Running head: A DEVELOPMENTAL STUDY OF NORMATIVE RITUALISTIC

A Developmental Study of Normative Ritualistic and Compulsive Behaviour in Elementary School Children

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Abstract

The high prevalence of compulsive-like behaviours in normal childhood suggests that these behaviours may play an important role in development. Furthermore, the similarities between the typical compulsive behaviours of childhood and the clinically significant behaviours that characterise Obsessive Compulsive Disorder (OCD) suggest that these two phenotypes may share similar neuropsychological profiles. In this study, two theories are investigated; one, that the neuropsychological deficits attributed to the pathogenesis of OCD also play a role in the manifestation of typical compulsive behaviours of childhood. Two, that compulsive behaviour supports the advancement of adaptive behaviour.

The participants were 48 elementary school children (19 males) between the ages of 72 and 152 months ($M = 106.5$, $SD = 24.49$). Parents rated the frequency of typical compulsive behaviour on the Childhood Routines Inventory (CRI; Evans et al., 1997). Adaptive behaviour was assessed with the Vineland Adaptive Behavior Scales – Survey Form (VABS; Sparrow, Balla, & Cicchetti, 1984). The measure of set shifting was the manual 64-card version of the Wisconsin Card Sort Task (WCST; Kongs, Thompson, Iverson, & Heaton, 1981). Response inhibition was tested with the Conners' Continuous Performance Test (CPT; Conners, 2000) and the Tapping Test (Diamond & Taylor, 1996). Stepwise multiple regressions were performed to examine the relationships amongst variables of interest. The participants were later divided into three groups (seven years and younger, seven to ten years, ten years and older) to examine relationships by age. Adaptive behaviour and response inhibition were predictive of levels of typical compulsive behaviour across the age range. Together, coping skills and play and leisure skills as assessed on the VABS emerged as the most important predictors of the repetitive compulsive behaviours.

Response latency on the tapping task was the strongest predictor of increased levels of just right compulsive behaviour. Set shifting did not predict levels of compulsive behaviour although positive correlations were found in the youngest group. Overall, the data support the notions that clinical OCD and the typical compulsive and ritualistic behaviour of childhood share similar neuropsychological profiles, and that compulsive behaviour in childhood supports the development of increasingly advanced adaptive behaviour.

Résumé

Cette étude avait pour but d'examiner deux théories des rituels chez les enfants. La première théorie stipule que les déficits neuropsychologiques attribués à la pathogénie du Trouble Obsessionnel Compulsif (TOC) jouent un rôle dans la manifestation des rituels développementaux. La deuxième théorie suggère que les rituels chez les enfants contribuent au développement des comportements adaptatifs.

Quarante-huit enfants (19 mâles) âgés de 72 à 152 mois (*M*=106.5, *SD*=24.49) participèrent à cette étude. Les parents ont complété le "Childhood Rountines Inventory" (CRI; Evans et al., 1997) pour évaluer la fréquence des rituels développementaux. Le comportement adaptatif a été évalué à l'aide du "Vineland Adaptive Behavior Scales – Survey Form" (VABS; Sparrow, Balla, & Cicchetti, 1984). Le "Wisconsin Card Sorting Task" version manuelle à 64 cartes (WCST; Kongs, Thompson, Iverson, Et Heaton, 1981) a été utilisé pour évaluer la flexibilité cognitive. L'inhibition du comportement a été examinée avec le "Conners' Continuous Perfromance Task" (CPT; Conners, 2000) et le "Tapping Test" (Diamond & Taylor, 1996). Des régressions multiples par étapes ont été effectuées pour identifier les relations entre les variables. De plus, les participants ont été assignés à un des trois groupe d'âge (7 ans et moins; 7 à 10 ans; 10 ans et plus) pour examiner les modèles de régression en fonction du groupe d'âge.

Les comportements adaptatifs et les capacités d'inhibition ont prédit la fréquence des rituels développementaux dans les trois groupes d'âge. Ensemble, les compétences d'adaptation et les compétences de jeu et de loisirs tel qu'évaluées par le VABS ont émergé en tant que facteurs de prédiction les plus importants des rituels de répétitions. Tandis que la latence de réponse au "Tapping Test" était le facteur qui a prédit le mieux les taux de rituels de vérifications. La flexibilité cognitive ne semblait pas prédire les rituels développementaux bien que des corrélations positives ont été identifiées chez les enfants de 7 ans et moins. Généralement, les données soutiennent la notion que le TOC et les rituels développementaux partagent un profile neuropsychologique semblable, et que les rituels chez les enfants contribuent au développement des comportements adaptatifs plus complexes.

A Developmental Study of Normative Ritualistic and Compulsive Behaviour in Elementary School Children

Typically developing children often perform compulsive-like behaviours as part of normal development (Evans et al., 1997). For example, children may repeatedly arrange their stuffed animals on their bed until they are placed in a precise pattern or kiss them goodnight in a specific order, only to repeat the entire process until they feel it is done in just the right way. At mealtimes, many children eat in a circumscribed way, as they may only eat foods of a specific colour or in particular combinations. These childhood idiosyncrasies are observed in various cultures and emerge in a set pattern with minimal deviation in their age of onset (Evans et al., 1997; Zohar & Felz, 2001). The high prevalence of this aspect of childhood behaviour suggests that these behaviours may play an important role in development.

Gesell (1928) proposed that the typical compulsive behaviours of childhood serve an adaptive role. He described children's use of ritualistic and repetitive behaviours as a way to acquire and master the adaptive skills of early childhood such as toileting, feeding, and self-regulation. However, this notion is not consistently supported by empirical research. For example, Evans and Gray (2000) reported no relation between adaptive and typical compulsive behaviour in children aged two to four years. This finding was inconsistent with Evans and Gray's prediction that compulsive behaviours at this peak time of occurrence in the preschool years would be associated with adaptive behaviour. Another finding that was not anticipated by Evans and Gray was that more advanced adaptive behaviour was positively related to more frequent and intense normative compulsive behaviour among children between the ages of five to seven years. This positive relation between adaptive and compulsive behaviours was unexpected as compulsive and ritualistic behaviours are thought to be too restrictive to be adaptive in older children who require more flexibility to navigate their increasingly complex daily life. The relationship between compulsive-like and adaptive behaviour warrants further investigation in order to resolve the conflict between these unanticipated findings and the longstanding theory of the role of compulsive-like behaviour in development.

Neuropsychology and Typical Compulsivity

Adaptive behaviour is likely only one of a host of variables that may help inform the understanding of the presentation of normative compulsive behaviour in children. For example, brain development and neuropsychological functioning may be related to the typical compulsive behaviours in early childhood. During the preschool years, children often experience difficulties in inhibiting impulsive behaviour (Dowsett & Livesey, 2000), a clear indication that the areas of the brain responsible for behavioural control are not yet fully mature (Diamond, 1988; Diamond & Taylor, 1996). This immaturity may manifest itself in increased levels of compulsive and ritualistic behaviour as the neuropsychological and neurobiological restraints used to stymie this behaviour are not yet fully developed. Difficulties with suppressing impulsive behaviour are also central to the manifestation of Obsessive Compulsive Disorder (OCD), the clinically significant incarnation of compulsive and ritualistic behaviours. The striking similarities between the typical compulsive behaviours of childhood and the behaviours that characterise OCD suggest that these two phenotypes may share similar neuropsychological profiles.

The neuropsychological and neurobiological accounts of pathogenesis in individuals with OCD are supported empirically (for reviews, see Tallis, 1997; Whiteside, Port, & Abramowitz, 2004), and generally serve as the dominant explanatory paradigms for OCD

(Schultz, Evans, & Wolff, 1999). Within the neuropsychological theory of OCD, two executive functions, response inhibition and set shifting, are thought to be responsible for the ability to suppress compulsions and transfer focus away from an obsession – the core aspects of OCD. In order to illuminate whether the typical compulsive behaviours of childhood and the clinically significant behaviours in OCD share the same neurological underpinnings, the neuropsychological framework of OCD has been applied in the study of typical childhood compulsive behaviours, with inconsistent results. In particular, among children aged six to eight years, difficulties on tasks of response inhibition and set shifting are not consistently related to increased levels of typical compulsive behaviours as would be predicted by the neuropsychological framework of OCD (see Evans, Lewis, & Iobst, 2004; Pietrefesa & Evans, in press). By delineating the neuropsychological correlates of the typical compulsive behaviours of childhood we may be able to elucidate whether the typical behaviours of childhood can be attributed to the same areas of the brain that are thought to be central in OCD. Confirmation that normal and clinically significant behaviours are associated with the same neuropsychology, and by extrapolation, the same neurobiology, is key to understanding the continuum of normality and pathology and may help inform the divide between these two phenotypes, as well as lead to improved diagnostic and treatment capabilities.

Goals of the Present Study

In the present study, the relationship between the typical compulsive behaviours of childhood, adaptive behaviour, and neuropsychological functioning are examined. Two theories are investigated; one, that the neuropsychological deficits attributed to the pathogenesis of OCD also play a role in the manifestation of typical compulsive behaviours of childhood. Two, that compulsive behaviour supports the advancement of adaptive behaviour. To date, research conducted on these two theories has resulted in discordant findings and these discrepancies are addressed via three main goals. One goal is to assess whether difficulties on tasks of executive function are related to increased compulsive behaviours in children aged six until twelve years. The second goal is to determine if the skills of adaptive behaviour, such as coping skills or self-care abilities, are related to compulsive-like behaviours in elementary school aged children. The third aim of this study is to evaluate the predictive relationship between neuropsychology and compulsive-like behaviour and inform the conceptualisation of the shared neuropsychological profiles between normality and pathology.

A Framework for the Study of the Continuity Between Normality and Pathology

The notion of a continuum between typical development and psychopathology is central to the examination of compulsive-like behaviour in this study. Current knowledge from one end of the continuum, the framework of neuropsychological deficits in OCD, is applied to the study of typical compulsive-like behaviours. Likewise, elements from the typical end of development, adaptive behaviour, are also examined in relation to the normative compulsive behaviours of childhood. Aspects from both normality and pathology are thus combined and examined with the aim of informing both ends of this continuum. The concept of a continuum is central in developmental psychopathology – the theoretical framework for this study. The principal theoretical underpinning of developmental psychopathology is that psychopathology is best understood within the context of normal development and that the disciplines of pathology and normal development are mutually informative (Cicchetti, 1984). Within this framework, developmentalists argue against the "disease entity" approach to psychiatric diagnoses in which pathological states are viewed as wholly distinct from the process of normal development and behaviour. For example, Werner (1948) argued that the organism-environment interactions of persons with schizophrenia share common features of the organism-environment interactions of typically developing young children thereby highlighting the shared developmental influences of pathology and normality. In this study, consistent with the framework of developmental psychopathology, the typical compulsions and rituals of children are examined as occupying one end of the continuum - with the full blown, clinically significant obsessions and compulsions that are present in OCD occupying the other end. By framing these behaviours in this way, the mutual influences affecting OCD and typical compulsive-like behaviour are highlighted. The overarching objective is to understand what aspects of normal development can teach us about both the typical and clinical presentations of compulsive behaviour.

One End of the Continuum: Obsessive Compulsive Disorder

At the extreme end along the continuum of ritualistic and compulsive behaviour lies obsessive-compulsive disorder (OCD). OCD is an anxiety disorder that is characterised by time consuming (e.g., more than one hour per day) and recurrent obsessions and compulsions. Central diagnostic criteria for OCD are the experience of marked distress in the individual and significant impairment to daily life due to the obsessions and compulsions (American Psychiatric Association [APA], 2000). OCD is characterized by *obsessions* that are persistent and intrusive ideas, thoughts, or impulses that cause anxiety and are experienced as both inappropriate and disturbing (APA, 2000). Examples of common obsessions include fear of contamination by germs, worry about having left the stove on, and arranging objects symmetrically (Attiullah, Eisen, & Rasmussen, 2000). The individuals who experience these obsessions are cognisant that their thoughts come from their own mind and are not the product of thought insertion (APA, 2000).

Compulsions are repetitive behaviours or mental acts that are aimed at reducing or preventing anxiety or distress (APA, 2000). Compulsions may consist of elaborate routines, such as tapping specified objects in a certain order, hand washing, arranging objects in a certain manner, or repeating a phrase to oneself (APA, 2000). Individuals with compulsions often feel driven to perform the compulsive behaviour to reduce the distress that accompanies a particular obsession or to prevent an unwanted or feared event (Insel, 1990; March & Leonard, 1996). For example, hand washing typically follows an obsessive thought of contamination (Evans & Leckman, 2006). Other compulsions are not as clearly related to an obsession, such as ordering objects in a specific way as a response to an obsession that a family member is going to die in a tragic accident. These types of compulsions may require magical thinking to sustain the connection between the thought and behaviour (Evans, Milanak, Medeiros, & Ross, 2002). Although afflicted individuals recognise that their obsessions or compulsions are unreasonable, they persist nonetheless.

