possible reason for this may be that this task is a
sensitive measure of VSWM in preschool-aged children, and is tapping into this cognitive construct, which is reflected by the ability of females to perform well on this task.

Another possibility is that individuals who display obsessional traits, such as those who engage in restrictive eating behaviours such as pickiness, are uniquely suited to perform better on tests of memory due to their heightened conscientiousness. Moritz and colleagues (2009) demonstrated that the presumed memory deficits that are thought to underlie and precipitate OCD are not present in all cases, and may be more attributable to comorbid depression. For instance, OCD patients performed at the same level as healthy controls on tests of verbal, non-verbal, immediate, and delayed memory. The authors also suggest perfectionism as a potential moderator of memory and obsessive symptoms (Moritz, Kloss et al. 2009).

Significant positive associations have been observed between perfectionism and working memory performance, implying that possessing perfectionistic traits confers an advantage when attempting tasks requiring working memory capacity (Slade, Coppel et al. 2009). Patients with AN tend to exhibit high levels of perfectionism (Shafran, Cooper et al. 2002, Franco-Paredes, Mancilla-Diaz et al. 2005, Pieters, de Bruijn et al. 2007), along with greater attention to detail as a result of a bias toward local detail processing at the expense of a more global approach (Southgate, Tchanturia et al. 2008, Tenconi, Santonastaso et al. 2010, Rozenstein, Latzer et al. 2011, Harrison, Tchanturia et al. 2012, Roberts, Tchanturia et al. 2013). Together, these factors could account for the greater accuracy exhibited by food avoidant female children in our study.

Another explanation of the current findings is that female children who exhibit greater Food Avoidance are more sensitive to punishment, resulting in fewer errors on the task. A meta-analysis of sensitivity to reward and punishment in EDs found that individuals with AN exhibit greater harm avoidance than healthy controls (Harrison, O'Brien et al. 2010). In a study of decision-making in patients with EDs, Neveu and colleagues (2016) found that both AN patients with restricting and binge/purge subtype exhibited a higher aversion to losses than controls during a gambling task. The pattern of responses exhibited on the SWM task in the present study suggests a similar approach to the task by food avoidant females in our sample: these individuals were careful to avoid returning to a box in which a token had already been found. It is of note that a research assistant was present and monitored the child’s task completion during administration of the CANTAB. The presence of
this individual may have increased the desire of individuals who were especially harm-avoidant to prevent the possibility of punishment by making as few mistakes as possible.

This can be further understood in the context of Response Sensitivity Theory (Pickering, Diaz et al. 1995). The Behavioural Inhibition System controls, and in some cases allows the individual to avoid high levels of anxiety in situations in which punishment or the removal of a reward might be experienced (Carver and White 1994). A number of studies have demonstrated high levels of harm avoidance among female patients with AN (Brewerton, Hand et al. 1993, Klump, Bulik et al. 2000, Fassino, Abbate-Daga et al. 2002, Atiye, Miettunen et al. 2015, Tanaka, Yoshida et al. 2015). In addition, Schmidt and Treasure (2006), throughout years of clinical practice, have consistently observed that patients with AN typically adhere to rigid, self-imposed eating rituals and often distance themselves from friends and family. The authors assert that these behaviours all serve the purpose of avoiding the experience of negative emotions – feelings of failure in the former and the criticism of or conflict with others in the latter scenario. Several studies have confirmed this, reporting that female patients with AN feel positively about their AN symptoms, because they help them to suppress their emotions (Serpell, Teasdale et al. 2004, Espíndola and Blay 2009, Schoen, Lee et al. 2012).

The Behavioural Inhibition System may therefore play a role in the present results, inhibiting the division of attention during the SWM task in females and promoting enhanced accuracy, thereby allowing the individual to avoid the anticipated negative emotions or criticism that could be experienced following the commission of an error. This predisposition to harm avoidance extends to the child’s eating behaviour, resulting in a tendency to avoid food as well. This Food Avoidance is also linked to the experience of emotions, as evidenced by higher scores on Emotional Undereating in this group.

