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Exploring the Relationships among Executive Functioning, Behaviour, and Adaptive Skills in Young Children

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Abstract

This study aimed to investigate the relationships among executive functions (EFs), adaptive skills, and behaviour problems in young children. Participants were divided into four behaviour groups: high internalizing (INT), high externalizing (EXT), combined high internalizing and externalizing (COMB), and within the normal range (NORM). The predictive ability of inhibition, shift, working memory, adaptive skills, age, and sex on group membership was explored using regression analyses. A person-oriented perspective was also explored using cluster analysis. Fifty-five kindergarten and Grade one educators in Ontario, Canada completed the Behaviour Rating Inventory for Executive Functioning (second or preschool edition) and the Behaviour Assessment System for Children (third edition) for their students (N = 789). There were significant differences across the four behaviour groups in relation to their levels of executive functioning and adaptive skills. Shift was the strongest predictor of INT group membership, whereas inhibition was the strongest predictor of EXT and COMB group membership. Higher levels of adaptive skills were associated with decreased likelihood of being in any of the three behavioural groups. Cluster analysis results produced two EF clusters: those with elevated EF deficits, and those within the normal range of EF. Most children within the normal range of executive functioning were not displaying high levels of behaviour problems; conversely, there were children with EF deficits that were not displaying high levels of behaviour problems. Results provide information in relation to the unity/diversity of EF, the etiology of behaviour problems in young children, and therefore early intervention practices.

Keywords: Executive Functioning, Behaviour Problems, Young Children, Adaptive Skills, Inhibition, Shift, Working Memory

Lay Summary

The present study aimed at better understanding behaviour problems in young children. Externalizing (outwardly directed) and internalizing (inwardly directed) behaviours were examined. The relationship between behaviour problems and cognitive capacities known as executive functions, adaptive skills, gender, and age were explored. Results revealed that different executive functions were related to different types of behaviour problems in young children. Furthermore, levels of adaptive skills were related to both types of behaviour problems. The structure of executive functions in young children was also explored in order to better understand the unity and diversity of these cognitive capacities. The results of this study provide valuable information in relation to early intervention practices for youth with internalizing and/or externalizing behaviour problems.

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Table of Contents

List of Tables

List of Figures

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Introduction

In the past few decades, research surrounding executive functions (EFs) has become more abundant, alongside a push to understand how these capacities underlie behaviour in children and adolescents. Obtaining an understanding of these relationships has become a prominent theme in relation to informing interventions aimed at reducing behaviour problems in young children. The present article will therefore first explore the current state of literature surrounding EF development, as well as the complex relationships found among various EFs and behaviour problems in young children. The additional factors of gender, age, and adaptive skills, and how these factors relate to EF and behaviour will then be explored

Although several definitions of EF exist, EFs are generally known as a collection of higher order cognitive capacities that support the planning and execution of goal-directed activity (Friedman & Miyake, 2017). Poor executive functioning has been associated with several negative outcomes in children, including lower levels of academic achievement (Lubin, Regrin, Boulc'h, Pacton, & Lanoë, 2016), poorer emotional and behavioural functioning (Espy, Sheffield, Wiebe, Clark, & Moehr, 2011), and lower life satisfaction later in life (Kruger, 2011). Conversely, strong EF scores tend to be predictive of positive future outcomes (Ribner, Willoughby, & Blair, 2017), such as higher rates of self-concept (Hughes, 2011), self-regulation (Heatherton & Wagner, 2011; Hofmann, Schmeichel, & Baddeley, 2012; Smith et al., 2017), and academic achievement (Roebers, Cimeli, Röthlisberger, & Neuenschwander, 2012).

Although numerous EFs exist, they are thought to share both commonalities and differences, as outlined by the unity/diversity framework (Hatoum, Rhee, Corley, Hewitt, &

Friedman, 2017). According to this framework, EFs have shared and distinct functions, are robustly correlated but separable, and activate both common and specific neural areas (See Figure 1). More specifically, they share a central commonality, but have unique differences, making them distinct constructs that can be studied separately in both children and adults (Friedman & Miyake, 2017). The commonality in this model refers primarily to an attentional capacity that is needed in order to effectively use any EF, although some point to more of an inhibitory control capacity as the commonality (Karr et al., 2018). There is still debate, however, in relation to the unity/diversity of EF in younger children, with some studies finding distinct constructs in preschool children (Memisevic & Biscevic, 2018; Schoemaker et al., 2013), and others finding a more unified EF at this age (Hughes, 2011; Willoughby et al. 2010).

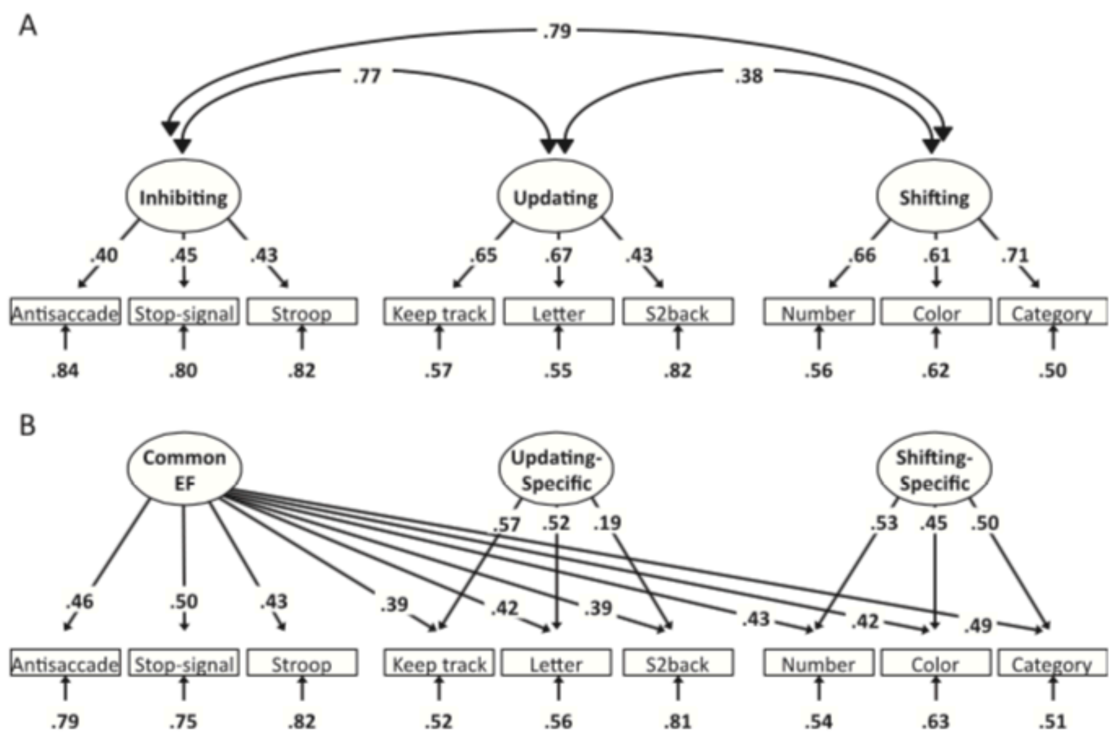

Figure 1. The Unity/Diversity of Executive Functioning as reported in Friedman & Miyake, 2017. Single headed arrows represent factor loadings. Curved double-headed arrows represent correlations between variables.