In adults, the onset of OCD is linked to the occurrence of increased uncontrollable life events. For example, the incidence of OCD is often related to illness and bereavement in the months prior to onset (Khanna, Rajendra, & Channabasavanna, 1988; McKeon, Roa, & Mann, 1984) as well as pregnancy and the postpartum period (Lo, 1967; Maina, Albert, Bogetto, Vaschetto, & Ravizza, 2000; Neziroglu, Anemone, & Yaryura-Tobias, 1992). The current prevalence rates of OCD range from .3% to 2.5% in adults (Samuels & Nestadt, 1997) and from 2 to 4% in paediatric populations (Geller, 2006) with similar frequencies found in various countries (Weissman et al., 1994). Modal age at onset for males is between 6 and 15 years and between 20 and 29 years for females (APA, 2000) with approximately equal distribution of OCD across gender in adults (Zohar, 1999). Variants of the behaviours noted in OCD are also present in typical populations. The obsessive and compulsive behaviours of typically developing individuals were first examined in adults with the aim of clarifying the similarities between the two phenotypes so as to better understand the experience of typical adults and what might define the divide between normality and pathology.

The Typical End of the Continuum: The Obsessions and Compulsions of Normal Development

In the early stages of OCD research, when theories of causality regarding the appearance of obsessions were forwarded, a continuity between pathology and normality was assumed. Rachman (1971) supposed that healthy adults experienced obsessions that were akin to those experienced by individuals with OCD. Rachman and de Silva (1978) investigated this assumption and attempted to identify what, if anything, differed about the obsessions experienced by typical adults and those reported by individuals with OCD. Accordingly, they examined the obsessions of 124 typically developing adults drawn from a university population (mean age = 27.7 years) and found that the majority of the group admitted to the presence of intrusive and unacceptable thoughts and impulses. In a second more detailed stage of this study, the obsessions of 40 individuals from the original sample were compared to those of eight obsessional patients. The obsessional patients were individuals seeking psychiatric treatment for obsessions but were not diagnosed with OCD. The obsessions of both groups were found to be similar in form (whether the obsession was a thought or impulse), in their expressed relationship to mood (more depression led to more frequent obsessions and greater discomfort), and meaningfulness to the individual. The main difference was that obsessional patients were more likely to experience multiple obsessions that lasted longer, were more intense and frequent, and led to more discomfort than the typical adults. Using the same questionnaire as Rachman and de Silva, Salkovskis and Harrison (1984) found that normal obsessions were common and reported by 88% of a non-clinical sample of 178 individuals (mean age = 23.8 years). In these typical adults, discomfort due to obsessions was related to how easily the obsession was dismissed rather than the type or frequency of the obsession. Consistent with earlier findings, Freeston, Ladouceur, Thibodeau, and Gagnon (1991) detailed the frequency of obsessions in the lives of healthy adults and found that the vast majority of a sample of university students (N = 125) admitted that they experienced cognitive intrusions in their daily lives.

The research into the obsessions of typical adults was expanded to investigate whether compulsions were also frequent and, like obsessions, similar to those experienced by individuals with OCD. Muris, Merckelbach, and Clavan (1997) found that more than half of a group of 150 college students and campus staff (mean age = 24.7 years) experienced compulsions. In order to assess whether the compulsions of the typical adults differed from the compulsions of those with OCD, the compulsions of a typical group of 82 adults (mean age = 24.7 years) and of a group of 38 patients with OCD (mean age = 33.0 years) were reviewed by a panel of psychologists and psychotherapists. The panel was unable to distinguish between the compulsions produced by the two groups. However, when the compulsions were rated by the judges - who remained blind to clinical status - the clinical compulsions were found to be more frequent, intense, and related to negative mood and frequently involved rituals such as hand washing. Typical compulsions were more frequently related to magical and protective behaviours. Therefore, both the obsessions and compulsions that characterize OCD are also seen in healthy, typical adults. The primary difference is that non-clinical obsessions and compulsions are generally less frequent and intense, of shorter duration, are less varied, and cause less discomfort. Although the frequencies of obsessions and compulsions in adults are often noted, these behaviours are less well understood in childhood. Knowledge about the genesis of typical compulsive-like behaviour is imperative to understand the entire continuum of typical and pathological compulsive behaviours.

Normative Compulsive Behaviour in Childhood

The typical compulsive-like behaviour of childhood is very similar to the behaviour of children and adults diagnosed with OCD. These typical behaviours are discriminated from clinically significant ones by considering timing of onset, content of compulsions, and severity (Leonard, Goldberger, Rapoport, Cheslow, & Swedo, 1990). Children's typical compulsive behaviours are seen in their preferences for symmetry (e.g., insisting that their socks be pulled up to the same spot on their legs) and wholeness (e.g., refusal to eat a broken cookie) and in their heightened sensory sensitivities for shade of colour, texture, taste (Evans et al., 1997). These subtle preferences are often manifested in the way children set out particular requirements for their environment. These requirements may be so strict and imperceptible that they frustrate caregivers – especially novel caregivers who may be unaware of the exact specifications (Evans & Gray, 2000). These specifications - for example that a particular story be recounted with the exact voice and intonation - are common childhood quirks that bear close similarity to the sensory perceptual stipulations exacted by those with OCD on their environments (Evans, Gray, & Leckman, 1999; Leckman, Walker, Goodman, Pauls, & Cohen, 1994). The high prevalence of these behaviours across cultures (Evans et al., 1997; Zohar & Felz, 2001) suggests that they may play an important role in development.

Early Theories Regarding the Role of Compulsive-like Behaviour in Children

The emergence of compulsive-like behaviour in children has been attributed to the neutralization of fears and attempts to control fears by acting on the environment in a specific, controlled way (for a review see, Feygin, Swain, & Leckman, 2006). For example, Werner (1948) drew comparisons between the way children believe their actions affect the environment and the way schizophrenics believe superstitious rituals lead to desired outcomes. He underlined the importance of magical thinking in children's ritualistic behaviour whereby children act out scripted and rigid behaviours to achieve a sense of connection with the environment and a sense of control (for a review, see Evans, 2000). For example, a child may skip over a crack in the sidewalk to ensure that no harm befalls loved ones. Evans and Gray (2000) reviewed how the psychoanalytically oriented theorists stressed the social-emotional role of rituals in the anal phase of development and their importance in the developing parent-child relationship. Freud (1919) argued that children suppress their thoughts and anxiety, related to unconscious sexualized urges toward their parents, by engaging in compulsive and ritualistic behaviour. Although he did not specifically address compulsive behaviour, Piaget (1952) stressed the usefulness of repetition in cognitive development. For example, in the sensorimotor stage of development, an infant learns about his ability to affect his environment by repeatedly banging blocks together or allowing them to drop to the floor. Another developmentalist, Arnold Gesell, in his observations of compulsive-like behaviour in typically developing two to three year olds (Ames, Ilg, & Frances, 1976; Gesell, 1928; Gesell, Ames, & Ilg, 1974) contended that the unfolding of rituals was patterned in such a way as to support the development of early skills of independence (e.g., toileting, feeding oneself) where intense repetition was needed to acquire skills. The observations of many of these early theorists, that ritualistic and compulsive-like behaviour in childhood is common and likely serves an adaptive purpose, was not investigated empirically until recently in part because no measures were available to assess this normative behaviour in children.

Quantifying Normative Compulsive Behaviour

Assessment of the prevalence and developmental trajectory of normative compulsive-like behaviour in young children began when Evans et al. (1997) developed the Childhood Routines Inventory (CRI). The two principal components of the CRI are the "just right" and "repetitive" factors. The just right factor refers to carrying out behaviours until sensory-perceptual criteria for being "just so" are satisfied (Leckman et al., 1994). Items include "*prefers to have things done in a particular way*" and "*arranges objects or performs certain behaviours until they seem 'just right.*'" The second component relates to repetitive behaviour and insistence on sameness. Items on this factor include "*acts out the same thing over and over in pretend play*" and "*prefers the same household schedule or routine every day.*" This parent-report measure was completed by over 1400 parents of children ranging in age from 8 to 72 months. The repetitive and just right behaviours were noted throughout childhood and did not differ by gender. The repetitive, compulsive-like behaviours emerged earlier than the sensory-perceptual just right ones. According to parent ratings, between 34% and 86% of children in the 24 to 47 months age range demonstrated repetitive and just right behaviour. These children, aged 24 to 47 months, engaged in both sets of behaviours (i.e., repetitive, just right) with more frequency and intensity than both older and younger children. The developmental course of compulsive-like behaviour in children was further explored by Zohar and Felz (2001) who administered the CRI to mothers of daycare children in Israel in order to further evaluate normative compulsive and ritualistic behaviour during its peak stage in young children. Mothers completed the CRI (N = 228) as well a measure of childhood temperament (EAS; Buss & Plomin, 1984), a novel fear inventory constructed specifically for this study, and the Hebrew Child Behaviour Checklist, a measure of internalising (e.g., depression) and externalising (e.g., aggression) problem behaviours in children (Hebrew CBCL; Auerbach, Yirmiya, & Kamel, 1996). Children were assigned a score of ritual intensity based on the intensity of their overall ritualistic behaviour – a sum of frequency ratings on each of the 19 factors of the CRI. Consistent with Evans et al.'s (1997) findings, no gender differences in ritualistic behaviour were found, although the girls were reported to be more fearful. Age of onset for ritualistic behaviours was on average three months later than the onset observed by Evans et al. but the order of presentation of compulsive and ritualistic behaviours was highly similar lending further empirical support to the conceptualisation of typical compulsive behaviour as universal and developmentally scripted.

Neuropsychological and Neurobiological Findings in OCD and Typical Compulsive and Ritualistic Behaviour

The development of the CRI marked the advent of empirical inquiry into the normative compulsive behaviour of young children. Neuropsychological and neurobiological accounts of OCD serve as the dominant explanatory paradigms for OCD (Evans et al., 2004) and knowledge of neuropsychological and neurobiological similarities between the pathological and normative presentations of compulsive and ritualistic behaviour may help further the understanding of the continuity and discontinuities of psychopathology. In this section, relevant aspects of neuropsychological research and functioning are reviewed.

Executive Functioning

Executive functioning (EF) refers to various higher-order cognitive abilities (Fuster, 1997; Milner & Petrides, 1984) that foster the control of the mental attention necessary for task completion (Dempster, 1992). Some examples of these abilities include goal-directed behaviour, set-shifting, response suppression, planning, problem solving, time perception, working memory, self-monitoring, verbal self-regulation, motor control, and the regulation of emotion (Schultz et al., 1999). Executive functioning is attributed to the frontal lobe, an area of the brain that, from birth until age two years, increases considerably in size and undergoes a second spurt of growth from the age of four until seven years (Dempster, 1992). A slower increase in the size of the frontal lobes continues until young adulthood (Luria, 1973). Over the course of early childhood development (e.g., during the preschool and early elementary school years), executive functions, including inhibitory control, improve. Inhibitory control, the ability to suppress irrelevant information and behaviours (Durston, Thomas, Yang, Ulug, Zimmerman, & Casey, 2002), is a crucial part of set shifting and response inhibition. These two executive functions are thought to relate to the key symptoms of OCD (i.e., the inability to suppress thoughts and actions and difficulty shifting focus) and are both implicated in the neuropsychological model of OCD.

Response Inhibition

A key component of the repetitive and compulsive behaviours of childhood is lack of inhibitory control (Dowsett & Livesey, 2000). Inhibitory control improves over the course of early childhood. For example, in infancy, children evidence deficits in inhibitory control on the classic Piagetian 'A not B' task (Diamond, 1985). In this task, the infant looks on as a toy is hidden in one of two identical wells. Following a delay of a few seconds, the infant is permitted to reach for the toy. Infants are able to find the toy when it is hidden in the first well (A) but are unable to retrieve the toy when it is hidden in the second well (B) as they continue to look to the first well. This error highlights the infant's difficulty inhibiting a response that is prepotent even when faced with a more rewarding alternative (Evans et al., 2004). Damage to the prefrontal cortex in rhesus monkeys contributes to more A not B errors

(Diamond, 1990) and prefrontal cortex development is implicated in the advances of A not B performance in humans and primates (Diamond & Goldman-Rakic, 1989; Diamond, Zola-Morgan, & Squire, 1989). Abilities of response inhibition continue to develop over the course of early childhood (Bell & Livesey, 1985; Livesey & Morgan, 1991) with significant improvement on response inhibition tasks occurring by age seven (Carver, Livesey, & Charles, 2001). More subtle improvements (i.e., faster reaction times) continue until the age of 20 years (Band, van der Molen, Overtoom, & Verbaten, 2000; Williams, Ponesse, Schachar, Logan, & Tannock, 1999).