However, it must be taken into account that when the covariates were introduced into the model the significance of the effect on Food Avoidance at age 6 was reduced to a trend level, necessitating caution when making interpretations of these findings. In addition, because these associations were present at both age 4 and 6, it is not possible to determine whether this pattern of neuropsychological performance precedes the onset of Food Avoidance behaviours. Therefore,
based on the current findings, we cannot be certain that this response style on the SWM task represents a cognitive vulnerability to food avoidant behaviours.

We did not observe any significant associations between any of the CANTAB predictors and child BMI z-scores at either age 4 or 6. However, significant gender differences in BMI z-scores at age 4 were found, even after controlling for child birth size percentile, maternal BMI, maternal depression, and maternal Emotional Eating. Specifically, males tended to have higher BMI z-scores at age 4. This is in line with findings by Lundeen and colleagues (2016), who demonstrated that in boys, the incidence of overweight and obesity tended to be highest between the ages of 4-12, while girls were found to be heaviest between 11-15.

Maternal BMI was also significantly associated with child BMI z-scores at age 4. Maternal BMI has been found to be a strong predictor of child BMI in the literature. Johannsen and colleagues (Johannsen, Johannsen et al. 2006) found that when maternal BMI was added to a multiple regression, it eliminated previously found significant relationships between parental feeding attitudes and practices, and child BMI in 3-5-year-old children.

Significant associations between obesogenic eating behaviours and disruptions in response inhibition and decision-making have been reported in the literature (Rosval, Steiger et al. 2006, Groppe and Elsner 2014, Groppe and Elsner 2015). However, we were unable to demonstrate a significant relationship between these cognitive constructs and overeating outcomes (e.g. Food Approach and high BMI z-scores). This requires us to consider the possibility that neuropsychological impairment does not represent an endophenotype for development of disordered eating patterns characterized by overeating and binge eating.

In the present study, we did not assess depressive symptoms in our preschool-aged sample. However, several studies have demonstrated a relationship between negative affect and decision-making in individuals who engage in binge eating (Danner, Evers et al. 2013, Guillaume, Gorwood et al. 2015, Matsumoto, Hirano et al. 2015). Negative affect has also been hypothesized to play a role in the promotion of impulsive actions in individuals at-risk of developing bulimic behaviours, which is one of the factors thought to underlie the decision-making pattern exhibited by individuals who engage in bulimic-type behaviours (Lavender, Green et al. 2015).
important potential moderator of the relationship between decision-making, impulsivity, and eating behaviour, and should be taken into account in future investigations of these constructs.

The lack of significance observed between neuropsychological performance and the obesogenic outcomes could also be attributed to the chosen outcome measure for the study. The CEBQ may be insufficiently sensitive to the constructs at hand. At present, there are no studies in the literature investigating whether CEBQ subscale scores obtained at age 4 are predictive of later disordered eating and ED diagnoses. However, the correlations that were performed between the same subscales at age 4 and 6 are .50 or higher in the present study. In addition, coefficients of congruence performed between the factors obtained from the factor analysis of the CEBQ subscales at ages 4 and 6 indicate that the factors obtained at age 4 can be considered identical to those obtained at age 6. These findings partially mitigate any concerns about the reliability of measurements of eating behaviour obtained with the CEBQ.

Scores on the CEBQ subscales that are intended to detect facets of binge/overeating have been shown to increase with age in children, with these behaviours becoming more apparent by the age of 10 (Ashcroft, Semmler et al. 2008). This may have also contributed to why no significant relationships were detected between neuropsychological functioning and the Food Approach factor at age 6, which is comprised of these same overeating subscales (Food Responsiveness, Desire to Drink, and Emotional Overeating).

Another possibility is that the neuropsychological tests selected may not have been sufficiently sensitive to, or associated with the eating behaviours that we wished to predict. In a sample of females diagnosed with BN, Wolfe and colleagues (1994) did not find a significant relationship between impulsivity and frequency of binge eating episodes, purging, current body weight, or previous high body weight.