Based on the unity/diversity model, EF is generally categorized into three main sub-components: inhibition, working memory (i.e. updating), and cognitive flexibility (i.e. shifting). Inhibition refers to the deliberate control over (or ability to suppress) automatic or dominant responses when necessary (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). In classroom settings, inhibition is necessary for tasks such as raising ones' hand as opposed to shouting out an answer, wherein the child must inhibit the automatic response of shouting. Working memory refers to the ability to keep information in an active, quickly retrievable state over a temporary period of time (Hofman, Schmeichel, & Baddeley, 2012) and is used to support ongoing cognitive activities (Alloway, Gathercole, Kirkwood, & Elliott, 2009). For young children in classroom settings, working memory is needed for several activities, from writing a letter or number as instructed by the teacher to remembering instructions associated with a given task.

Cognitive flexibility (also referred to as set-shifting or shifting) refers to the ability to disengage (or shift) between certain behaviours or thought processes in order to re-engage in a different behaviour or thought process. More specifically, it involves the back-and-forth transfer of attention from one stimulus to another and involves the ability to filter task-relevant stimuli from task-irrelevant stimuli (Graziano, Garb, Ros, Hart, & Garcia, 2016). In classroom settings, cognitive flexibility may be identified by a child's ability to stop ongoing behaviour in order to move to a different task; for example, transitioning from one subject to another requires the child to disengage with the current activity in order to shift attention and re-engage in the next activity.

Separately, and in line with the unity/diversity framework, each component of EF has been found to uniquely correlate with several important abilities. Inhibition, for example, has been found to be predictive of reading, spelling, and writing scores for children ages eight to 11 (Karasinski, 2015), whereas a meta-analysis conducted by David (2012) found that working memory has been repeatedly associated with performance on math related activities in children ages eight to 11, and that this relationship was more prominent for younger children. Higher levels of cognitive flexibility have been associated with stronger reading abilities, higher levels of resilience in relation to stress and negative life events, and higher levels of creativity (Dajani & Uddin, 2015). Of additional importance in the study of EF is understanding the relationships among EF and behaviour problems in children, as behaviour problems are predictors of lower school adjustment and school readiness, which, at the kindergarten level, are predictive of long-term academic and social outcomes (Graziano et al., 2016).

Behaviour Problems and EF

Both theory and research indicate a relationship between EF and behaviour. Bandura's (1991) social cognitive theory of self-regulation, for example, states that mental processes related to self-regulation influence and regulate human behaviour. Furthermore, a growing consensus now exists within neuroscience research that EF underlies the ability to self-regulate behaviour (Heatherton & Wagner, 2011). More specifically, self-regulation is dependent on the development of EF, as EF influences the ability to set goals, problem solve, and regulate emotions, all of which determine one's ability to self-regulate (Smith et al., 2017).

EF can also be thought of as the capacity component of self-regulation, wherein, according to Hofmann et al. (2012), self-regulation is composed of three primary components: 1) the standards of thoughts, feelings, or behaviours endorsed by the individual, 2) motivation to invest effort into maintaining or achieving these standards, and 3) the cognitive capacity to achieve these standards. EFs are therefore viewed as the central components or capacities needed in order to perform self-regulatory tasks. For example, if a child is displaying a deficit in self-regulatory behaviour in the classroom, this could be related to the child's cognitive capacity to self-regulate (EF), the child's motivation to do so, or the child's belief about how to behave properly in the classroom. Expectedly, self-regulatory functioning can be affected when deficits in EF occur, which may result in social-emotional and therefore behavioural difficulties (Smith et al., 2017); therefore, an understanding of EF is essential to the understanding of behavioural problems in children.

There are typically two main presentations of behavioural psychopathology in young children: 1) internalizing behaviour problems, or inwardly directed distress, such as anxiety or depression, and 2) externalizing behaviour problems, or outwardly directed behaviours such as aggression or violence. Among younger children (ages four to seven), approximately 10-15% have mild or moderate behavioural problems, and, for this population, boys tend to have higher rates of aggression and hyperactivity (Janus, 2009). Externalizing behaviour problems typically emerge during the preschool period, whereas internalizing problems tend to peak later in childhood or adolescence (Gartstein, Putnam, & Rothbart, 2012). The majority of adolescents with behavioural problems, however, typically begin to exhibit these problems at a young age (Janus, 2009). Internalizing problems can also begin to manifest and can be observed at the preschool age (Gartstein et al., 2012), suggesting that early identification of risk factors and areas to focus interventions may aid in reducing adolescent behaviour problems.

Although internalizing and externalizing behaviour problems are typically moderately-to-highly correlated (Hatoum et al., 2017), these two behaviour categories, similar in nature to EF, are thought to have separable brain correlates and may predispose young children to different types of future psychopathology (Blanken et al., 2017). Petty et al. (2008), for example, found that early internalizing behaviour problems can be predictive of future problems such as generalized anxiety disorder, separation anxiety disorder, social phobia, agoraphobia, and separation anxiety disorder. Early externalizing problems, however, can be predictive of problems such as disruptive behaviour disorders.

Behaviour problems are multiply determined, with internalizing and externalizing behaviour problems sharing both common and separate risk and protective factors. Risk factors for both behaviour problems include adverse or challenging environments and negative care-giver traits such as unpredictability or unresponsiveness (Ogundele, 2018), peer victimization in school (Reijntjes, Kamphuis, Prinzle, & Telch, 2010), and/ or having a highly stressed parent at home (Keyser, Ahn, & Unick, 2017). Child temperament and cognitive capacities also play a role in behaviour problems. Gartstein, Putnam, and Rothbart (2012), for example, found that temperament attributes such as negative emotionality and effortful control were associated with both types of behaviour problems, whereas high surgency was associated with externalizing problems, and low surgency was associated with internalizing problems in preschool children (Gartstein, Putnam, & Rothbart, 2012). Furthermore, Delgado, Carrasco, González-Peña, & Holgado-Tello (2018) found that reactive temperamental traits such as negative affect were related to increased externalizing behaviour problems, and extraversion was a protective factor against internalizing behaviour problems in children ages three to six. Research continues to demonstrate that cognitive capacities are also related to behaviour problems; how these two behaviour problems are related to EF in young children, however, is not fully understood. As discussed below, research has found that the three main areas of EF may uniquely relate to different internalizing or externalizing behaviour problems for children at various ages.