Response inhibition and Obsessive Compulsive Disorder

The central features of OCD, such as the inability to inhibit recurrent thoughts and to inhibit inappropriate (perseverative) behaviours, prompted early researchers to investigate the links between response inhibition and pathological compulsive behaviour. In general, researchers found the performance of individuals with OCD on tasks of response inhibition was impaired when compared to healthy individuals. For example, Rosenberg et al. (1997) found that prior to any medical treatment, children and adolescents with OCD had difficulty with response suppression tasks and that their compulsive symptoms were positively correlated with response suppression errors. In a similar study, when asked to look at the opposite side of a visual field from where a novel stimulus was presented, 12 non-depressed, psychotropic medication-free adults with OCD had more difficulty inhibiting their responses than their age and gender matched healthy comparisons. Tien, Pearlson, Machlin, Bylsma, and Hoehn-Saric (1992) noted increased response-suppression errors on an antisaccade task in a group of 11 adults with OCD. Response inhibition difficulties were also noted on go/no go tasks, where individuals with OCD made more commission errors on the inhibitory aspects of the task and had slower reaction times on the interference trials (Bannon, Gonsalvez, Croft, & Boyce, 2002). Persons with OCD also tend to demonstrate less inhibition on tasks of semantic negative priming where they are instructed to respond to items that they were previously directed to ignore (Enright & Beech, 1990, 1993a, b). These deficits of inhibition are attributed to the functioning of the orbitofrontal region of the frontal lobe (see Evans et al., 2004; Liddle, Kiehl, & Smith 2001). In provocation studies where the brain is imaged at various time points before, during, and after OCD symptoms are provoked in clinical patients, the orbitofrontal cortex is consistently implicated (Saxena & Rauch, 2000). The orbitofrontal cortex has also been linked with the typical compulsive behaviours of childhood as, in typical children, the age of onset of compulsive behaviour coincides with the age at which tasks (e.g., rule learning, reversal learning) that rely on the functioning of the orbitofrontal cortex also emerge (Evans et al., 2004). Thus, the executive function of response inhibition is attributed to the orbitofrontal cortex, an area of the brain that is linked to symptom presentation in OCD and the emergence of compulsive behaviour in typical children. Examining response inhibition in typical children is imperative in order to clarify whether the same neuropsychological deficits and areas of the brain that are implicated in OCD are also implicated in the presentation of the typical compulsive behaviours of childhood.

Set Shifting and Obsessive Compulsive Disorder

Deficits of set shifting are also included in the neuropsychological conceptualisation of OCD and are attributed to the dorsolateral prefrontal cortical region of the brain (DLPFC; Schultz et al., 1999). Set shifting, or mental flexibility, is the ability to learn a rule and respond appropriately until the advent of new information whereupon the individual responds correctly to the new information while inhibiting the previous response (Evans, et al., 2004). Interest in this domain of executive function stems from the symptoms of OCD where individuals seem stuck, or unable to shift between sets, as seen with obsessions that are difficult to dismiss or compulsions that are repeated over and over again once their utility has passed (e.g., continuing to wash your hands once they are clean). One of the most widely used measures of set shifting and frontal functioning (Milner, 1963; Schultz et al., 1999) is the Wisconsin Card Sorting Task (WCST) – a measure that was initially developed to assess flexibility of thinking (Berg, 1948). On this task of set shifting, individuals with OCD are frequently impaired (Boone, Anant, Philpott, Kaur, & Djenderedjian, 1991; Lucey et al., 1987; Okasha et al., 2000) as are patients with lesions to the DLPFC region of the frontal lobe (Stuss et al., 2000). In general, patients with OCD commit more perseverative errors, complete fewer categories, and commit more total errors on this measure (Head et al., 1989; Sanz, Molina, Calcedo, Martin-Loeches, & Rubia, 2001). However, in other studies, no significant differences were found between the performances on the WCST of those with OCD and healthy comparisons (Abbruzzese, Ferri, & Sarcone, 1995; Deckersbach, Otto, Savage, Baer, & Jenike, 2000; Roth, Baribeau, Milovan, & O'Connor, 2004). The compulsive-like behaviour of typical adults has also been related to their set shifting ability. In 100 typical college students, modest positive associations between perseverative errors on the WCST and increased OCD symptoms, as measured by the Maudsley Obsessive-Compulsive Inventory (Hodgson & Rachman, 1977), were reported (Zohar, Labuda, Moschel-Ravid, 1995). Although support for the theory of a deficit of set shifting in OCD is not unilateral it remains an important consideration in OCD research as the DLPFC is implicated in the frontostriatal system of the frontal lobe. Support for a model of dysfunction of the frontolstriatal system, which includes the dorsolateral prefrontal cortex, lateral orbitofrontal cortex, anterior cingulated, supplementary motor area, and associated basal-ganglia structures (Bradshaw & Sheppard, 2000) in individuals with OCD is building (Insel, 1992) with greater support for the implication of the orbitofrontal cortex and the executive function of response inhibition in OCD than the dorsolateral prefrontal cortex and executive function of set shifting (Rosenberg, Dick, O'Hearn, & Sweeney, 1997). At the very least, a relationship between OCD and the frontal lobe is clear (Cavedini, Ferri, Scarone, & Bellodi, 1998). Generally, patients with OCD tend to respond more slowly on tasks of EF (Gehring, Himle, & Nisenson, 2000) and this tendency to respond slower is likely a reflection of the generation of alternate responses or more doubting and checking (Evans et al., 2004). In this study of typical children the executive functions of response inhibition and set shifting are examined in order to inform whether the same neuropsychological deficits that are implicated in OCD also play a role in the presentation of compulsive-like behaviour in childhood.

Neuropsychological Performance of Typical Children

Evidence that increased compulsive and perfectionistic behaviour among typical children is associated with performance on various neuropsychological tasks is emerging. For example, Evans and Iobst (2003a, b) administered innovative set shifting and response inhibition tasks to 45 children between the ages of six and eleven years. Normative compulsive behaviour was measured with the Childhood Routines Inventory (CRI; Evans et al., 1997). The response inhibition tasks included a *color discrimination/inhibition* task in which the child was instructed to focus on a computer screen displaying three coloured squares and click the mouse (i.e., respond) when the square in the middle of the array matched either of the outside squares. When neither outside square matched the middle one, the child was instructed to inhibit his or her response. In the second inhibition task, the child was instructed to respond when the color of an outlining square on the computer screen matched the color of the box in the center of the outline. Errors of omission and commission and response latency were recorded for both tasks of response inhibition. In the first of two set-shifting tasks, *the symbolic display match*, the child was required to learn a rule for matching two objects on the computer screen. Auditory feedback regarding the correctness of the response was provided. Much like the WCST, the rules changed during the task and the child was expected to shift among sets. In another set shifting task, known as *the conceptual discrimination task*, the child was presented with a 3 X 2 matrix of shapes and was required to determine which shape did not match according changing rules. In line with executive functioning research in individuals with OCD, the authors hypothesised that increased difficulties on tasks of executive functioning would predict increased frequencies of compulsive behaviour.

As expected, increased repetitive behaviours, one of two factors on the CRI, were predicted by increased errors on the *conceptual discrimination task* (set shifting) and increased response time and errors on the first *color discrimination task* (response inhibition). Errors on the conceptual discrimination task also predicted overall frequencies within each subdivision of the CRI (total items, just right items, repetitive items). Thus, inferior performance on a combination of response inhibition and set shifting tasks predicted increased compulsive behaviours on the CRI in a group of typical children between the ages of six and eleven years.

In a subsequent study of typical children, Pietrefesa and Evans (in press) expanded the work by Evans and Iobst (2003a, b) by using measures of set shifting and response inhibition that were also employed in the study of OCD. The participants included 39 typical, primarily Caucasian, middle class children between the ages of four and eight years (mean age = 5.97 years). Because EF abilities improve with development, the same EF tasks could not be administered to all the children as the older, more adept, children would likely find the tasks too simple. To account for this, the children were separated into two groups based on age. The Dimensional Card Sorting Task, a set-shifting task, was administered only to the children aged four to six years (DCST; Zelazo, Frye, & Rapus, 1996). In the DCST children are told the sorting rule (color or shape) and are required to match six cards to a target card in each of four phases. Sorting errors and response latency are recorded. In the Global-local "Stroop" Task (GLST), a task of selective attention and set shifting administered to the younger and older group, participants match cards to either a card with an image of a large open square or large open triangle. The matching cards are made up of three sets, each containing 10 cards. The first set contains smaller versions of the square and triangle targets. The second and third sets of cards are a combination of one target shape as the *local* shape and the other target shape as the *global* shape. For example, a large square (global shape) is made out of small triangles (local shapes). The children were instructed to match the cards to the targets beginning with the identical shapes and proceeding through the global and local shapes. The older group also completed the 64-card version of the Wisconsin Card Sort Task (WCST; Kongs, Thompson, Iverson, & Heaton, 2000). Children were told to match a card, one at a time, to one of four target cards. After sorting each card, the child was told whether or not their response was correct. After 10 correct responses the sorting criteria (i.e., color, shape, number) would change and verbal feedback would change accordingly. Although participants continued to receive feedback after sorting each card, they were never told directly that the sorting criteria had changed.

The response inhibition tasks that were administered to all children included the Livesey task (for a detailed description see Livesey & Morgan, 1991), an abbreviated version of the child's game "Simon says," the Conners Continuous Performance Task to children over age six (CPT; Conners, 2000), and the Kiddie Continuous Performance Task (K-CPT; Conners, 2001) to those younger than six years. On the CPT, a response inhibition task administered on computer, children were instructed to click the mouse as fast as they could each time they saw a letter but to withhold their response when they saw the letter 'X'. The K-CPT was also administered on computer but children responded to target images instead of letters.

The performance of the children was analysed and the younger (less than six years) and older (over six years) age groups did not differ significantly on mean scores of the overall CRI, the just right factor, or the repetitive factor, but the trends were still in the predicted direction with the children over six years exhibiting somewhat lower scores on the three indices of typical compulsive behaviour as measured by the CRI. In children younger than age six years, increased errors of commission on the CPT were related to increased ritualistic and repetitive behaviours as measured with the CRI (overall CRI). These younger children also evidenced more difficulty shifting sets on the GLST and this was related to increased repetitive behaviour. In children older than age six, the findings were in the opposite direction, as errors of commission increased indices of compulsive behaviour (repetitive and just right) decreased indicating that increased difficulties of executive function were related to *less* compulsive behaviours. The performance on the two tasks of set shifting in the older children, the WCST and DCCS, did not predict whether the children displayed more or less compulsive behaviour. Thus, results from response inhibition and set shifting tasks in younger children were in line with the hypothesis that increased EF difficulties would predict increased compulsive behaviour.

The findings that difficulties of executive function were unrelated to levels of repetitive behaviour in children older than age six years were counterintuitive as, based on the neuropsychological studies of OCD, more difficulty on tasks of response inhibition was expected to be related to increased frequencies of compulsive-like behaviour. Moreover, these results differed from those reported earlier by Evans and Iobst (2003a, b) who found that EF difficulties were indeed related to increased compulsive behaviour. The two different neuropsychological tasks used in the two studies may explain these differences. Pietrefesa and Evans (in press) also suggested that the failure to find both set shifting and response inhibition as predictors of compulsive behaviour in the children older than age six may reflect brain development as maturation of the prefrontal cortices peaks between two and six years (Casey, Giedd, & Thomas, 2000; Diamond, 1988). The brains of the older children were likely more mature and compulsive behaviour was less likely in these children.

In children younger than six years, the results from both the Pietrefesa and Evans (in press) and the Evans and Iobst (2003a, b) study were more consistent as increased compulsive behaviour and increased difficulties on tasks of set shifting and response inhibition were noted in both studies. These findings in the younger children, that increased compulsive behaviour are related to increased difficulties on tasks of executive function, are similar to those seen in individuals with OCD and lend preliminary support to the premise that similar neuropsychological (and possibly neurobiological) functions play a role in the onset and maintenance of both clinically-relevant and typical compulsive behaviours in children.