Further, some studies indicate that response inhibition and impulsivity (as measured by the SST and IST in the present study) may be more strongly associated with restrictive eating behaviours versus overeating. In a sample of patients diagnosed with either AN, BN, or EDNOS, Stulz and colleagues (2013) found a significant positive association between impulsivity and avoidance of fattening foods. The authors interpreted this counterintuitive finding as a potential precursor to, and catalyst of, the extreme rigid control that eventually becomes typical of AN, and could also help to
explain the high degree of diagnostic crossover between AN and BN. In addition, participants who scored highly on a measure of restrained eating were found to have significantly slower Stop Signal Reaction Times (indicating greater impulsivity) than those who did not endorse restrained eating (Nederkoorn, Van Eijs et al. 2004). In addition, restrained eaters scored significantly higher on a trait impulsiveness scale, and a measure of reward responsiveness, indicating not only the presence of an impairment in behavioural inhibition in individuals who display this eating style, but a difference in reward processing as well. In the present study we predicted that this response style would be more highly associated with Food Approach behaviour and high BMI z-scores. However, the SST may be a more appropriate predictor of future Food Avoidance behaviour.

Finally, although the neuropsychological tests chosen for the present study were selected based on their demonstrated appropriateness for use with this sample, the possibility exists that our sample was too young for these tests to accurately assess the constructs that they were designed for. Rose and colleagues (Rose, Frampton et al. 2014) caution that when administering a neuropsychological test to a population for which no norms exists (for instance, a very young pediatric population), we must develop a more thorough understanding of the developmental trajectory of the function we are testing prior to attempting to generalize and draw conclusions about clinical ED populations.

8.2. Limitations

There are a number of limitations in the current study. As mentioned previously, the sample for the present study was taken from a large, longitudinal study called the MAVAN project. The MAVAN sample is largely Caucasian, limiting its generalizability (O'Donnell, Gaudreau et al. 2014). In addition, a great number of measures are administered in the larger project, beyond what has been discussed in the present study. Unfortunately, this has contributed to a high attrition rate for this project and subsequently, a significant amount of missing data (O'Donnell, Gaudreau et al. 2014). This is most apparent for the more taxing measures, or those that require an in-person study visit. Approximately 27% of the Food Approach and Food Avoidance factor scores were missing at age 4, and approximately 34% were missing at age 6. Based on observations of the raw data, the primary
reason for the relatively high frequency of missing data on this measure appeared to be the way it was presented to the mothers. The CEBQ was double-sided, and presented as a single sheet of paper to the mothers. Some mothers failed to turn the page over, and thus did not complete half of the questions for this measure. When missing data was detected, efforts were made by research assistants to follow-up with mothers by phone and obtain responses to missing items within a reasonable amount of time after their study visit. However, this was not possible in all cases.

A global baseline measure of intellectual functioning was not obtained in the present study due to limited resources. Therefore, we were unable to control for a general deficit in cognitive functioning versus specific impairments in the cognitive domains of interest.

In the present study we were unable to measure set-shifting in our sample. Assessment of the ICC of the IED, a measure of cognitive flexibility and set-shifting in the CANTAB battery, revealed poor stability over 3 separate measurements taken between ages 4 and 6. Therefore, it was concluded that this measure may not be measuring the construct that it purported to measure in adults, potentially due to the young age of our sample. However, impaired set-shifting has been repeatedly associated with restrictive eating behaviours, both theoretically and in the laboratory (Tchanturia, Anderluh et al. 2004, Schmidt and Treasure 2006, Treasure and Schmidt 2013). This cognitive inflexibility is manifest in the resistance that AN patients display in admitting the detrimental effect their restricted food intake is having, instead often insisting on the benefits of their emaciated physique (Schmidt and Treasure 2006). However, it is unclear whether this cognitive construct is sufficiently developed in preschool-aged children to allow for accurate assessment of its impact on eating behaviours (Luciana and Nelson 2002). Nevertheless, it is an important aspect of neuropsychological functioning and the role it plays in disordered eating warrants further assessment with age-appropriate measures.