Inhibition

Several studies have linked deficits in inhibition to disruptive behaviour disorder (DBD), attention deficit hyperactive disorder (ADHD), and externalizing behaviour problems in children (Ford, Farah, Shera, & Hurt, 2007; Pauli-Pott & Becker, 2011; Raaijmakers et al., 2008; Schoemaker et al., 2013). In relation to the younger elementary years, studies have shown that preschool children with aggressive behaviour patterns (Utendale, Hubert, Saint-Pierre, & Hastings, 2011) and kindergarten children with disruptive behaviours and ADHD symptoms (Monette, Bigras, & Guay, 2015) tend to possess a deficit in inhibition. The relationship between internalizing behaviours and inhibition, however, is not as clear, with some studies finding a prominent association between internalizing behaviour problems and inhibition (Gardiner & Iarocci, 2017; Martel et al., 2004), and other studies finding factors such as shifting to be more predictive of internalizing behaviour (Emerson et al., 2005; Mocan et al., 2014).

Research regarding non-clinical samples is not as plentiful as the research involving clinical samples, particularly children with ADHD. What has been found for non-clinical samples, however, may show a similar pattern to the results found in clinical samples in relation to inhibition and behaviour problems. For typically developing children ages two-six years, inhibitory control has been correlated with externalizing difficulties (Utendale & Hastings, 2011) and aggressive behaviour (Spann & Gagne, 2016). Furthermore, Utendale and Hastings (2011) found that this relationship strengthened from toddlerhood through to kindergarten. Low inhibitory control has also been found to significantly correlate with high levels of internalizing symptoms such as anxiety and depression in children ages seven to 12 (Vuontela et al., 2013), depressive symptoms for children ages five to 13 (Gardiner & Iarocci, 2017) and both externalizing and internalizing behaviour problems in nine-year-old children (Karasinski, 2015).

Working Memory

There is some evidence that children ages three-to-six with ADHD exhibit deficits in working memory (Pauli-Pott & Becker, 2011; Monette et al., 2015) and that, for this demographic, a correlation between working memory and externalizing behaviour exists (Schoemaker et al., 2013). Furthermore, a study of typically developing nine-year-old children also found that working memory was related to different types of aggression (Granvald & Marciszko, 2016). For children ages three to 16, those with lower levels of working memory have been reported to have more attentional, behavioural, and academic difficulties at school in comparison to children with normal levels of working memory (Aronen, Vuontela, Steenari, Salmi, & Carlson, 2005). Deficits in working memory have also been correlated with high levels of distractibility, inattentive symptoms, short attention spans, problems monitoring quality of work, and difficulty generating new ideas in a sample of children ages five-to-nine years who were identified as having low (at or above the eighth percentile of the sample) working memory scores (Gathercole et al., 2008). These results have been furthered by Alloway, Gathercole, Kirkwood, and Elliott's (2009) study in which children ages five to 11 with very low working memory scores were found to have higher ratings of inattentive behaviour, forgetfulness, and distractibility. Although there is research to suggest a relationship between working memory and externalizing symptoms as well as broad attentional difficulties, there is currently no clear relationship between working memory and internalizing behaviour problems.

Cognitive Flexibility

The research on cognitive flexibility as it relates to behaviour is both limited and mixed across populations. Schoemaker et al. (2013), for example, found a correlation between cognitive flexibility deficits and externalizing behaviour problems for children ages three-to-six years with ADHD or Disruptive Behaviour Disorders (DBD), whereas Pauli-Pott and Becker (2011) found that children with ADHD or DBD do not present this deficit. Additionally, a meta-analysis revealed both inconsistent results and small effect sizes between cognitive flexibility and ADHD, suggesting that the relationship between ADHD, deficits in cognitive flexibility, and behaviour problems remains unclear (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005).

Research regarding the relationship between cognitive flexibility and behaviour problems in non-clinical samples is also scarce, mixed, and is frequently associated with older children. Hatoum et al. (2017), for example, found that while overall EF was related to internalizing behaviour problems, shifting was primarily related to externalizing behaviours in children ages seven to 16. Other studies, however, have shown a relationship between internalizing symptoms and cognitive flexibility in children ages seven to 11 (Mocan et al., 2014) and in boys age nine to 11 (Emerson et al., 2005). Interestingly, a study conducted by Friedman et al. (2007) found a correlation between shifting and attention problems at some ages (seven, nine, 10, and 11) but not others (eight, 12, 13, and 14), suggesting that more research may be warranted in this area.

Sex

In relation to sex differences, there are studies that suggest that sex may play a role in the relationship between EF and behaviour (Raaijmakers et al., 2008; Schoemaker et al., 2013), and studies that suggest it may not (Hatoum et al., 2017; Spann & Gagne, 2016;

Utendale et al., 2011). Differences tend to be most prominently found for externalizing behaviour problems, wherein studies find higher levels of externalizing behaviour, such as physical aggression (Baillargeon et al., 2012; Raaijmakers et al., 2008), in boys as opposed to girls. A meta-analysis conducted by Schoemaker et al. (2013) also found that studies with a higher percentage of boys tended to produce higher effect sizes regarding the relationship between externalizing behaviour problems and inhibition deficits for children with ADHD.

The relationship between externalizing behaviour problems and boys may be due to socialization differences; specifically, an argument put forth by Crick et al. (1997) (as cited in Spann & Gagne, 2016), stated that boys tend to use overt aggression such as physical aggression, whereas girls tend to use covert aggression such as relational aggression (for example excluding others from activities). These covert aggressions may therefore go unnoticed by teachers or parents, which could lead to lower levels of aggression reported, and therefore lessen any associations between externalizing behaviour problems and EF for girls. These social differences tend to not be as distinct when looking at internalizing behaviour problems, with several studies showing no gender differences in parent and teacher rated levels of internalizing behaviour problems amongst school aged children (Mocan et al., 2014; Vuontela, 2013).

Adaptive Skills

Of additional importance to child development and success in the classroom is the presence and acquisition of adaptive skills. As opposed to the maladaptive behaviour problems discussed above, adaptive skills refer to a set of skills needed for adequate application of cognitive potential to real-world scenarios, including communication, practical, and social skills (Gardiner & Jarocci, 2017). Levels of EF have been shown to correlate with adaptive skills in children as young as preschool (Loe, Chatay, & Alduncin,

2015) and into early adolescence (Clark, Prior, & Kinsella, 2002). This relationship has also been shown in children with autism spectrum disorder (ASD) (Gilotty, Kenworthy, Sirian, Black, & Wagner, 2002; Pugliese et al., 2015), with one study indicating that, when measured longitudinally, earlier levels of EF problems have been found to contribute to lower levels of future adaptive behaviour for children with ASD (Pugliese et al., 2016). Gardiner and Jarocci (2017), however, found that for children ages five to 13, EFs (mainly metacognitive processes) were predictive of adaptive behaviour for both children with and without ASD, suggesting that this relationship is not exclusive to children with ASD.