Adaptive Behaviour

The commonplace occurrence of compulsive behaviours in children suggests that they likely serve an adaptive function. For example, more frequent compulsive behaviours in younger children may support earlier developmental tasks that require more rigidity (e.g., the repetitive practice needed to learn how to tie your shoes). Thought of in evolutionary terms, the tendency to repeat a sequence until it seemed 'just so' may have encouraged earlier species to repeatedly check to ensure that their caregiver was nearby and likely to offer protection. Similarly, the tendency to engage in repetitive behaviour may have encouraged the learning of skills that required intensive rehearsal such as hunting. Although seemingly adaptive earlier in evolution and in younger stages of development, the utility of "just right" and repetitive behaviours may wane as important life skills become more complex and demand increased flexibility. For example, as children progress through elementary school, the desire to wear only clothes that satisfy a certain sensory-perceptual criteria (e.g., texture of the fabric) may be replaced with the desire to wear the types of clothing endorsed by one's peer group. In general, the more complex skills required over the course of development (e.g., negotiating the subtleties of friendships) may be incompatible with rigid and circumscribed behaviours. The child's ability to adopt new information into their repertoire of behaviour may reflect their overall adaptive development (e.g., more adaptively advanced children put on a night light to feel reassured in their bedroom at night) and may also be central to understanding the developmental role of typical compulsive behaviour (e.g., less advanced children rigidly arrange their toys before bed as it provides them with a calming sense of order at this anxiety provoking time) as well as understanding key differences and similarities between clinically relevant and normative compulsive behaviour.

In an exploratory study on adaptive behaviour and compulsivity in children, Evans and Gray (2000) examined the adaptive correlates of compulsive-like behaviour in typically developing children between the ages of two and seven years (mean age 4.56 years). The children were divided into two groups based on age with one group of children aged two to five years and one group of children aged five to seven years. In the group of children aged two to five years, no associations were found between any of the variables of the CRI and adaptive behaviour. However, in the older group of children, from age five to seven (mean age of six years), increased amounts of just right behaviours on the CRI were positively correlated with overall adaptive behaviour, communication, and socialization as measured with the Vineland Adaptive Behaviour Scales - Screener (Sparrow, Carter, & Cicchetti, 1993). These findings are surprising both because of the lack of relationship between adaptive behaviour and compulsive-like behaviour among the younger children and because of the increased relationship between the CRI and more mature adaptive development in the children over age four. Although compulsive-like behaviour was hypothesized to promote adaptive behaviour in children less than age five, based on these preliminary findings, it seems likely that compulsive-like behaviours may support the advancement of adaptive behaviour in children beyond the preschool years. Thus, in this study, the *predictive* relationship between compulsive-like behaviours and adaptive behaviour in children aged six and older (i.e., in the elementary school years) is examined. Understanding the timing and role of compulsive-like behaviour in the promotion of adaptive behaviour is critical to better understand the developmental function of these behaviours.

Rationale and Study Design

In this study, adaptive behaviour and executive functioning were examined in relation to the typical, ritualistic and compulsive behaviours of elementary school aged children. The overarching rationale is that atypical and typical development are mutually informative and that knowledge garnered from one state can be used to extend knowledge in the other. Furthermore, the knowledge of typical compulsive behaviour gathered in this study may be useful in delineating the developmental role of compulsive behaviours (e.g., do these behaviours promote the advancement of adaptive behaviour) and deciding if OCD and typical compulsive behaviours share a continuum of development, including a shared neuropsychological profile.

The age group selected for study ranged from six to twelve years in order to encompass the entirety of the elementary school years. The younger limit of the age range was chosen so that, in the interest of comparisons, the same neuropsychological tasks, with standardized scores beginning at age six, could be administered to the entire group. Children less than six years are typically administered executive functioning tasks that are shorter and less complex than children older than six years (e.g., the Kiddie version of the Continuous Performance Test of response inhibition, K-CPT; Conners, 2001). The older limit was chosen to minimize confounds associated with a vastly different context of daily life (i.e., high-school) as well as a different stage of neurodevelopment. The age span was selected in order to draw from a broad range of typical compulsive and ritualistic (e.g., lining up of toys in younger children and food particularities in older children) and adaptive behaviours (e.g., cooperative play in early childhood versus hobbies and board games in older children).

The primary tool to assess the ritualistic and compulsive behaviour in the participants was the Childhood Routines Inventory (Evans et al., 1997). This is the only validated measure of typical compulsive and ritualistic behaviour in children. The compulsive behaviours as assessed with the CRI were examined in relation to two areas of executive functioning – set shifting and response inhibition. The same set shifting and response inhibition tasks that are used in the study of persons with OCD, as well as in emergent neuropsychological research in typical compulsive behaviour, were selected whenever appropriate. As several tests were administered in a single testing session, instruments with brief administration times were prioritised to the extent possible. The 64-card version of the Wisconsin Card Sorting Task was selected to test set shifting as it is commonly used in the OCD literature and in the research of typical compulsive behaviour (for example, Lucey et al., 1987; Pietrefesa & Evans, in press). Since performance on the WCST is heavily influenced by IQ (Schultz et al., 1999) the Leiter brief IQ (Roid & Miller, 1997) was included in order to assess the IQ of the participants. The Continuous Performance Test (CPT; Conners, 2000) was chosen to measure response inhibition since it is a computerized, standardized, and normed measure that provides a highly reliable administration across children. The tapping test (Diamond & Taylor, 1996) was also included as a second measure of response inhibition because of its brief administration time.

Adaptive behaviour was assessed by parental response to the Vineland Adaptive Behaviour Scales (VABS; Sparrow et al., 1984). This is a commonly used measure of adaptive behaviour and a shorter variant of this form has been used before in research into the typical ritualistic behaviour of childhood (Evans & Gray, 2000). The short form of the parent Conners Rating Scales (CRS-R:S; Conners, 1997) was included as a measure of attention in order to assess possible confounds of the response inhibition of the participants.

Method

Participants

Forty-eight children between the ages of 72 and 152 months (*M* = 106.5, *SD* = 24.49) participated in the study (see Table 1 for descriptive statistics). Nine children were recruited from a local elementary school via a letter of invitation sent home to their parents. The other 39 participants were recruited through advertisements in a local paper. Children diagnosed with ADHD were excluded from the study to minimize confounds. The study was approved by the McGill University Faculty of Education Ethical Review Board.

Parent Completed Measures

Childhood Routines Inventory

The Childhood Routines Inventory Version 1.2 (CRI; Evans et al., 1997) is a 19-item parent report measure of normative compulsive and ritualistic behaviours. Frequency of compulsive behaviours are rated on a 5-point Likert scale ranging from "*not at all/never*" to "*very much/always.*" The CRI has good internal consistency with a two-factor structure ("just right" and "repetitive behaviours") that is relatively stable across age groups after the age of 24 months (Evans et al., 1997). Examples of the seven just right items include "*does your child line up objects in straight lines or symmetrical patterns?*" and "*does your child seem very aware of, or sensitive to, how certain clothes feel?*" Examples of the six repetitive items include "*does your child strongly prefer to stick to one game or activity rather than change to a new one?*" and "*does your child prefer the same household schedule or routine everyday?*" Items were summed and an average score was obtained for the just right and repetitive items. For the overall CRI score, a mean of all 19 items was obtained.

Table 1

Descriptive Statistics for Chronological Age, Gender, and IQ by Age Group

	Group 1	Group 2	Group 3	Total
		Males		
N	6	4	9	19
CA *M* (*SD*)	77.7 (4.7)	102.0 (10.4)	133.2 (11.1)	109.1 (26.7)
IQ *M* (*SD*)	101.5 (16.4)	97.5 (20.4)	116.4 (11.1)	107.7 (16.5)
		Females		
N	7	15	7	29
CA *M* (*SD*)	76.9 (4.2)	102.7 (10.5)	137.3 (10.2)	104.8 (23.3)
IQ *M* (*SD*)	110.3 (9.5)	115.3 (13.3)	110.0 (11.7)	112.8 (12.0)

Note. IQ represents the child's standard score on the Leiter Brief IQ.

Adaptive Behaviour

The Vineland Adaptive Behavior Scales – Survey Form (VABS; Sparrow et al., 1984) is a measure of social and personal competence in children (birth until 19 years). Information was obtained via a semi-structured parent interview. The measure includes two domains of interest. In the Daily Living Skills domain, questions address three subdomains; personal living habits, domestic task performance, and behaviour in the community. Within the Socialization domain, three subdomains are addressed; interpersonal relationships with others, play and leisure time skills, and coping skills. For each domain, a standardized score (M = 100, SD = 15) and age equivalent score is obtained. Only age equivalent scores are available for the six subdomains. An overall Adaptive Composite score (standardized score) that measures the child's functioning in the domains of Daily Living Skills, Socialization, and Communication, was also obtained. This test reports excellent psychometric properties (Sparrow et al., 1984).

Parental Report of Attentional Behaviours

Parents completed the Conners Rating Scales—Revised: Short Form (CRS-R:S), in order to provide a measure of the child's attentional abilities and ensure that difficulties of executive function were not due to underlying attention problems. The CRS-R: S includes 27 items that are divided into four subscales of attentional abilities including oppositional behaviours, cognitive problems/inattention, hyperactivity, and the ADHD index which assesses ADHD symptoms based on Diagnostic and Statistical Manual for Mental Disorders, Fourth Edition (DSM-IV-TR; APA, 2000; Conners, 1997). Sample items include "*defiant*," "*fails to complete assignments*," and "*restless in the 'squirmy' sense.*" Items are scored on a Likert scale of 0–4 with 0 as "Not True at All" and four as "Very Much True." For each of the four subscales, a T-score is obtained (*M* = 50, *SD* = 10). This measure has excellent reported reliability and validity (Conners, 1997).

Child Measures

Intelligence

The Leiter-R (Roid & Miller, 1997) was used as a brief measure of non-verbal intelligence. This measure is suitable for individuals aged 2 to 20 years when a "culturally fair" (e.g., a measure of IQ that does not rely on language mastery) IQ assessment is required. For this abbreviated version of the Leiter, adequate reliability and validity are reported (Roid & Miller, 1997) as well as a high correlation with the non-verbal portion of the WISC-III (Wechsler, 1991). Four subtests (Figure Ground, Form Completion, Sequential Order, Repeated Patterns) were administered to arrive at the brief Intelligence Quotient (standardized score).

Neuropsychological Measures: Set Shifting

The manual 64-card version of the Wisconsin Card Sort Task (WCST; Kongs et al., 1981) was used to assess set shifting ability. Adequate reliability and validity are reported for this measure (Kongs et al., 1981). The test consists of 64 cards that differ by colour, number, and shape of geometric figure. In this task, participants are directed to match cards to one of four target cards but no further directions regarding how to group the cards are provided. Feedback, as to whether or not the card was matched correctly, is provided after each card is sorted. Once a predetermined number of correct responses are achieved (10 correct responses), a new series begins where the sorting criteria differ. Participants are then required to 'shift cognitive set' and sort according to the new experimenter feedback (Heaton, 1981). Response latency (total time to complete the task), total number of errors (number of cards sorted incorrectly), perseverative responses (number of times a card was sorted *correctly* according to the previously correct sorting strategy) and perseverative errors (number of times a card was sorted incorrectly according to the previously correct sorting strategy or when a card is sorted incorrectly with the second unambiguous sorting error), and number of items to achieve the first correct set were recorded.

Response Inhibition

The Conners' Continuous Performance Test (CPT; Conners, 2000) was used to assess response inhibition. Excellent reliability and validity are reported for this measure (Conners, 2000). The task was administered on a Toshiba laptop computer with a 17" monitor and external mouse. The participant was instructed to click the mouse for every letter shown *except* for the letter "X" while maintaining speed and accuracy. The stimulus was displayed for 250 ms with inter-stimulus intervals of one, two, and four seconds. Prior to the test administration a short practice session was administered to ensure that the child understood the task. The complete test lasted for 15 minutes. T-scores for errors of omission (failure to respond to correct target) and commission (response to an incorrect target), the average speed of correct responses, perseverations (reaction time less than 100 ms indicating failure to consider the stimulus or reaction based on past stimulus), and response style (speed accuracy trade-off where higher values indicate a slower response style) were obtained.