Finally, in the present study one of the main outcome measures was the CEBQ, which relies on the mother’s self-report. This measure is therefore limited to only the eating behaviour that the child engages in in the mother’s presence (Carnell and Wardle 2007). In addition, self-report measures are highly susceptible to socially-desirable responding. This is especially relevant for a measure like the CEBQ, which contains items that might raise sensitive issues, and be perceived by the mother to reflect poorly on her feeding or parenting practices. For instance, low SES women are
more likely to view Emotional Overeating as a negatively stigmatized behaviour that results from neglect or abuse (Hayman, Lee et al. 2014). Due to these negative perceptions, mothers (especially those of a low SES background) might be more likely to misrepresent or under-report behaviours related to Emotional Overeating in their children. Although the majority of our sample was above the Canadian low income cut off, 8.8% were classified as low income. This raises the possibility that negative stigmatization of Emotional Overeating may have impacted maternal ratings of eating behaviour for these individuals. In fact, in the present study many mothers did not provide a response for the item “Do you have the desire to eat when somebody lets you down?” on the DEBQ, which is a component of the Emotional Eating subscale. The high number of individuals who left this item blank indicates that this may not be a random occurrence, and it is possible that the mothers in the present study did not wish to endorse these types of behaviours. This could reflect a negative stigmatization associated with Emotional Eating, and may have impacted the reports that these mothers gave on behalf of their children concerning these same behaviours.

The opposite reporting pattern might be evident in mothers with EDs. Four-year-old children of mothers with a history of AN scored highly on a mother-report measure of Emotional Overeating (de Barse, Tharner et al. 2015). This finding may reflect an effect of maternal EDs on the development of disordered eating patterns in their offspring. However, another possibility is that mothers who engage in disordered eating are more likely to perceive problems with their child’s eating behaviour. Although none of the mothers in the present study endorsed an acute ED at the time of assessment, approximately 15% of the mothers scored above the 95th percentile on the Emotional Eating subscale of the DEBQ, and therefore might be more likely to perceive problem eating behaviours in their children.

Regardless of the reason for misrepresentation in parent ratings, several studies have demonstrated discrepancies between parent and child/adolescent reports of both ED symptoms and eating behaviours. Poor to moderate inter-rater agreement was found between a sample of 8-18-year-olds and their parents on a self-report assessment of ED pathology (Mariano, Watson et al. 2013). For binge eating in particular, poor agreement between youth and parent reports have been consistently reported in community samples (Johnson, Grieve et al. 1999, Steinberg, Tanofsky-Kraff et al. 2004, Tanofsky-Kraff, Yanovski et al. 2005). Parents and children also differ on their ratings of
Food Responsiveness and Emotional Eating on self-report measures of eating behaviour (Braet, Soetens et al. 2007). Parents tended to rate their children (aged 7-15) as having higher levels of Food Responsiveness and Emotional Eating than the children report. Further, convergence between parent and child ratings were lowest among the youngest members of the sample (7-9-year-olds; Braet, Soetens et al. 2007). van Strien and Oosterveld (2008) found that Emotional Eating was very infrequently endorsed in their sample of 7-12-year-old children, and that this age group may have the more biologically appropriate reaction of reducing their food intake in response to a stressor. They further suggested that Emotional Eating begins later in life.