Associations between adaptive skills and certain behaviour problems have also been found. Young children with high levels of disruptive behaviour (such as high levels of aggression), for example, tend to also demonstrate impaired social skills in comparison to those without disruptive or aggressive behaviour (Brennan, Shaw, Dishion, & Wilson, 2015). Adaptive skills have also been linked to self-regulation, depression, and anxiety in children ages eight to 18 (Buckner, Mezzacappa, & Beardslee, 2009). Furthermore, children and adolescents with ADHD tend to have lower levels of adaptive skills such as communication, socialization, and daily living skills (Balhoni, Incognito, Belacchi, Bonichini, & Cubelli, 2017; Clark, Prior, & Kinsella, 2002), as well as higher levels of externalizing behaviour problems (Schoemaker et al., 2013), suggesting a possible relationship between these two factors. Overall, the extent to which adaptive skills can have a predictive impact on internalizing and externalizing behaviour problems in non-clinical populations remains unclear.

The Present Study

The present study aimed to further explore the relationships among inhibition, working memory, shift, adaptive skills, sex, age, and both internalizing and externalizing behaviour problems in kindergarten and first grade children. Although literature surrounding the relationship between inhibition and externalizing behaviour problems is fairly consistent, heterogeneity in the literature surrounding how shifting and working memory relate to externalizing behaviour problems, how each of the EFs relate to internalizing behaviour problems, and how they relate to children with both internalizing and externalizing problems remains. One study, for example, found that young children with internalizing behaviour problems do not possess any deficits in EF (Blanken et al., 2017).

Furthermore, research in this area remains primarily measured in both older children and children in clinical populations, such as children with ADHD or ASD, and tends to use broad age ranges. This creates a gap in relation to the typical classroom alongside children of a younger age. Identifying patterns related to both impaired cognition and emerging psychopathology at a young age may provide valuable information in relation to the etiology of behaviour problems and early intervention practices. Identifying these patterns at a young age within the general population as opposed to clinical populations may be particularly useful in relation to informing early intervention practices, as many individual clinical assessments have historically occurred during the later primary/junior years (Ontario Psychological Association, 2018), and neuropsychological assessments are often not conducted until the later school years (Baron & Anderson, 2012). Deficits and treatment plans may therefore not yet be known during this time period; in this case, understanding the relationships between behaviour problems and cognitive capacities found amongst the general population may aid practitioners in choosing which EF should be targeted.

Additionally, studies examining EF and behaviour typically use correlated, continuous internalizing or externalizing variables; when looking at behaviour problems in children, however, recent studies have consistently identified four different psychopathological profiles: children with high levels of externalizing behaviour problems (EXT), children with high levels of internalizing behaviour problems (INT), children with both internalizing and externalizing problems (COMB), and children within the typical or normal range for behaviour problems (NORM) (Basten, 2013; Bianchi et al., 2017; Blanken et al., 2017; Willner, Gatzke-Kopp, & Bray, 2016). Although these profiles continuously emerge, to the best of this author's knowledge, no study to date has examined how the three main EFs relate to each group. Understanding how various EFs relate to each behaviour group will also add specificity in relation to the etiology of both internalizing and externalizing behaviour problems separately, as well as combined, and can better inform targeted intervention practices for each group.

The present study examined the relationship between the three main subcomponents of EF (inhibition, working memory, and shift), adaptive skills, age, sex, and internalizing and externalizing behaviour problems in kindergarten and first grade children, using the four behaviour groups discussed above. In order to obtain a more comprehensive picture of this relationship, three research questions were addressed. The first research question was: are there differences in the levels of executive functioning and adaptive skills across the four behaviour groups? Consistent with previous research, it was hypothesized that there would be differences in the levels of EF across the four behaviour groups. Specifically, the EXT, INT, and COMB groups would possess higher levels of EF deficits in comparison to the NORM group. Furthermore, it was hypothesized that the INT and COMB groups would have higher shifting or working memory deficits in comparison with the EXT group (Gathercole et al., 2008), and the EXT and COMB groups would have higher levels of inhibition deficits in comparison to the INT group.

The second research question was: to what extent are executive functions predictive of behaviour group membership in children? Additionally, do variables such as adaptive skills, sex, or age add to the prediction of group membership? Consistent with the research described above, it was hypothesized that all three EFs would play a predictive role in relation to group membership, with inhibition playing the most significant role in the EXT and COMB groups, whereas shifting or working memory would be more predictive of INT group membership.

As discussed above, adaptive skills have been linked to EF scores (Gardiner & Iarocci, 2017; Loe et al., 2015), wherein early EF may be predictive of later adaptive functioning in children. Due to this, it was hypothesized that adaptive skills would be univariately predictive of group membership, but no longer predictive when EF scores are taken into account, as EF scores may underlie adaptive skills. Due to the social differences between sexes, it is hypothesized that this may play a confounding role in the predictive ability of EF in relation to behaviour problems. Specifically, externalizing behaviour problems may be more frequently reported for boys as opposed to girls, making boys more likely to be placed in the groups associated with high externalizing behaviour problems. Lastly, due to internalizing behaviour problems peaking later in comparison to externalizing behaviour problems, it was predicted that older children may be more likely to be placed in the groups associated with high levels of internalizing behaviour problems.

The third research question for this study was: does taking a person-oriented view add any additional information when looking at executive functioning and behaviour? Person-oriented approaches to data analysis focus on homogeneous subgroups of individuals and are beneficial in circumstances where results may differ across individuals, such as in school settings (von Eye et al., 2006). Taking a person-oriented view can often produce different results in comparison to a variable-oriented view, and may provide valuable information in order to understand a more complete picture of how EF is related to behaviour problems.

Methods

Participants

For the present study, data from a larger project aimed at evaluating the effectiveness of a social-emotional learning and mindfulness program was used. The data were derived from fifty-five junior/senior kindergarten (JK/SK) and grade one classrooms across seventeen schools in a Southwestern Ontario school board. The majority of children (63.9%) in the sample were identified as White. Other ethnicities within the sample included: Latin American (5.4%), South Asian (3.0%), West Asian (0.1%), Korean (0.2%), Black (1.9%), Filipino (1.2%), Arab (1.0%), Southeast Asian (0.2%), Aboriginal/First Nations/Metis/Inuit (0.1%), Chinese (0.5%), and Other (13.9%). Additional participant characteristics can be found in Table 1.

Table 1

Variables		Frequency (%)
Sex		
	Male	380 (48.1)
	Female	409 (51.8)
Age		
	3 years	29 (3.7)
	4-5 years	632 (80)
	6-7 years	122 (15.4)

Measures

Behaviour Assessment System for Children - Third Edition (BASC-3). The BASC-3 (Reynolds & Kamphaus, 2015) teacher rating scale was used to obtain both adaptive skills scores and scales for both internalizing and externalizing behaviour problems. The BASC-3 preschool version (ages two through five years) and the child version (ages six through eleven years) were used, depending on the age of the child. The BASC-3 is composed of 105 questions in which teachers respond using a four-point scale (from 0 – never to 3 – almost always). These questions yield ten clinical scales to measure maladaptive behaviour (aggression, anxiety, attention problems, atypicality, conduct problems, depression, hyperactivity, learning problems, somatization, and withdrawal) and six adaptive scales (activities of daily living, adaptability, functional communication, leadership, social skills, and study skills). These scales then form composite scales of externalizing behaviour problems, internalizing behaviour problems, and adaptive skills, which were the scales used in this study. The composite scales are described in further detail below.