Tapping test. This non-standardized task was used as a brief measure of response inhibition (Diamond & Taylor, 1996). During administration, the child and experimenter sat facing one another. In the first phase, the child was instructed to tap a wooden dowel the same number of times as the experimenter. For verbatim instructions, please see Appendix F. The experimenter tapped the dowel once on the table and then handed the dowel to the child so that s/he could exactly copy the experimenter's actions (pre-switch phase). Several trials were then conducted with one and two taps. In the second part of the task (post-switch phase), the child was told that the rules of the game had changed. The child was then instructed to tap once when the experimenter tapped twice and to tap only once when the experimenter tapped twice. Errors and total time for each phase (pre and post-switch) were recorded. A time difference variable was then computed where the length of time to perform the tapping test pre-switch was subtracted from the length of time to perform the tapping test post-switch.

Procedure

The parents from the local school completed the questionnaire package that included the demographic questionnaire (see Appendix A), the CRI, and the CRS-R:S and returned it in a sealed envelope to school officials. The children were tested in a quiet classroom during school hours. All the parents provided informed written consent and students provided informed verbal assent before each session. The parents were contacted by telephone to complete the Vineland interview. The families that were recruited through newspaper advertisements came to McGill University and completed testing in a private office. The children completed a series of cognitive tasks while parents completed questionnaires just outside the testing area. All the children received gift certificates for their participation.

Results

Descriptive analyses were performed for all the variables of interest and only those that were normally distributed were included in subsequent analyses. Outliers greater than 2.5 standard deviations from the mean on independent variables were excluded. Mean and standard deviations are provided for all variables in Table 2 and Table 3.

Neuropsychological Performance and the Childhood Routines Inventory

To control for the effects of attentional difficulties in the prediction of compulsive-like behaviour, stepwise regression analyses were first conducted to test whether any of the four subscales of attentional abilities (i.e., oppositional behaviours, cognitive problems/inattention, hyperactivity, and ADHD index) would predict variance in the CRI. None of the attentional factors predicted significant variance in the CRI.

Tapping Test

A series of stepwise multiple regressions were performed (see Tables 4 and 5 for correlations among variables of interest). The time difference (post-switch time minus pre-switch time) variable, the number of post-switch errors, and the post-switch response time of the tapping test were entered together as predictors for each of the three factors of the CRI (i.e., just right, repetitive, total CRI; see Table 6). The regression model was statistically significant for the post-switch response time accounting for significant variance in the mean CRI, $\beta = .31$, $R^2 = .08$, $F(1,39) = 4.24$, $p < .05$, repetitive, $\beta = .36$, $R^2 = .09$, $F(1, 39) = 5.72$, $p < .05$, and just right factor, $\beta = .33$, $R^2 = .11$, $F(1, 39) = 4.89$, $p < .05$. Thus, increased length of time to respond on the post-switch phase was related to all three indices of increased compulsive behaviour. The effects of attentional difficulties on the length of time to respond on the post-switch were tested. None of the four subscales of attentional abilities (i.e., oppositional behaviours, cognitive problems/inattention, hyperactivity, ADHD index), when entered into a stepwise regression, predicted significant variance on the length of response time for the post-switch phase.

Table 2

Means, Standard Deviations, and Sample Sizes for Childhood Routines Inventory, Tapping test, and the Conners' Continuous Performance Task

Variables	*M* (*SD*), *N*			
	Group 1	Group 2	Group 3	Total
		CRI		
Mean CRI	2.4 (0.9), 13	2.4 (0.6), 19	2.1 (0.9), 16	2.3 (0.8), 48
Mean just right	2.4 (1.0), 13	2.2 (0.7), 19	1.9 (0.8), 16	2.1 (0.8), 48
Mean repetitive	2.2 (1.0), 13	2.3 (0.9), 19	1.8 (0.9), 16	2.1 (0.9), 48
		Tapping Test		
Completion time (seconds), pre-switch	36.9 (4.1), 11	35.6 (6.1), 18	30.3 (4.8), 16	34.0 (5.8), 45
Completion time (seconds), post-switch	48.2 (10.0), 12	38.1 (6.4), 19	30.7 (5.0), 16	38.2 (9.7), 47
Post-switch time minus pre-switch time (seconds)	19.4 (8.1), 10	11.6 (3.9), 18	10.4 (2.6), 16	12.9 (5.9), 44
Errors pre-switch	0.4 (1.0), 13	0.1 (0.5), 19	0.0 (0), 16	0.15 (0.5), 48
Errors post-switch	1.1 (1.2), 10	0.7 (1.1), 19	0.3 (0.5), 16	0.62 (1.0), 45
		CPT		
Errors of omission	50.6 (9.8), 10	48.6 (6.5), 19	44.7 (6.1), 16	47.7 (7.4), 45
Errors of commission	53.8 (8.7), 11	50.2 (9.5), 19	49.5 (9.0), 16	50.8 (9.1), 46
Average speed of correct responses	56.3 (7.8), 11	45.3 (8.5), 19	44.7 (9.1), 16	47.4 (9.8), 46
Perseverations	46.6 (3.9), 10	47.5 (4.4), 18	46.0 (3.9), 16	46.8 (4.1), 44
Response style	54.1 (13.2), 12	49.0 (5.6), 19	45.8 (7.0), 16	49.2 (9.0), 47

Note. CPT scores are T-scores.

Table 3

Means and Standard Deviations for Wisconsin Card Sorting Task and Vineland Adaptive Behaviour Scale (VABS)

Variables	*M* (*SD*), *N*			
	Group 1	Group 2	Group 3	Total
		VABS		
Living Skills	80.6 (13.1), 13	112.3 (22.0), 19	126.6 (31.8), 16	108.5 (29.7), 48
Personal living skills	83.5 (21.7), 13	127.1 (44.6), 19	153.1 (46.1), 16	123.9 (48.0), 48
Domestic skills	81.2 (15.3), 13	102.2 (22.5), 19	126.0 (38.4), 16	104.4 (32.1), 48
Community skills	80.8 (10.6), 13	117.5 (24.3), 19	140.3 (17.5), 16	115.2 (30.0), 48
Socialization age	90.2 (18.1), 13	124.3 (30.8), 19	158.7 (26.6), 16	126.5 (37.3), 48
Interpersonal age	91.5 (21.0), 13	124.4 (31.2), 19	159.8 (22.1), 16	127.3 (36.8), 48
Play/leisure skills	99.1 (32.3), 13	130.8 (39.3), 19	154.4 (38.4), 16	130.1 (42.3), 48
Coping skills	91.0 (27.7), 13	121.2 (36.1), 19	166.6 (34.8), 16	128.2 (44.6), 48
Adaptive composite	105.0 (16.2), 13	114.5 (7.7), 17	107.1 (8.8), 16	109.2 (11.6), 46
		WCST		
Completion time (seconds)	379.2 (85.1), 12	335.8 (76.4), 19	285.3 (99.9), 16	329.7 (92.8), 47
Total number of errors	28.5 (7.7), 13	20.8 (8.2), 19	18.6 (8.6), 16	22.2 (9.0), 48
Perseverative responses	12.6 (6.7), 11	10.7 (4.6), 19	10.7 (6.2), 16	11.2 (5.6), 46
Perseverative errors	11.1 (4.7), 11	10.2 (4.2), 19	9.5 (4.7), 16	10.2 (4.5), 48
# of items to complete first set	17.8 (9.5), 12	13.9 (4.6), 19	13.4 (4.3), 16	14.7 (6.3), 46
		ADHD index		
Oppositional	52.6 (11.2), 13	56.3 (13.8), 19	52.3 (11.3), 16	54.2 (12.2), 48
Cognitive problems	56.0 (11.5), 13	55.9 (14.4), 19	50.8 (9.3), 16	54.9 (11.9), 48
Hyperactivity	55.5 (13.5), 13	55.9 (12.2), 19	51.2 (8.4), 16	54.7 (11.3), 48
Total ADHD	55.9 (11.9), 13	57.6 (14.3), 19	50.5 (8.9), 16	55.3 (12.0), 48

Note. VABS are shown in age equivalent scores (months). WCST are raw scores. ADHD index is T-scores.

Table 4
Pearson Intercorrelations of CRI and Chronological Age

	1.	2.	3.
1. Mean CRI score			
2. Mean just right	.903**		
3. Mean repetitive	.909**	.769**	
4. Chronological age	-.237	-.325*	-.251

*$p < .05$, **$p < .01$

Table 5

Pearson Intercorrelations for all Criterion and Dependent Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Mean CRI									
2. Mean just right	.903**								
3. Mean repetitive	.909**	.769**							
4. Tapping test completion time, pre-switch	.394**	.415**	.358*						
5. Tapping test completion time, post-switch	.328*	.450**	.288*	.677**					
6. Post-switch time minus pre-switch time	.000	.063	.046	-.037	.710**				
7. Tapping test errors pre-switch	-.037	-.007	-.006	.164	.187	.336*			
8. Tapping test errors post-switch	.102	.097	.033	-.005	.118	.416**	.190		
9. Errors of omission CPT	-.007	.081	-.058	.050	.234	.278	.391**	.390**	
10. Errors of commission CPT	.128	.235	.060	.307*	.381**	.145	-.108	.041	.210

**p* < .05, ***p* <.01

Table 5

Pearson Intercorrelations for all Criterion and Dependent Variables

	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
1. Mean CRI	.021	.000	.076	-.249	-.238	-.147	-.210	-.192	-.163	.010
2. Mean just right	.101	.071	.088	-.299*	-.328	-.188	-.269	-.262	-.209	-.118
3. Mean repetitive	.067	.030	.160	-.194	-.184	-.104	-.197	-.176	-.159	.085
4. Tapping test completion time, pre-switch	.129	.028	.073	-.444**	-.407**	-.483**	-.409**	-.438**	-.421**	-.275
5. Tapping test completion time, post-switch	.453**	.157	.130	-.629**	-.545**	-.578**	-.698**	-.681**	-.600**	-.501**
6. Post-switch time minus pre-switch time Tapping Test	.318*	.036	.159	-.400**	-.290	-.308*	-.538**	-.534**	-.451**	-.425**
7. Tapping test errors pre-switch	.193	.000	.029	-.267	-.290*	-.204	-.274	-.322*	-.273	-.246
8. Tapping test errors post-switch	.254	.041	.304*	-.345*	-.162	-.274	-.370*	-.375*	-.483**	-.229
9. Errors of omission CPT	.306*	.400**	.650**	-.174	-.165	-.133	-.326*	-.361*	-.393**	-.254
10. Errors of commission CPT	-.323*	.202	.116	-.208	-.297*	-.155	-.180	-.192	-.201	-.134

$^*p < .05$, $^{**}p < .01$

Table 5
Pearson Intercorrelations for all Criterion and Dependent Variables

	21.	22.	23.	24.	25.	26.	27.
1. Mean CRI	-.274	.129	.234	.201	-.144	-.095	265
2. Mean just right	-.302*	.039	.285	.265	-.172	-.139	277
3. Mean repetitive	-.289*	.130	.225	.301*	-.138	-.097	209
4. Tapping test completion time, pre-switch	-.444**	-.038	.579**	.248	.190	.196	.084
5. Tapping test completion time, post-switch	-.661**	-.139	.645**	.358*	.079	.112	.214
6. Post-switch time minus pre-switch time	-.504**	-.327*	.277	.241	.013	.027	.240
7. Errors pre-switch Tap. Test	-.317*	-.435**	.104	.024	-.067	-.076	-.084
8. Errors post-switch Tap. Test	-.329*	-.019	.032	.090	.068	.141	.167
9. Errors of omission CPT	-.348*	.263	.202	.290	-.039	.015	.071
10. Errors of commission CPT	-.197	-.002	.385**	.134	.105	.107	-.067
11. Rate of response (CPT)	-.440**	-.146	.172	.428**	.056	.105	.180

*$p < .05$, **$p < .01$

Table 5

Pearson Intercorrelations for all Criterion and Dependent Variables

	11.	12.	13.	14.	15.	16.	17.	18.	19.
12. Perseverations (CPT)	.295								
13. Response style (CPT)	.241	.339*							
14. Living skills age equivalent VABS	-.350*	-.087	-.225						
15. Personal living skills VABS	-.243	-.024	-.078	.674**					
16. Domestic skills age equivalent VABS	-.314*	-.074	-.230	.819**	.683**				
17. Community skills age VABS	-.569**	-.166	-.366*	.778**	.706**	.755**			
18. Social skills age VABS	-.505**	-.155	-.286	.812**	.726**	.749**	.831**		
19. Interpersonal age VABS	-.542**	-.220	-.439	.749**	.654**	.717**	.849**	..886**	
20. Play/leisure VABS	-.333*	-.091	-.155	.688**	.582**	.641**	.610**	.794**	.643**
21.Coping skills VABS	-.440**	-.132	-.216	.707**	.661**	.658**	.746**	.917**	.766**