Despite the various limitations associated with relying on maternal report outcome measures, it could be argued that one of the strengths of this type of measure is that it provides a more dimensional approach to measuring disordered eating behaviour. At present, the frequency of ED diagnoses based on currently accepted diagnostic criteria in pediatric populations is low (Nicholls, Chater et al. 2000, Peebles, Wilson et al. 2006, Madden, Morris et al. 2009, Walker, Watson et al. 2014, Kurz, van Dyck et al. 2015), and is associated with numerous challenges (Rosen 2003, Bravender, Bryant-Waugh et al. 2010, Lafrance Robinson, Boachie et al. 2013, Girz, Robinson et al. 2014). In contrast, a dimensional approach to EDs and dysregulated eating behaviours is more in line with current trends in psychiatric research, and arguably more appropriate when assessing pediatric samples. This has also been called for in the adult literature (Brooks, Rask-Andersen et al. 2012). The National Institute of Mental Health has proposed the Research Domain Criteria (RDoC; http://www.nimh.nih.gov/research-priorities/rdoc/index.shtml) for this purpose. RDoC allows the researcher to consider several possible contributing dimensions from genetics to self-report when assessing a psychiatric disorder of interest. Further, it allows for individuals to be placed along a continuum of behaviour, from normal to abnormal. In this way, RDoC allows for a richer and more robust investigation and understanding of a particular disorder. While we did not follow a strictly RDoC approach in the present study, by assessing various eating behaviours associated with the extremes of overeating and restriction, the current work is in line with the goals of assessing underlying dimensions of disorders rather than limiting outcomes to mutually exclusive diagnostic categories.
Further support for applying this type of approach comes from Wagner and colleagues (2006) who, through latent class analysis, identified two different clusters of women recovered from EDs. One cluster was characterized by high inhibition, harm avoidance, and state anxiety, while women in the other cluster were dysregulated and displayed high impulsivity. Women in both clusters displayed anxiety and obsessionality. This highlights the high degree of overlap and shared characteristics of discrete ED diagnostic categories, and provides a basis for the use of a more dimensional approach. In addition, the authors noted that the clusters were independent of DSM diagnoses, which has been found in other studies (Clinton, Button et al. 2004, Krug, Root et al. 2011).

To date, few studies of EDs have been carried out that adhere to an RDoC framework. However, several reviews have been undertaken which identify links between several RDoC dimensions and ED phenotypes. For example, Vannucci and colleagues (2015) found support for the contributory role of the RDoC Negative Valence System to binge eating. The Negative Valence System is made up of 5 constructs/subconstructs: acute threat (“fear”), potential threat (“anxiety”), sustained threat, loss, and frustrative nonreward (NIMH 2011). In their model, negative affect, which is theorized to precede and drive episodes of binge eating, is thought to interact with corticolimbic functioning and neuroendocrine dysregulation when a stressor is encountered (Vannucci, Nelson et al. 2015).

Caglar-Nazali and colleagues (2014) conducted an extensive review of the literature in support of the role of the Social Processes domain of RDoC in the development and maintenance of EDs. This domain includes the constructs of affiliation and attachment, social communication, perception and understanding of self, and perception and understanding of others (NIMH 2011), which are areas that have been implicated in clinical accounts of ED patients, as well as in studies of the etiology of disordered eating. The authors identified several areas of this domain in which individuals with EDs showed abnormality, including impaired facial emotion recognition, increased facial avoidance, high negative self-evaluation, poor emotion identification and expression (alexithymia), and poor understanding of the mental states of others (theory of mind). In addition, people with EDs tend to experience dysregulation in their interactions with family members, reporting attachment insecurity, low perceived parental care, and high parental overprotection (Caglar-Nazali, Corfield et al. 2014), which has been echoed in many clinical accounts of ED patients.
These reviews highlight some recurring themes in the ED literature, while simultaneously emphasizing the complexity inherent in delineating what is a risk factor, and what is a perpetuating factor when it comes to disordered eating. It is precisely this complexity which necessitates the use of an RDoC-based framework when approaching psychiatric disorders which possess such a high degree of overlap, as well as frequent comorbidity, as the EDs do. Further, it would allow for the testing of theories of ED development and maintenance, such as the previously mentioned Cognitive-Interpersonal Maintenance Model of AN, which makes mention of many of the RDoC subconstructs that are purported to contribute to ED phenomenology.