The BASC-3 generates a composite scale of externalizing behaviour problems that is comprised of the aggression and hyperactivity subscales for the preschool age, with the addition of the conduct problems subscale for the school age composite scale. Aggression is defined as the tendency to act in a hostile manner (physical or verbal) that is threatening to others. Hyperactivity is defined as the tendency to be overly active, rush through work or activities, and act without thinking. Conduct problems is defined as the tendency to engage in antisocial and rule-breaking behaviour, including destroying property.

For both age groups, the internalizing behaviour problems composite scale is comprised of anxiety, depression, and somatization subscales. Anxiety is defined as the tendency to be nervous, fearful, or worried. Depression is defined as feelings of unhappiness, sadness, and stress that may result in an inability to carry out everyday activities or may bring on thoughts of suicide. Somatization is defined as the tendency to be overly sensitive to and complain about relatively minor physical problems and discomforts.

For the adaptive skills composite scale, adaptability, social skills, and functional communication subscales were used for the preschool age, with leadership and study skills added on to the school age scale. Adaptability is defined as the ability to adapt readily to changes in the environment. Social skills are defined as the skills necessary for interacting successfully with peers and adults in home, school, and community settings. Functional communication is defined as the ability to express ideas and communicate in a way others can easily understand. Leadership is defined as the skills associated with accomplishing academic, social, or community goals, including the ability to work with others. Lastly, study skills refer to the skills that are conducive to strong academic performance, including organizational skills and good study habits.

According to Reynolds and Kamphaus (2015), the internal consistency levels, test-retest reliability, reliability coefficients, and interrater reliability for the composite scales of the BASC-3 TRS are excellent, with reliability coefficients ranging from .89 to .98 across all ages. Reliability coefficients for the data set used in this study were in line with previous results, wherein Cronbach's alpha scores ranged from .91 to .93 for the BASC preschool composite scales, and from .95 to .98 for the BASC child composite scales.

Behaviour Rating Inventory of Executive Functioning (BRIEF-P and BRIEF2). The BRIEF teacher rating scale (TRS; BRIEF-Preschool version or BRIEF2 child version) was used to obtain EF scores, depending on the age of the child. The BRIEF-P (Gioia, Espy & Isquith, 2003) is designed for children aged two years to five years 11 months, and the BRIEF2 (Gioia, Isquith, Guy, & Kenworthy, 2000) is designed for children ages 5-18. The BRIEF2 is a standardized, 63 item measure that includes nine clinical scales: Inhibit, Self-Monitor, Shift, Emotional Control, Initiate, Working Memory, Task Monitor, Plan/Organize, and Organization of Materials. These subscales yield three broad indexes (Behavioural Regulation Index, Emotion Regulation Index, and Cognitive Regulation Index) and one composite score (Global Executive Composite). Each question is rated on a 3-point scale as either “never”, “sometimes”, or “often”. Although the BRIEF-P is similar in structure to the BRIEF2, one key difference is that the BRIEF-P yields only five clinical scales: Inhibit, Shift, Emotional Control, Working Memory, and Plan/Organize.

Three scales were used from the BRIEF-P and the BRIEF2 to assess the three main subcomponents of executive functioning: the inhibition, shift, and working memory scales. The inhibit scale refers to impulse control and stopping/modulating behaviour. The shift scale refers to the ability to shift from one activity to another or solve problems flexibly. The working memory scale refers to the process of holding information in mind for the purposes of completing a task and staying with an activity.

According to Gioia et al. (2000), for the BRIEF2, the three scales used in this study demonstrate high levels of internal consistency, with Cronbach’s alpha scores ranging from .88 to .93. The three scales also possess good test-retest reliability, with correlation coefficients ranging from .83 to .87, and good interrater reliability, with scores ranging from .55 to .71 between parent and teacher ratings. For the BRIEF-P, internal consistency levels are high, with Cronbach’s alphas for the three BRIEF-P clinical scales ranging from .90 to .94 (Gioia et al., 2003). The three scales also possess adequate test-retest reliability, with correlation coefficients ranging from .65 to .94. Reliability coefficients for the data set used in this study were in line with previous results, wherein Cronbach’s alpha scores ranged from .91 to .96 for the BRIEF preschool scales, and from .90 to .94 for the BRIEF child scales.

Procedure

This study drew from the research obtained through a larger study aimed at evaluating a social-emotional learning and mindfulness program in elementary school settings. The Western University Non-Medical Research Ethics Board approved the research project and protocols (see Appendix A and Appendix B). In addition, the study was approved by the research department of the school board. A total of 789 students (ranging from junior kindergarten to grade one) were included in this study. Parental/guardian consent was obtained for each child participating. As part of the larger study, either a classroom teacher or an early childhood educator (for junior and senior kindergarten only) filled out the Behaviour Assessment System for Children – Third Edition (BASC-3) and either the Behaviour Rating Inventory of Executive Function-Second Edition (BRIEF2) or the Behaviour Rating Inventory of Executive Function – Preschool Version (BRIEF-P) for each child in the classroom that was enrolled in the research study. A demographic questionnaire for each child was also completed by a parent/guardian in order to obtain sociodemographic characteristics of the children and families.

Data Analysis

In order to obtain four behaviour groups within the data, the clinical cut-offs set by the developers of the BASC-3 were used. Specifically, according to Reynolds and Kamphaus (2015), t-scores of 60 or higher on the externalizing and internalizing behaviour problems composite scores indicate children displaying at-risk-to-clinical levels of behaviour problems. Scores at or above 60 therefore indicated a 'high' score, placing participants in the group associated with that score.

Firstly, a one-way ANOVA was used to assess whether differences in EF and adaptive skills exist across the four behaviour groups. Secondly, a multinomial logistic regression was used to assess which subcomponents of EF were predictive of group membership, alongside the predictive ability of adaptive skills, age, and sex. For this analysis, behaviour group was the dependent variable, with the EF subcomponents (inhibit, shift, and working memory) and the adaptive skills composite score, age, and sex entered as independent variables.

Lastly, a two-step cluster analysis followed by a cross-tabulation with the four behaviour categories was used to assess whether, when taking a person-oriented view, similar results are seen in comparison to the variable-oriented view. Cluster analyses assign individuals exclusively to a group in which they are most similar and utilize a person-oriented approach to data analysis (DiStefano & Kamphaus, 2006).

Results

Research Question #1: Are there differences in the levels of executive functioning and adaptive skills across the four behaviour groups?