*$p < .05$, **$p < .01$

Table 5
Pearson Intercorrelations for all Criterion and Dependent Variables

	11.	12.	13.	14.	15.	16.	17.	18.	19.
22. Adaptive composite VABS	-.146	.056	-.153	.365	.216	.378	.342*	.357*	.376*
23. WCST completion time	.172	.145	.222	-.402**	-.486**	-.444**	-.522**	-.452*	-.407**
24. WCST total errors	.428**	.360*	.359*	-.412**	-.460**	-.326*	-.568**	-.419**	-.539**
25. WCST perseverative responses	.056	-.007	.153	-.258	-.214	-.328*	-.251	-.103	-.270
26. WCST perseverative errors	.105	.051	.178	-.278	-.235	-.342*	-.284	-.164	-.327*
27. WCST Number of items until first set	.180	-.214	-.055	-.205	-.279	-.245	-.262	-.192	-.148

*$p < .05$, **$p < .01$

Table 5
Pearson Intercorrelations for all Criterion and Dependent Variables

	20.	21.	22.	23.	24.	25.	26.
21. Coping skills VABS	.527**						
22. Adaptive composite VABS	.368*	.257					
23. WCST completion time	-.343*	-.398**	-.141				
24. WCST total errors	-.289*	-.320*	-.185	.427**			
25. WCST perseverative responses	-.094	-.022	-.077	.324*	.493**		
26. WCST perseverative errors	-.134	-.082	-.064	.330*	.542**	.979**	
27. WCST Number of items until first set	-.092	-.174	.006	.295*	.342*	.120	.135

$^*p < .05$, $^{**}p < .01$

Table 6

Stepwise Multiple Regression Analyses with each CRI Factor as Criterion and Tapping Test Variables as Predictors

Variable	R	R^2	F (1, 39)	*p*
Mean CRI				
Post-switch response time	.31	.08	4.24	.046
Mean Just Right Behaviours				
Post-switch response time	.33	.09	4.89	.033
Mean Repetitive Behaviours				
Post-switch response time	.36	.11	5.72	.022

Continuous Performance Task

A series of stepwise multiple regressions was then performed for errors of omission, errors of commission, number of perseverative responses, response style, and average speed of correct responses with each of the three CRI factors entered as dependent variables (see Table 7). Errors of commission on the CPT significantly predicted variance in the just right factor of the CRI, $\beta = .31$, $F = (1, 41) = 4.39$, $p < .05$ accounting for 8% of the variance. Thus, increased errors of commission were associated with increased frequencies of just right behaviours. In this model, a high degree of multicollinearity was noted. To address this, all non-essential predictors were excluded and only errors of commission and omission were retained. When only two predictors were retained, the model was no longer significant indicating that performance on the CPT did not predict frequencies of compulsive behaviour.

Wisconsin Card Sorting Task

Pearson product-moment correlations were performed to determined if IQ was significantly related to performance on the WCST. No significant correlations were found (see Table 7). Regression analyses were then used to test whether WCST variables predicted compulsive-like behaviour (i.e., CRI factors). Raw scores were used in order to include participants who were slightly younger than the standardized normative sample of the WCST. Because of this, forward regressions were used to account for age differences, and age was entered first in the regression equation. None of the WCST scores accounted for significant variance in the CRI.

Table 7

Pearson Intercorrelations of WCST and IQ

	1.	2.	3.	4.
1. WCST time				
2. Perseverative responses	.324*			
3. Perseverative errors	.330*	.979**		
4. Number to 1st category	.295*	.120	.135	
5. Leiter IQ	.155	.052	-.005	-.111

*$p < .05$, **$p < .01$

Compulsivity as a Predictor of Adaptive Behaviour

A series of stepwise multiple regressions was conducted to determine if levels of compulsivity (mean CRI, just right, repetitive factor) would predict levels of adaptive behaviour (see Table 8). The mean CRI, mean just right, and mean repetitive behaviours were entered as predictors for the Daily Living skills domain and the three subdomains (personal living skills, domestic task performance, and behaviour in the community). The three factors of the CRI were also entered as predictors for the Socialization skills domain and three subdomains (interpersonal relationships with others, play and leisure time skills, and coping skills). Frequencies of just right behaviours accounted for 9% of the variance in the personal living skills subdomain, $\beta = -0.33$, $F(1, 46) = 5.55$, $p < .05$. The just right behaviours also accounted for 7% of the variance in the coping skills subdomain, $\beta = -0.30$, $F(1, 46) = 4.63$, $p < .05$. Thus, increased frequencies of just right behaviours predicted lower age equivalent scores on both the personal living skills and coping skills subdomains. None of the other frequency measures of compulsive behaviour (i.e., mean CRI, mean repetitive behaviours) predicted significant variance for any of the domains of adaptive behaviour.

Adaptive Behaviours as Predictors of the CRI

A series of stepwise multiple regressions was then conducted to determine if the Vineland domain and subdomain age equivalent scores would predict (see Table 9) significant variance in the three factors of the CRI (mean CRI, just right, repetitive). Within the Daily Living skills domain, the age equivalent for the personal living skills subdomain accounted for 11% of the variance in the just right factor, $\beta = -0.33$, $F(1,46) = 5.55$, $p < .05$. Within the Socialization domain, the age equivalent of the coping skills subdomain accounted for 9% of the variance in the just right factor, $\beta = -0.30$, $F(1,46) = 4.63$, $p < .05$.

Table 8

Stepwise Multiple Regression Analyses with each Vineland Adaptive Behaviour Scale Domain and Subdomain as Criterion and CRI Variables as Predictors

Variable	R	R^2	F (1, 46)	*p*
Personal Living Skills				
Mean Just Right response time	.33	.09	5.55	.023
Coping Skills				
Mean Just Right	.30	.07	4.63	.037

Table 9

Stepwise Multiple Regression Analyses with each CRI as Criterion and Vineland Adaptive Behaviour Scale Domain and Subdomain Variables as Predictors

Variable	R	R^2	F (1, 46)	*p*
Mean Just Right				
Personal Living Skills	.33	.09	5.55	.023
Coping Skills	.30	.07	4.63	.037
Repetitive				
Coping Skills and Play and Leisure	.40	.12	4.32	.019

Thus, age equivalents on the personal living skills and coping skills subdomains were negatively related to the frequency of just right behaviours. The age equivalent scores for both the coping skills and play and leisure time skills subdomains together accounted for 16% of the total variance in the repetitive factor of the CRI, $F = (2, 45) = 4.32$, $p < 0.05$. The age equivalent score on the coping skills subdomain was negatively related to the frequency of repetitive behaviour, $\beta = -.46$, $p < .01$, while the age equivalent of the play and leisure time skills subdomain was positively related to the frequency of repetitive behaviours, $\beta = .33$, $p <.05$. Thus, more advanced coping skills predicted that repetitive behaviours would be *less* frequent while more advanced play and leisure time skills predicted that repetitive behaviours would be *more* frequent. None of the standard scores on the domains of adaptive functioning or the overall Adaptive Composite score predicted significant variance for any of the three factors of the CRI.

Overall Regression Model

A subsequent set of regression analyses was conducted (see Table 10) where all variables that emerged as significant predictors of compulsive behaviour were re-entered to determine which variable was most predictive of the just right and repetitive factors. Further analyses for the mean CRI were not required as only one variable (response latency on the tapping task) emerged as a significant predictor. For the just right factor, personal living skills age, coping skills age, and completion time on the tapping test post-switch were entered. The post-switch completion time emerged as the most important predictor accounting for 19% of the variance, $\beta = .45$, $F = (1,45) = 11.41$, $p<.01$ for the frequency of just right behaviour factor. For the repetitive factor of the CRI, coping skills age, play and leisure time skills age, and completion time for the post-switch phase of the tapping test were entered. Together, coping skills age, $\beta = -.47$; $p<.05$, and play and leisure skills age, $\beta = .33$, $p <.05$, emerged as the most important predictors accounting of 13% of the total variance, $F = (2, 44) = 4.32$, $p<.05$. In sum, both the mean CRI and the just right factor were best predicted by response latency on the tapping task (time post-switch). For the repetitive behaviour factor, coping skills age and play and leisure skills age contributed independent and additive variance.

Table 10

Overall Regression Models with Significant Predictors of Compulsive Behaviour Re-entered to Determine most Predictive Variables

Variable	R	R^2	F (1, 45)	*p*
Mean Just Right				
Post switch Completion time	.45	.19	11.41	.002
Mean Repetitive CRI				
Coping Skills and Play and leisure	.41	.13	4.32	.019

Exploration of Age Trends

To examine the age trends more closely, the participants were separated into three age groups (see Table 2 and 3 for means and standard deviations of each variable by age group). The youngest group included children seven years and younger. The second group was made up of children older than seven years until the age of 10 years. The last group ranged from 10 until 12 years. For each age group, Pearson product-moment correlations were performed between each of the three variables of the CRI and the adaptive subdomains and the executive functioning variables.

Age Groups: Adaptive Behaviour

The age equivalent scores for the adaptive subdomains of play and leisure skills in the children under age seven was positively related to mean CRI, $r(13) = .70$, $p < .01$, mean just right, $r(13) = .64$, $p < .05$, and the mean repetitive factor, $r(13) = .63$, $p < .05$. No other significant correlations emerged between the three age groups and the adaptive behaviour subdomains.

Age Groups: Executive Function

The only significant correlation that emerged for the executive function of set shifting was in the group of children younger than seven years. In these children, the number of items to achieve the first category on the WCST was positively correlated to the mean CRI, $r(13) = .62$, $p < .05$, and to mean frequency of repetitive items, $r(13) = .75$, $p < .01$. In the oldest children, those over the age of ten years, the overall hit reaction time of the CPT was positively correlated with the mean CRI, $r(12) = .60$, $p < .05$, and with the mean repetitive factor, $r(12) = .64$, $p < .05$. In the seven to ten year old group, the overall hit reaction time on the CPT was positively correlated with all measures of the CRI, including the mean CRI, $r(19) = .55$, $p < .05$, the mean just right factor $r(19) = .47$, $p < .05$, and the mean repetitive factor $r(19) = .55$, $p < .05$. Thus, when the participants were examined separately by age groups, associations between compulsive behaviour and performance on the CPT and set shifting tasks were found.

Discussion

The general goal of this study was to evaluate how adaptive behaviour and the executive functions of set shifting and response suppression relate to the normative ritualistic and compulsive behaviours of elementary school aged children. Based on the theory that increased levels of compulsive behaviour in early childhood help advance adaptive behaviour development, a primary hypothesis was that more frequent compulsive behaviour would be associated with less advanced adaptive behaviour. Likewise, increasingly advanced adaptive behaviour was expected to predict fewer compulsive-like and ritualistic behaviours as more advanced adaptive behaviours, including social and personal development, demand increasing behavioural flexibility (e.g., navigating complex social networks). Thus, compulsive-like behaviours are thought to wane during these more advanced stages of adaptive behaviour development (e.g., after age seven), as they are too rigid to encourage flexible patterns of behaviour. Consistent with findings from research and theory on adults with OCD, difficulties on tasks of executive functioning were expected to predict increased levels of ritualistic and compulsive behaviour. This is concordant with the neuropsychological framework of OCD, in which deficits of response inhibition and set shifting, and the neurobiology responsible for these functions, are implicated in the pathogenesis of OCD.

The findings generally support the hypotheses that both adaptive behaviour and neuropsychological functioning are related to, and predict, levels of compulsive behaviour in elementary school aged children. For the most part, increased levels of adaptive skills predicted decreased levels of compulsive behaviour. This relationship is in keeping with the general developmental trend to exhibit fewer compulsive behaviours over the course of childhood. Also, more frequent compulsive-like behaviour predicted lower levels of adaptive behaviour. Neuropsychological performance, specifically increased response latency on tasks of response inhibition, predicted increased levels of compulsive behaviour. Set shifting deficits did not predict compulsive behaviour, although some associations were observed among the youngest children. Overall, the data support the notions that clinical OCD and the typical compulsive and ritualistic behaviour of childhood share similar neuropsychological profiles, and that compulsive behaviour in childhood supports the development of increasingly advanced adaptive behaviour.