8.3. Future Directions

In order to strengthen the conclusions of the present study, future studies will need to confirm these findings in a larger sample. Future researchers may also benefit from studying a slightly older sample (e.g. age 7) in order to include measures of other relevant cognitive domains which fully develop later in life, such as set-shifting. Further, it must be determined whether this effect is specific to working memory, or if the task selected for the presented study (the SWM) is tapping into some other domain that is responsible for the significant relationship that has been observed, such as motivation. Future work should include memory tasks that involve a delayed recall component, which rely less on motivation for successful performance.

Central coherence was not measured in the present study, but is another important neuropsychological function which has been strongly associated with restrictive EDs in the literature (Tenconi, Santonastaso et al. 2010, Rozenstein, Latzer et al. 2011, Harrison, Tchanturia et al. 2012, Roberts, Tchanturia et al. 2013). However, this may be another cognitive domain that is not yet fully developed at age 4, and requires a sample of slightly older children in order to accurately assess its impact on disordered eating development. Martens and colleagues (2014) found that 5-year-olds utilize more of a local approach when solving the Rey-Osterrieth Complex Figure, while 7-year-olds applied a more global approach, indicating that this cognitive skill might be underdeveloped at this young age, and does not necessarily reflect the presence of an ED-related impairment.
Another domain that would be of particular interest for future research is emotion recognition and regulation. It has been suggested that ED symptoms may be a coping mechanism invoked to manage aversive or intense emotions (Fairburn, Cooper et al. 2003). In addition, the expectation that engaging in disordered eating behaviours will alleviate negative emotions may constitute a risk factor for BN (Hayaki 2009). Emotion dysregulation has also been implicated in non-ED samples who exhibit abnormal eating patterns, such as obese individuals (Görlach, Kohlmann et al. 2016). Bruch (1962) has suggested that the main deficit present in individuals with EDs is an inability to accurately recognize their emotional states and a tendency to give very limited descriptions of these states, which are behaviours that are consistent with alexithymia. Alexithymia is characterized by difficulty in identifying and expressing emotions, coupled with a failure to distinguish emotions from bodily sensations (Sifneos 1973). Individuals with EDs have been found to exhibit higher levels of alexithymia than healthy controls (Cochrane, Brewerton et al. 1993, Courty, Godart et al. 2015, Matsumoto, Hirano et al. 2015). Similar patterns have been found in non-clinical samples who exhibit disordered eating attitudes and behaviours (Berger, Elliott et al. 2014, Alpaslan, Soylu et al. 2015). Alexithymia has also been proposed to underlie EDs using the RDoC framework (Caglar-Nazali, Corfield et al. 2014). Although strictly defined alexithymia might be difficult to assess in preschool-aged children, future studies may benefit from the inclusion of a measure of emotion dysregulation to obtain a more comprehensive picture of cognitive risk for disordered eating.