A one-way ANOVA was used to assess whether differences exist across the four behaviour groups in relation to executive functioning and adaptive skills. For this analysis, behaviour category was the independent variable. Inhibition, shift, working memory, and adaptive skills t-scores were used as dependent variables. Prior to conducting the analysis, the relevant assumptions of this statistical analysis were tested. The independence of observations assumption was violated based on the inherent clustering created by classroom teachers entering the data for children in their classroom, as children were clustered within classes and were assessed by the same individual. The assumption of homogeneity of variances, based on Levene's test of homogeneity, was also violated for three of the five independent variables: shift ($p = < .001$), working memory ($p = .036$), and GEC ($p = .005$). Additionally, the assumption normality of independent variables across the dependent variable was violated. Lastly, outliers were identified on three of the independent variables. Welch's ANOVA was used with the Games-Howell post hoc in order to address the violation of homogeneity, as Welch's ANOVA is uniquely designed to account for this violation (Liu, 2015). The dataset was also bootstrapped in order to address outliers and normality violations.

As shown in Table 2, significant differences were found between the four behaviour groups in relation to inhibition (*Welch's F*(3,94.87) = 181.64 , *p* = < .001), shift (*Welch's F*(3,87.55) = 86.03 , *p* = < .001), working memory (*Welch's F*(3,92.29) = 54.32 , *p* = < .001), and GEC (*Welch's F*(3,91.44) = 136.63 , *p* = < .001). Specifically, the NORM group (*M* = 53.7, *SD* = 8.4) had higher levels of adaptive skills in comparison to the EXT (*M* = 45.8, *SD* = 7.7, *p* = < .001), INT (*M* = 45.7, *SD* = 8.7, *p* = < .001), and COMB group (*M* = 38.1, *SD* = 7.1, *p* = < .001). The COMB group had significantly lower levels of adaptive skills in comparison to the INT (*p* = < .001) and EXT (*p* = < .001) group. There were no significant differences between the INT and EXT group in relation to levels of adaptive skills (*p* = 1.00).

The NORM group (*M* = 49.5, *SD* = 9.3) had lower levels of inhibition deficit in comparison to the EXT (*M* = 75.6, *SD* = 10.2, *p* = < .001), INT (*M* = 54.8, *SD* = 10.4, *p* = < .001), and COMB (*M* = 73.0, *SD* = 8.2, *p* = < .001) groups. The EXT group had higher inhibition deficits in comparison to the INT group (*p* = < .001) but did not differ significantly from the COMB group (*p* = .566). The COMB group had higher inhibition deficits in comparison to the INT group (*p* = < .001).

In relation to shift, there were significant differences across all four behaviour groups. Specifically, the NORM group (*M* = 46.8, *SD* = 7.8) had lower levels of shift deficit in comparison to the EXT (*M* = 52.4, *SD* = 11.7, *p* = < .01), INT (*M* = 62.8, *SD* = 13.2, *p* = < .001, and COMB (*M* = 74.5, *SD* = 13.3, *p* = < .001) groups. The INT group had higher levels of shift deficits in comparison to the EXT group (*p* = <. 001), and lower deficits in comparison to the COMB group (*p* = < .001). The EXT group also had lower shifting deficits in comparison to the COMB group (*p* = < .001).

The NORM group (*M* = 52.2, SD = 11.4) had lower levels of working memory deficit in comparison to the EXT (*M* = 67.8, *SD* = 12.9, *p* = < .01), INT (*M* = 60.4, *SD* = 13.2, *p* = <

.001, and COMB (*M* = 72.9, *SD* = 12.8, $p = < .001$) group. In comparison to the INT group, the EXT ($p = < .01$) and COMB ($p = < .001$) groups had higher working memory deficits. The EXT and COMB group did not differ significantly ($p = .276$) in relation to their levels of working memory deficit.

There were statistically significant differences across all behaviour groups in relation to GEC. Specifically, the NORM group (*M* = 49.6, *SD* = 9.7) had lower levels of GEC deficits in comparison to the INT (*M* = 61.5, *SD* = 11.7, $p = < .001$), EXT (*M* = 69.6, *SD* = 12.0, $p = < .001$), and COMB (*M* = 80.1, *SD* = 11.2, $p = < .001$) group. The INT group had lower levels of GEC deficits than the EXT ($p = < .001$) and COMB group ($p = < .001$). The COMB group had higher levels of GEC deficits in comparison to the EXT group ($p = < .001$).

Table 2

One-Way ANOVA Comparing Independent Variables across Behaviour Groups

	NORM[a] *M (SD)*	EXT[b] *M (SD)*	INT[c] *M (SD)*	COMB[d] *M (SD)*	Comparison Statistic
Adaptive skills	53.7 (8.4)[b,c,d]	45.8 (7.7)[a,d]	45.7 (8.7)[a,d]	38.1 (7.1)[a,b,c]	F (3, 96.99) = 73.19***
Inhibit	49.5 (9.3)[b,c,d]	75.6 (10.2)[a,c]	54.8 (10.4)[a,b,d]	73.0 (8.2)[a,c]	F (3, 94.87) = 181.64***
Shift	46.8 (7.8)[b,c,d]	52.4 (11.7)[a,c,d]	62.8 (13.2)[a,b,d]	74.5 (13.3)[a,b,c]	F (3, 87.55) = 86.03***
Working memory	52.2 (11.4)[b,c,d]	67.8 (12.9)[a,c]	60.4 (13.2)[a,b,d]	72.9 (12.8)[a,c]	F (3, 92.29) = 54.32***
GEC	49.6 (9.7)[b,c,d]	69.6 (12.0)[a,c,d]	61.5 (11.7)[a,b,d]	80.1 (11.2)[a,b,c]	F (3, 91.44) = 136.63***

Superscript denotes column of profile from which group differs significantly (e.g. ‘a’ denotes difference from NORM group)
*** $p < 0.001$

Research Question #2: To what extent are executive functions predictive of behaviour group membership in children? Do variables such as adaptive skills, sex, or age add to the prediction of group membership?

A multinomial logistic regression (MLR) was used to measure the predictive power of executive functions, age, sex, and adaptive skills on behaviour group membership. For this analysis, behaviour category was the dependent variable. Inhibition, working memory, shift, adaptive skills, and global executive composite (GEC) t-scores were used as continuous independent variables. Age and sex were treated as covariates and were both categorical variables.

MLR Assumptions. Prior to conducting the analysis, the relevant assumptions of this analysis were tested. The dependent variable for this analysis was behaviour group, which was coded to be a nominal variable. There were both continuous (EF and adaptive skills) and categorical (age and sex) variables loaded onto the regression model. As previously stated, the assumption of independence of observations was violated due to the inherent clustering created through data being collected by teachers in classroom settings. Due to this, results must be interpreted with caution. In relation to multicollinearity, although the independent variables were correlated (see Table 3), multiple linear regressions were run in order to obtain a more robust assessment of collinearity through assessing the VIF and Tolerance scores. No scores possessed VIF scores near or above five, with all VIF scores being less than 2.5, and all Tolerance levels were higher than .2, indicating that the variables were moderately correlated, but not enough to cause concern.