Neuropsychological Functioning

Response Inhibition

Difficulty on tasks of response inhibition predicted frequency of compulsive behaviour. Slower response times during the post-switch phase of the tapping task, a task of response inhibition, predicted more frequent repetitive, just right, and overall compulsive-like behaviours. Moreover, increased response latency emerged as the most important predictor of the just right factor of the CRI. The relation between compulsive behaviours and number of errors on the tapping task was not significant. This is similar to the finding among individuals with OCD that increased response latency on tasks of response inhibition is more common than are difficulties with accuracy (Bucci, Mucci, Volpe, Merlotti, Galderisi, & Maj, 2004; Galderisi, Mucci, Catapano, Damato, & Maj, 1995; Purcell et al., 1998; Veale et al., 1996). Unexpectedly, no significant predictors of compulsive behaviour emerged on the CPT, a computerized task of response inhibition. This is inconsistent with Pietrefesa and Evans' (in press) finding that increased errors of commission on the CPT were related to fewer repetitive and just right behaviours. One reason for this difference might be that the children in the Pietrefesa and Evans study were more than a year and a half younger than those in this study, with a mean age of 7.03 years as compared to the mean age of 8.88 years. To further examine the relationship between response inhibition on the CPT and compulsive behaviour, the participants in this study were divided by age into groups of children aged six to seven years, eight to ten years, and ten to twelve years. Once separated into these three age groups, the rate of the correct responses (i.e., speed of response) was the only variable of the CPT that was related to compulsive-like behaviours. Among the two younger groups, the rate of correct responses was positively correlated with the number of repetitive behaviours, whereas among the group of children aged ten to twelve years, slower rates of correct responses on the CPT were related to *less* repetitive behaviour. Based on the findings from the tapping test and the CPT, the results support the premise that ritualistic and compulsive behaviours are associated with executive functioning difficulties – in particular increased response latency. This result was especially evident among the children *younger* than age ten years. The finding of a positive relationship between response inhibition difficulties and increased compulsive-like behaviour lends support to theory that both OCD and the typical compulsive-like behaviours of childhood share similar neuropsychological profiles. As the executive function of response inhibition is thought to be governed by the orbitofrontal cortex (OFC) - an area of the frontal lobe that is implicated in the neurobiological model of pathogenesis in OCD (Schultz et al., 1999), the extrapolation is that the same brain circuitry involved in the presentation of clinical OCD is implicated in the typical compulsive-like behaviour of childhood.

Set Shifting

As predicted, difficulties on tasks of set shifting were not related as strongly to compulsive behaviours as those of response inhibition. On the WCST, a set-shifting task, none of the variables measured such as response latency, total number of errors, perseverative responses, perseverative errors, and number of responses before achieving the first category, predicted significant variance in compulsive-like behaviour. This is consistent with the findings that individuals with OCD show no general impairment on the WCST (Abbruzzese, et al., 1995; Boone et al., 1991; Deckersbach et al., 2000; Gross-Isseroff et al., 1996; Moritz et al., 2001, 2002; Roth et al., 1991; Zielinski, Taylor, & Juzwin, 1991), and that the WCST was unrelated to ritualistic and compulsive behaviour in children older than six years (Pietrefesa & Evans, in press). The relation between set shifting and compulsive behaviour was further examined with the participants divided into three groups by age (six to seven years, seven to ten years, and ten to twelve years). When analysed in this way, more responses before achieving a correct set on the WCST were positively related to increased repetitive behaviour among the children aged six to seven years old. This supports Pietrefesa and Evans' finding that the positive correlation between compulsive-like behaviour and set shifting among typically developing children wanes after the age of six years as the brain matures and tasks of set shifting are no longer compromised. This likely reflects brain development as maturation of the prefrontal cortices peaks between two and six years allowing for improved executive function (Casey et al., 2000; Diamond, 1988). The finding that set shifting difficulties are related to increased compulsive-like behaviours among young children may be understood as support for the argument that similar brain structures underlie both typical and clinically significant compulsive behaviours. For example, compromised functioning on the WCST is reported among adults with OCD (Boone et al., 1991; Lucey et al., 1997; Okasha et al., 2000). As compared to healthy adults, individuals with OCD commit more perseverative errors, complete fewer categories, and make more total errors on the WCST (Goodwin & Sher, 1992; Head et al., 1989; Sanz et al., 2001). These difficulties are attributed to the dorsolateral prefrontal cortex (DLPFC), as patients with lesions to this area of the brain also perform poorly on the WCST (Stuss et al., 2000). The DLPFC is an area of the brain implicated in the neuropsychological and neurobiological understanding of OCD pathogenesis. Thus, the results of executive functioning in this study are consistent with research on OCD (Adler, McDonough-Ryan, Sax, Holland, Arndt, & Strakowski, 2000; Breiter et al., 1996; Saxena et al., 1998) in which response inhibition and, by extrapolation, the OFC seem to play a larger role in the presentation of typical compulsive behaviours than set shifting (and the DLPFC).

Adaptive Behaviour

The hypothesis that compulsive-like behaviour is related to adaptive development was supported in the current study. Increased just right behaviours predicted less advanced personal (e.g., dressing yourself, self-care) and coping (e.g., ability to follow societal rules, controlling anger when denied your own way) skills. Correspondingly, increased repetitive behaviours predicted less advanced coping skills. Thus, when children engaged in more just right and repetitive behaviours, their adaptive behaviour was less advanced. When adaptive behaviour was used to predict compulsive-like behaviour, the reverse relationships were observed. More advanced personal and coping skills predicted less frequent just right behaviours and, better coping skills predicted fewer repetitive behaviours. Contrary to expectations that increased repetitive behaviours would be associated with inhibited play skills since flexibility is needed for elaborate pretend play, increased play and leisure skills were actually associated with increased amounts of repetitive behaviour in children. However, when understood from the perspective that children with more advanced play skills increasingly engage in rule-based games such as card, board, and computer games, this finding seems more intuitive. In these play activities, rigidity and repetitiveness may offer an advantage and therefore improve the child's proficiency at play. Additionally, hobbies were also included in the measure of play and leisure skills used here and children who engage in more repetitive behaviours would likely enjoy the repetitive nature that characterise many hobbies (e.g., repeatedly rearranging hockey cards by year and/or by team) as well as the rote and detailed aspects required in these types of activities (e.g., ensuring symmetrical and straight placement of a sticker collection, intricacies of assembling a scrapbook collage).

In general, more mature adaptive behaviour predicted fewer just right and repetitive behaviours. This may be interpreted in two ways. One, as adaptive behaviour matures, the ritualistic and compulsive behaviours of childhood recede as they are no longer developmentally useful or appropriate. For example, children may engage in increased repetitive behaviour – acting out the same bedtime routine – before more advanced coping skills emerge to deal with the anxiety provoked at bedtime. However, once more mature adaptive skills are acquired, such as verbalizing their anxiety to a parent, turning on a nightlight, engaging in relaxation techniques, or simply acquiring an increased sense of self-sufficiency and confidence about sleeping in their own bed, the less developmentally advanced behaviours, such as engaging in repetitive and just right behaviours, decrease. A second interpretation is that just right and repetitive behaviours among younger children are most prevalent before the emergence of more mature adaptive behaviours and that children engage in compulsive-like behaviours to help the transition toward more advanced adaptive behaviour. For example, in early adaptive development, when the primary personal skills that the child needs to acquire include behaviours that require intensive rote practice, such as dressing oneself and toileting, children simultaneously engage in compulsive and ritualistic behaviours that focus on achieving a sensation of things being "just so." During these stages of development when intensive practice is needed to acquire skills (e.g., closing buttons), the child is pre-programmed to engage in detail oriented, repetitive behaviour where a subjective feeling of success requires a high degree of precision (e.g., the desire to line up one's stuffed animals until they are positioned "just so"). This is consistent with Piaget's (1952) notions that increased repetitive behaviours were essential in the development of voluntary motor behaviours and Gesell's (1928) that the rituals of childhood facilitated mastery over many of the early, personal skills of adaptive behaviour, such as toileting and feeding. At the very basic level then, the ritualistic and compulsive behaviours are most prevalent at stages when increased repetition, attention to detail, and insistence on correctness support the mastery of age appropriate skills. As children enter more advanced stages of development that demand increased flexibility and less rote practice, the ritualistic and compulsive behaviours that were typical of earlier childhood begin to fade.

Strengths: Original Contribution to Knowledge

This dissertation is an original contribution to research in the field of normative ritualistic and compulsive behaviour and developmental psychopathology. In this study, two theories were confirmed. One, the compulsive-like behaviours of early childhood play a role in the advancement of adaptive behaviour. Two, the neuropsychology implicated in the pathogenesis of OCD is also related to the typical compulsive-like behaviours of childhood.

A strength of this study was the exploration of the relationship of compulsive and ritualistic behaviours and neuropsychology within a *broad age range* (six to twelve years) of children. This age range allowed for the exploration of a wide array of compulsive and adaptive behaviours while using the same neuropsychological tasks with all the participants. Using the same neuropsychological tasks is critical in order to make inferences regarding the underlying neurobiology. Moreover, the neuropsychological tasks were, whenever appropriate, the same tasks used in research with individuals with OCD. This allowed for maximum comparison between the neuropsychology of typical children and that of individuals with OCD.

Limitations

In order to fully assess the findings of the present study, certain methodological issues need to be considered. One, the inference of brain involvement was based on neuropsychological performance and not on direct observations of brain activity. Thus, conclusions regarding brain loci are dependent on evidence from other studies in which performance on tasks of executive function were related to relevant neurobiological structures (e.g., Berman et al., 1995; Demakis, 2003). Furthermore, neuropsychological tests can only be used to speculate about the exact areas of the brain that are implicated as multiple brain areas are often drawn upon to complete a task (Kuelz, Hohagen, & Voderholzer, 2004). For example, performance on tasks of response inhibition implicate aspects of both motor control and working memory and these executive functions are not all localized within the same areas of the frontal lobe as response inhibition (Kuelz et al., 2004). Moreover, there is inherent overlap between performance on tasks of response inhibition and set shifting as within set shifting a child is also required to *inhibit* a response (Evans et al., 2004). Two, due to the location of the participating elementary school as well as the readership of one of the newspapers where the study was advertised, the participants were mostly drawn from a higher socioeconomic status and the mean IQ of the sample was nearly a standard deviation above the mean. Thus, the findings may not generalize to individuals from other upbringings as the development of executive function and the prefrontal cortex appears to be affected by socioeconomic status (Farah & Noble, 2005). Three, the neuropsychological tests were administered in a fixed order to all the participants and, accordingly, some general priming effects of order (e.g., better or worse performance on one task based on the prior administration of another task) cannot be ruled out. Four, parental report on the CRI was the sole measure of compulsive behaviour in this study. Ratings of compulsive behaviour from other observers may offer a varying perspective and further corroboration of behaviour, for example, teacher ratings of compulsive-like behaviour in the classroom. However, the majority of compulsive-like behaviour among young children is primarily exhibited in environments that would inhibit such observation (e.g., the bedroom, the family dining room).

Conclusions, Implications, and Future Directions

In conclusion, the main findings are that, increased compulsive behaviour in childhood coincides with less advanced adaptive behaviour. At the same time, children evidence difficulties on tasks of executive functioning that predict increased frequencies of compulsive behaviours. These difficulties of executive function closely resemble the difficulties of individuals with OCD. As children develop, adaptive behaviour matures, the compulsive behaviours wane, and the skills of executive functioning improve. These findings are consistent with the premise that the compulsive behaviours of childhood support the progression of adaptive behaviour by encouraging the child to engage in rote practice and detail oriented behaviours that ultimately seem to support the acquisition of more advanced skills. The findings that increased difficulties of response inhibition are related to increased compulsive-like behaviour also lends credence to the theory that the same neuropsychological difficulties implicated in the pathogenesis of OCD, and by extrapolation the same neurobiology, also play a role in the presentation of the typical compulsive behaviour of childhood. The implication of these findings is that the usefulness of conceptualising OCD as a disease entity that is completely disjointed from typical development is tenuous. The continuities between OCD and typical compulsive behaviours highlight the need to consider these two phenotypes along a continuum where the shared neuropsychology and neurobiology of both behavioural presentations is considered.

Future research into the neurobiological correlates of just right and repetitive behaviours is warranted based on findings that difficulties of executive functioning were the best predictors of the just right factor and that adaptive behaviours best predicted levels of repetitive behaviour. The slight differences between these two types of compulsive behaviour (e.g., just right and repetitive) may offer insight into the divide between normal and pathological compulsive behaviour. Moreover, research into possible gender differences of typical compulsive behaviours in *older* children – at the point in development when compulsive behaviours are expected to wane - may begin to shed light on the differential age of onset of OCD in males and females. Finally, investigations into the development of the frontal lobe and direct observations (e.g., brain imaging) of the neurobiology implicated in the presentation of typical compulsive behaviour may enlighten the neurobiological differences among typical compulsive behaviours, child onset OCD, and adult onset OCD, and thereby may lead to better diagnostic and treatment capabilities.