Another domain that warrants further investigation is sensitivity to punishment and reward. Given the potential role for harm avoidance in EDs characterized by restriction (Brewerton, Hand et al. 1993, Klump, Bulik et al. 2000, Fassino, Abbate-Daga et al. 2002, Atiye, Miettunen et al. 2015, Tanaka, Yoshida et al. 2015), as well as the sensitivity to reward displayed by those who engage in overeating and bingeing behaviours (Farmer, Nash et al. 2001, Boeka and Lokken 2006, van den Berg, Pieterse et al. 2011), these two constructs represent important potential moderators in the relationship between neuropsychological functioning and disordered eating. Inclusion of these variables would allow for the assessment of the mechanisms of ED development suggested by Response Sensitivity Theory, as well as clarify whether sensitivity to punishment is associated with the greater accuracy on the SWM evidenced by food avoidant females in our sample.
As noted above, one of the limitations of the present study was the reliance on maternal reports of eating behaviour. Future studies may benefit from including a laboratory taste test to supplement parental reports and provide a direct measure of the child’s food choices and intake patterns. External Eating as measured by the DEBQ, which is analogous to the CEBQ construct of Food Responsiveness and is an aspect of Food Approach, has been found to mediate the relationship between impulsivity and unhealthy food intake (Kakoschke, Kemps et al. 2015). Although good validity has been demonstrated between the Satiety Responsiveness, Food Enjoyment, and Food Responsiveness subscales of the CEBQ and multiple laboratory-based behavioural measures of eating, the inclusion of both measures would allow for the consideration of input from both the mother and child regarding the child’s eating behaviours (Carnell and Wardle 2007). In addition, while the CEBQ provides an idea of the child’s typical eating behaviours over a period of time, through a laboratory-based eating paradigm one can obtain an objective snapshot of the child’s actual food preferences and consumption. Inclusion of both types of measures would also overcome some of the limitations associated with eating behaviour research. Namely, many studies rely on a single measure of eating behaviour in order to test their hypotheses, which is usually a laboratory-based eating paradigm (Carnell and Wardle 2007). However, because this is a state versus a trait measure, the primary outcome of interest is highly susceptible to the many variables that could impact the individual’s behaviour on the testing day. Epstein (1983) suggested that different behavioural measures could actually be tapping into specific latent variables assessed by a single self- or other-report. As a result, he advocated for the use of behavioural measures to supplement psychometric measures of behaviour. Investigating the interaction between maternal reports and actual behaviour may provide a more robust picture of disordered eating in preschool-aged children.

Finally, we did not include a traditional diagnostic interview to assess for EDs in the child sample in the present study. This was excluded in part because EDs are difficult to detect using traditional methods in preschool-aged children for a number of reasons (Jaffe and Singer 1989, Bryant-Waugh and Lask 1995, Nicholls, Chater et al. 2000, Rosen 2003, Madden, Morris et al. 2009, Bravender, Bryant-Waugh et al. 2010, Walker, Watson et al. 2014). However, because this is a longitudinal study, one of the advantages of such a design is that it is possible to assess whether these children eventually develop ED symptoms which meet diagnostic criteria at an older age. Food
Avoidance, as it has been conceptualized in the present study, may represent a precursor to more serious pediatric EDs, such as ARFID or Food Avoidance Emotional Disorder. The presence of low Food Enjoyment and Food Fussiness, as measured by the CEBQ, is in line with the typical eating-related presentations of ARFID, which include lack of interest in eating/food, or restriction of intake due to an aversion to some property of the food (Kurz, van Dyck et al. 2015). However, it is unknown whether this sample also experienced the associated weight loss, nutritional deficiency, or interference with psychosocial functioning, as these factors were not measured. Interestingly, a recent study found that 12% of their sample of adolescents originally diagnosed with ARFID transitioned to AN (Norris, Robinson et al. 2014). As this is a fairly recent addition to the DSM, further work will have to be conducted to confirm whether this pattern is replicable. Therefore, an additional area for future consideration is the inclusion of a diagnostic interview, such as the Structured Clinical Interview for DSM-5 (First, Williams et al. 2015), or the Eating Disorder Examination Interview (Cooper and Fairburn 1987), which are designed to probe a number of ED symptoms in detail. Such a measure could be undertaken at an age when what are considered to be the core symptoms of EDs (e.g. overvaluation of body weight/shape and fear of fatness) become more obvious and can be verbalized, such as adolescence.

8.4. Conclusions

Taken as a whole, the results of the present study did not support our hypotheses. However, the finding that females who made fewer errors on the CANTAB SWM task at age 4 were rated as more food avoidant at ages 4 and 6 was interesting and unexpected. This is reminiscent of a large body of literature linking perfectionism and obsessive traits to disordered eating. A perfectionistic and overly cautious cognitive style may play a role in perpetuating aspects of Food Avoidance such as pickiness and emotional undereating, which may represent an intermediate phenotype of EDs. Future work should attempt to replicate this finding in females, as it may represent a potential target for clinical intervention.
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