Table 3

Inter-Correlations between Predictor Variables (r)

Variables	1	2	3	4	5
Inhibition (1)	-	.445***	.703***	.863***	-.477***
Shift (2)	-	-	.521***	.719***	-.545***
Working Memory (3)	-	-	-	.896***	-.634
Global Executive Composite (4)	-	-	-	-	-.662***
Adaptive Skills (5)	-	-	-	-	-

***Correlation significant at <.001 level (2-tailed)

In order to assess the linearity of the logit, squared variables were created, and univariate multinomial logistic analyses were run in order to test for a quadrilateral relationship between the squared variable when entered alongside the original variable; the squared variable was significant for working memory only, indicating that a linear relationship was present for all other variables. Lastly, outliers were identified for each of the continuous independent variables. In order to address this, outliers were taken out of the dataset, and analyses were run again. Interpretation of results did not change due to the absence of outliers, with one exception, which is discussed in the multivariate regression results.

Univariate Analyses. Univariate analyses indicated that age, sex, adaptive skills, and each executive function were associated with group membership for the EXT, INT, and COMB groups. Specifically, males were approximately two times (OR = 2.05) more likely to be in the EXT group and were 36% (OR = 1.36) more likely be placed in the COMB group in comparison to females. Students aged four-to-five were 47% (OR = 0.53) less likely to be in the INT group compared to those aged six-to-seven.

Analyses were adjusted for age and sex in order to account for the effect both variables had on group membership. Adjusted and unadjusted odds ratios and confidence intervals are provided in Table 4. Unadjusted results showed that shifting had the greatest impact on INT group membership, inhibition had the greatest impact on EXT group membership, and inhibition, followed closely behind by shifting, had the greatest impact on COMB group membership. In both models, increases in adaptive skills were associated with decreases in the likelihood of students being placed in any of the three behaviour categories.

Table 4

Odds Ratios and Confidence Intervals of Univariate Multinomial Logistic Regressions

	Unadjusted			Adjusted		
	Group 2 (EXT)	Group 3 (INT)	Group 4 (COMB)	Group 2 (EXT)	Group 3 (INT)	Group 4 (COMB)
Adaptive skills[b]	0.89 (0.86, 0.92)	0.89 (0.87, 0.92)	0.80 (0.76, 0.84)	.88 (.85, .92)	.90 (.87, .92)	.79 (.75, .83)
Inhibition[b]	1.26 (1.20, 1.31)	1.05 (1.03, 1.08)	1.22 (1.17, 1.30)	1.25 (1.20, 1.31)	1.05 (1.02, 1.07)	1.22 (1.17, 1.28)
Shift[b]	1.07 (1.04, 1.09)	1.13 (1.11, 1.17)	1.20 (1.16, 1.24)	1.06 (1.04, 1.93)	1.13 (1.11, 1.16)	1.20 (1.16, 1.24)
Working memory[b]	1.09 (1.07, 1.13)	1.05 (1.03, 1.07)	1.12 (1.09, 1.15)	1.09 (1.07, 1.11)	1.05 (1.03, 1.07)	1.12 (1.09, 1.15)
GEC[b]	1.15 (1.12, 1.18)	1.10 (1.07, 1.12)	1.24 (1.18, 1.29)	1.15 (1.12, 1.19)	1.10 (1.07, 1.12)	1.24 (1.19, 1.30)

[a]*Base category in multinomial regression is NORM.*
[b] *Estimates are expressed as Odds Ratio (95% Confidence intervals [OR (95% CIs)])*
* *All ORs are significant at the 0.01 level*
* Adjusted ORs are adjusted for age and sex

Multivariate Analysis. A multivariate multinomial logistic regression analysis with all independent variables and covariates was conducted in order to assess overall predictor impact on group membership (see Table 5). Notably, the odds of students being in the EXT and COMB group decreased by 8% (OR = .92) per one-unit increase in working memory deficit; this relationship was almost significant for the INT group (p = .053). This inverse relationship may be due to the high collinearity of inhibition and working memory (r = .7). The model was ran again without inhibition in order to assess this relationship, and working memory was again associated with increased likelihood of group membership. The model fit, however, decreased dramatically by removing inhibition. The model was therefore ran again with working memory removed; this model had a comparable model fit to the full model, and the effect of inhibition on group membership was reduced, suggesting that inhibition may have absorbed the shared variance with working memory. Due to the high collinearity between working memory and inhibition, the working memory linearity of the logit assumption violation, comparable model fitting information with working memory removed, and similar interpretations of results without working memory in the model, the final model excluded working memory.

In the final model (see Table 6), results indicated that inhibition and sex were predictors of EXT group membership. Adaptive skills was approaching significance for this group (p = .051), and, when outliers were removed, adaptive skills became a significant predictor of EXT group membership (p = .01). Specifically, the odds of participants being in the EXT group increased by 28% (OR = 1.28) per one-unit increase in inhibition deficit score. Males were also 2.9 times more likely to be in the EXT group in comparison to females. Shift and adaptive skills were predictors of INT group membership, wherein the odds of students being in the INT group increased by 12% (OR = 1.12) per one-unit increase in shifting deficit and decreased by 4% per one-unit increase in adaptive skills. Inhibition, shift, and adaptive skills were predictive of COMB group membership. Specifically, the odds of students being in the COMB group increased by 13% (OR = 1.13) per one-unit increase in inhibition deficit, and 11% (OR = 1.11) per one-unit increase in shifting deficit. The odds of students being in the COMB group decreased by 11% per one-unit increase in adaptive skills.

Table 5

Parameter Estimates in the Initial Multivariate Multinomial Logistic Regression (N =712)

	B (SE)	Wald χ2 (*df* = 1)	*p*	OR [95% CI]
EXT				
Working Memory	-.080 (.024)	11.417	.001	.923 (.88, .97)
Inhibition	.305 (.038)	65.163	.000	1.36 (1.26, 1.46)
Shift	-.027 (.025)	1.148	.284	.97 (.93, 1.02)
Adaptive Skills	-.125 (.039)	10.247	.001	.882 (.82, .95)
Age				
3-4	-.136 (1.106)	.015	.902	.87 (.10, 7.62)
4-5	-.674 (.551)	1.495	.221	.51 (.17, 1.5)
Sex	1.316 (.487)	7.311	.007	3.73 (1.44, 9.68)
INT				
Working Memory	-.032 (.017)	3.750	.053	.968 (.94, 1.00)
Inhibition	.015 (.017)	.814	.267	1.02 (.98, 1.1)
Shift	.120 (.015)	67.998	.000	1.13 (1.10, 1.16)
Adaptive Skills	-.058 (.021)	7.712	.005	.94 (.91, .98)
Age				
3-4	.694 (.790)	.772	.380	2.00 (.43, 9.43)
4-5	.103 (.416)	.062	.804	1.11 (.49, 2.50)
Sex	.070 (.288)		.807	1.07 (.61, 1.89)
COMB				
Working Memory	-.083 (.027)	9.474	.002	.92 (.87, .97)
Inhibition	.171 (.032)	27.996	.000	1.19 (1.11, 1.27)
Shift	.127 (.024)	28.203	.000	1.14 (1.08, 1.19)
Adaptive Skills	-.178 (.043)	16.797	.000	.84 (.77, .91)
Age				
3-4	.576 (1.413)	.166	.684	1.78 (.11, 28.36)
4-5	-.092 (.698)	.018	.895	.91 (.23, 3.58)
Sex	1.136 (.562)	4.093	.043	3.12 (1.04, 9.37)