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Appendix A

Demographic Information Form

Child's Gender: ____ Male ____ Female

Child's Date of Birth (Month/Day/Year):____________________

Today's Date:____________________

Child's Race/Ethnicity:

_____ White (not Hispanic/Latin)
_____ Black (not Hispanic/Latin)
_____ Hispanic/Latin
_____ Asian
_____ Aboriginal
_____ Other

Family Status: Check the line that best describes the adults living in this child's home at the present time.

_____ Mother and Father
_____ Mother only
_____ Father only
_____ Other Relatives
_____ Foster Parents
_____ Mother and Stepfather
_____ Father and Stepmother
_____ Other (please specify): ____________________

Mother's highest level of education (circle):

Elementary School
Some high school
High school diploma
Some college
Two-year Degree
Four-year degree
Professional degree
Graduate degree

Father's highest level of education (circle):

Elementary school
Some high school
High School Diploma
Some college
Two-year degree
Four-year degree
Professional degree
Graduate degree

Father's occupation: ______________________________________

Mother's occupation: ______________________________________

Does your child have any health problems? If so, please specify.

____

Appendix B

McGill

Faculty of Education
McGill University
3700 McTavish Street
Montreal, (Quebec)
Canada H3A 1Y2

Faculté des sciences de l'éducation
Université McGill
3700, rue McTavish
Montréal, (Québec)
Canada H3A 1Y2

(514) 398-4241
Fax
(514) 398-6968

Dear Parents/Guardians:

Thank you for your interest in this study on the development of childhood self-control, routines, rituals, and parenting style. The purpose of this project is to learn how children use daily routines and rituals to better understand their world and control their behaviour. We are also very curious about the role of parenting style and how this helps children control their behaviour. Self-control is essential to many different aspects of childhood including academic performance and social development.

We request your child's participation in a 75 minute (approximately) research session. Your child will receive a 10$ gift certificate to Chapter's in appreciation of his or her participation. During this research session your child will be asked to focus on the center of a computer screen and to respond by pressing a key when shown certain letters and withhold his or her response when shown other letters. We will also ask your child to complete a short series of game like tabletop tasks administered for the purpose of being able to compare your child's performance on the computer task to the performance of other children of the same intellectual functioning. Instructions for completing these tasks will be clearly explained to your child in the context of a game and will not be structured in an evaluative or judgmental manner. Similar tasks have been used before with other children who have enjoyed the experience. However, should your child wish to discontinue or refuse to participate, he/she may do so at any time.

We also request your participation as parent. Enclosed in this package you will find four brief questionnaires. The first asks about your child's routines and rituals in your home. The second asks about your parenting style. The third asks about your child's attention and behaviour. The fourth asks about your own rituals and routines in your daily life. The final aspect of your participation is a brief interview (15 – 20 minutes) where the principal investigator (Catherine Zygmuntowicz) will ask you about your child's social development at home.

A confidential code, known only by the researcher, has been placed on the questionnaires to identify your child. The data in this study will be used only for research purposes. Results will be published as group averages and no personal information will be used in the

Should you have ANY questions, please contact Catherine Zygmuntowicz at (514) 824-6643 or Jake Burack at (514) 398-3343 or email Catherine at attentionresearch@yahoo.ca Jake Burack is a professor at McGill University and is the director of the McGill Youth Study Team. Catherine Zygmuntowicz is a Ph.D. candidate in School and Applied Child Psychology and a childhood feeding specialist at the Montreal Children's Hospital.

Thank you for your consideration of this project.
Sincerely,
Jake Burack, PhD and Catherine Zygmuntowicz, MA

Appendix C

PARENTAL INFORMED CONSENT FORM
(Allowing the *child* to participate in research)

This is to state that I, ___________________, parent of ______________________, allow my child to participate in the research project entitled, A Developmental Study of Normative Ritualistic and Compulsive Behaviours in Elementary School Children.

Conducted by, *The McGill Youth Study Team.* Principal Investigator, *Catherine Zygmuntowicz, MA.*

I allow my child to participate in this study on the typical development of inhibition, routines, and parenting style.

I understand the purpose of this study and am aware that my child will be asked to complete a computer task that presents no known risk and has been used before with children of the same age as my child.

I am aware that the tasks will be presented in the context of a game and will not be structured in a pass/fail context.

I understand that my child is free to withdraw from participating at any time without any penalty or prejudice.

I am aware that the data will be used for research purposes only. I consent to the publication of the study results so long as they are presented in a manner that does not identify my child.

I understand that the researchers will be happy to answer any questions regarding the procedures of this study. The principal researcher, Catherine Zygmuntowicz, can be contacted at (514) 824-6643.

I have read the above and I understand all of the above conditions. I freely consent and voluntarily agree to allow my child to participate in this study.

Date	Signature of Parent or Guardian
Student's Name	Student's Date of Birth

Appendix D

INFORMED CONSENT FORM TO PARTICIPATE IN RESEARCH
(Consent of the parent)

This is to state that I, __________________, parent of _____________________, agree to participate in the research project entitled, A Developmental Study of Normative Ritualistic and Compulsive Behaviours in Elementary School Children. Conducted by, *The McGill Youth Study Team.* Principal Investigator, *Catherine Zygmuntowicz, MA*

I agree to participate in this study on the typical development of inhibition, routines, and parenting style.

I understand the purpose of this study and am aware that I am asked to complete four written questionnaires and one brief structured interview that present no known risk and have been used before with parents of children the same age as my child.

I understand that the questionnaires will take approximately 20 minutes to complete.
I understand that the interview will take approximately 20 minutes to complete

I understand that this research will be used to further understand how children develop inhibition and routines and how parenting style is related to this development.

I am aware that that this research may ultimately benefit children by teaching us how to help children better develop self-control.

I understand that I am free to withdraw from participating at any time without any penalty or prejudice.

I am aware that the data will be used for research purposes only and that the information collected will be kept strictly confidential. I consent to the publication of the study results so long as they are presented in a manner that does not identify me or my child.

I understand that the researchers will be happy to answer ANY questions regarding the procedures of this study. The principal researcher, Catherine Zygmuntowicz, can be contacted at (514) 824-6643.

I have read the above and I understand all of the above conditions. I freely consent and voluntarily agree to participate in this study.

Date Signature of Parent or Guardian
Child's Name

Appendix E

Childhood Routines Inventory, Version 1.2 c. David W. Evans

_______ Child's age (in months) Your relation to child _______________ Child's sex __________

At certain ages many children become very particular and like to have things in a certain way. Below are a few questions about this aspect of childhood. FEEL FREE TO GO INTO DETAIL ON THE BACK OF THE PAGE. Darken the appropriate circle next to each question: Then go to the right of each question and indicate how old your child was when the behavior began.

5. Very much/always
4. Quite a lot/often
3. Somewhat/sometimes
2. a little/rarely
1. not at all/never

If so, at what age (in months) did this begin?

DOES YOUR CHILD:

1. Prefer to have things done in a particular order or in a certain way (i.e. is he/she a "perfectionist"?)
2. Seem very attached to one favorite object?
3. Seem very concerned with dirt, cleanliness α or neatness?
4. Arrange objects, or perform certain behaviors until they seem "Just right" to him/her?
5. Have persistent habits?
6. Line up objects in straight lines or symmetrical patterns?
7. Prefer the same household schedule or routine everyday?
8. Act out the same thing over and over in pretend play?
9. Insist on having certain belongings around the house "in their place"?
10. Repeat certain actions over and over?
11. Have strong preferences for certain foods?
12. Like to eat food in a particular way?
13. Seem very aware of, or sensith ive to, how certain clothes feel?
14. Have a strong preference for wearing (or not wearing) certain articles of clothing?
15. Collect or store objects?
16. Seem very aware of certain details at home (such as flecks of dirt on the floor, imperfections in toys and clothes)?
17. Strongly prefer to stick to one game or activity rather than change to a new one?
18. Make requests or excuses that would enable him/her to postpone going to bed?
19. Prepare for bedtime by engaging in a special activity or routine, or by doing or saying things in a certain order or certain way?

Appendix F

Protocol for the Tapping Test

Diamond, A. & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to "do as I say, not as I do." *Developmental Psychobiology, 29,* 315-334.

Sit across the table from the child in a quiet room.

Part One: Imitation Phase

Immediately after the experimenter taps once with a wooden dowel, the child is to tap once with the dowel. Immediately after the experimenter taps twice, the child is to tap twice.

PRETEST

First Rule

Say: "When I tap one time like this (tap once), I want you to tap one time like this (tap once). Let's try that. When I tap one time (tap once), you tap …"

Hand the dowel to the child. If the child responds correctly (taps once), praise the child and proceed to the second rule.

If the child's response is incorrect, explain and demonstrate the first rule again, having the child respond using the dowel. Regardless of how the child performs the second time, go on to explain and demonstrate the second rule.

Second Rule

Say: "When I tap two times like this (tap twice), I want you to tap two times like this (tap twice). Let's try that. When I tap two times (tap twice), you tap …"

Hand the dowel to the child. If the child responds correctly (taps twice), praise the child ("very good," "good job," etc.).

If the child's response is incorrect, explain and demonstrate the second rule again, having the child respond using the dowel.

Continue the pretest by tapping once and handing the dowel to the child for a response. If the child is correct (taps once), praise the child. Then tap twice and hand the dowel to the child for a response. If the child is correct again (taps twice), praise him/her, and count these two trials as the first two trials of testing. If the child responded incorrectly on either of these trials, remind the child of both rules again

Appendix F

after the two trials are over, explaining first the rule the child had executed incorrectly.

TESTING

There is a pseudorandom series of 16 trials, and each trial is composed of the experimenter's tap(s) and the child's response.

After tapping, hand the dowel to the child for a response. Have the child return the dowel to you after he/she makes his/her response.

The series of taps is as follows:

2, 1, 1, 2, 1, 1, 2, 2, 2, 1, 2, 1, 1, 2, 2, 1

At the end of all the trials, **say:** "OK, now we are going to play a different game." Begin the pretest for Part Two.

Part Two: Non-Imitation Phase

Immediately after the experimenter taps once with a wooden dowel, the child is to tap twice with the dowel. Immediately after the experimenter taps twice, the child is to tap once.

PRETEST

First Rule

Say: "When I tap one time like this (tap once), I want you to tap two times like this (tap twice). Let's try that. When I tap one time (tap once), you tap ..."

Hand the dowel to the child. If the child responds correctly (taps twice), praise the child ("very good," "good job," etc.) and proceed on to the second rule.

If the child's response is incorrect, explain and demonstrate the first rule again, having the child respond using the dowel. Regardless of how the child performs the second time, go on to explain and demonstrate the second rule.

Second Rule

Say: "When I tap two times like this (tap twice), I want you to tap one time like this (tap once). Let's try that. When I tap two times (tap twice), you tap ..."

Appendix F

Hand the dowel to the child. If the child responds correctly (taps once), praise the child ("very good," "good job," etc.).

If the child's response is incorrect, explain and demonstrate the second rule again, having the child respond using the dowel.

Continue the pretest by tapping once and handing the dowel to the child for a response. If the child is correct (taps twice), praise the child. Then tap twice and hand the dowel to the child for a response. If the child is correct again (taps once), praise him/her, and count these two trials as the first two trials of testing. If the child responded incorrectly on either of these trials, remind the child of both rules again after the two trials are over, explaining first the rule the child had executed incorrectly.

TESTING

There is a pseudorandom series of 16 trials, and each trial is composed of the experimenter's tap(s) and the child's response.

After tapping, hand the dowel to the child for a response. Have the child return the dowel to you after he/she makes his/her response.

Do not influence the child's response by reaching for the dowel too early or by leaving it with the child too long. Do not give any feedback during testing.

The series of taps is as follows:

1, 2, 2, 1, 2, 2, 1, 1, 1, 2, 1, 2, 2, 1, 1, 2

Appendix G

Wisconsin Card Sort Verbal Directions

This test is a little unusual because I am not allow to tell you very much about how to do it. You will be asked to match each of the cards in this deck *(response deck)* to one of these four key cards.

You must always take the top card from the deck and place it below the card you thin it matches. I cannot tell you how to match the cards, but I will tell you each time whether you are right or wrong. If you are wrong, simply leave the card where you have placed it and try to get the next card correct.

There is no time limit to this test. Are you ready? Let's begin.

(begin timing)