[a] *Base category in multinomial regression is NORM.*

Table 6

Parameter Estimates in the Final Multivariate Multinomial Logistic Regression (N =712)

	B (SE)	Wald χ2 (*df* = 1)	*p*	OR [95% CI]
EXT				
Inhibition	.247 (.030)	68.657	.000	1.28 (1.21, 1.36)
Shift	-.042 (.024)	3.037	.081	.96 (.92, 1.01)
Adaptive Skills	-.065 (.033)	3.811	.051	.94 (.88, 1.00)
Age				
3-4	-.438 (1.007)	.189	.663	.65 (.09, 4.65)
4-5	-.823 (.539)	2.330	.127	.44 (.15, 1.26)
Sex	1.065 (.459)	5.376	.020	2.90 (1.18, 7.13)
INT				
Inhibition	-.005 (.015)	.109	.742	.995 (.97, 1.02)
Shift	.111 (.014)	64.638	.000	1.12 (1.09, 1.15)
Adaptive Skills	-.037 (.018)	4.205	.040	.96 (.93, .99)
Age				
3-4	.559 (.782)	.551	.475	1.75 (.38, 8.09)
4-5	.083 (.412)	.040	.841	1.09 (.48, 2.44)
Sex	-.038 (.281)	.018	.893	.96 (.55, 1.67)
COMB				
Inhibition	.118 (.026)	20.842	.000	1.13 (1.07, 1.18)
Shift	.102 (.022)	21.311	.000	1.11 (1.06, 1.16)
Adaptive Skills	-.120 (.039)	9.336	.002	.89 (.82, .96)
Age				
3-4	-.046 (1.345)	.001	.973	.96 (.07, 13.34)
4-5	-.316 (.662)	.228	.633	.73 (.20, 2.66)
Sex	.776 (.524)	2.190	.139	2.17 (.78, 6.07)

[a] *Base category in multinomial regression is NORM.*

A test of the full model versus a model with intercept only was statistically significant, χ^2 (21, N = 712) = 506.151, Nagelkerke R^2 = .64, $p < .001$. Compared to the EF only model (χ^2 (9, N = 712) = 497.49, Nagelkerke R^2 = .66 $p < .001$), adding age, sex, and adaptive skills into the final model only provided a slight improvement in relation to the model fit. In the final model, age and sex were no longer significant predictors (see Table 7).

Table 7

Predictors Unique Contributions in the Final Multivariate Multinomial Logistic Regression (N =712)

Predictor	χ^2	*df*	*p*
Inhibition	198.020	3	< 0.001
Shift	112.922	3	< 0.001
Adaptive Skills	14.461	3	< 0.01
Age	2.993	6	.810
Sex	7.203	3	.066

For each case, one could predict group membership by taking into account only the base rates of group membership. Using the current logistic model to make such predictions resulted in 83.0% correct prediction, which compares favourably to the null model, which would result in 75.7% of such predictions being correct. Correct predictions were most frequent for the EXT group (61.8%), followed by the COMB group (50.0%). Correct predictions were the least frequent for the INT group (27.4%).

In relation to specificity, or the ability to correctly identify those not in the NORM group, 56.6% of cases were correctly identified. In relation to sensitivity, or the ability to correctly identify those who were in the NORM group, 94.1% of cases were correctly identified. For the EXT group, the model was able to correctly identify 97.6% of cases that were not in this group, and 64.6% of cases that were in the EXT group. For the INT group, the model was able to correctly identify 96.8% of those not in the INT group, and 41.6% of those in the INT group. For the COMB group, the model was able to correctly identify 99.3% of those not in the COMB group, and 33.3% of those in the COMB group.

Predictor Strength. In order to better assess predictor strength, an additional multinomial logistic regression using standardized residuals was employed. Standardized residuals were used in order to account for distribution differences across the independent variables; it does so by transforming each variable in order to have a $M = 0$, $SD = 1$. Results indicated that inhibition was the strongest predictor of EXT (OR = 33.60) and COMB (OR = 7.72) group membership and shifting (OR = 4.96) was the strongest predictor of INT group membership. When using standardized residuals, working memory was no longer predictive of INT or COMB group membership. Working memory inversely predicted EXT group membership, wherein for each standardized residual unit increase in working memory deficit, the likelihood of students being in the EXT group decreased (OR = .52).

Research Question #3: Does taking a person-oriented view add any additional information when looking at executive functioning and behaviour?

A two-step cluster analysis was used to examine what natural EF clusters exist in the dataset. A cross-tabulation was then used in order to examine behaviour group membership among clusters. The two-step cluster analysis is ideal for larger datasets; however, the results are dependent on the order of the data in the data set (Hand & Singh, 2014). The dataset was therefore rearranged, and the analysis was run four separate times. Results remained consistent throughout each rearrangement. Both assumptions of the two-step cluster analysis were violated; however, this procedure is fairly robust to these violations (IBM Knowledge Center, 2019).

Cluster analysis divided participants into two groups: 1) a group within the normal range for inhibition (*M* = 47.4), working memory (*M* = 48.3), and shift (*M* = 45.7), and 2) a group with elevated levels of inhibition (*M* = 67.7) working memory (*M* = 71.7), and shifting (*M* = 61.9) deficits. Working memory was the strongest predictor of cluster group (1.00), followed by inhibition, (0.64) and finally shift (0.45). A One-Way ANOVA was conducted in order to assess whether significant differences exist across each of the EF variables used in the cluster analysis. As this analysis utilized the same variables as the previous one-way ANOVA, identical assumption violations occurred. Welch's ANOVA was therefore used to correct for the violation of the homogeneity of variance assumption, and the dataset was bootstrapped to address outlier and normality assumption violations. Results showed that significant differences existed between the two cluster groups in relation to inhibition (*Welch's* $F(1{,}287.34) = 578.49$, $p = < .001$), shift (*Welch's* $F(1{,}252.36) = 231.35$, $p = < .001$), and working memory (*Welch's* $F(1, 289.30) = 845.50$, $p = < .001$).

In relation to the overall quality of the cluster solution (i.e. goodness-of-fit), as indicated by the silhouette measure of cohesion and separation, the cluster solution was 0.6, indicating a good cluster solution. A secondary benefit of the two-step cluster analysis is that it allows the researcher to specify a fixed number of clusters in order to compare cluster quality. For this project, three, four, and five cluster solutions were explored; however, the two-cluster solution had the highest goodness-of-fit, with each of the specified cluster analyses producing only 'fair' cluster solutions (0.5).

When looking at behaviour grouping across the two clusters, most of the participants within the normal range of EF were not exhibiting behaviour problems (see Table 8). Additionally, there were more participants with elevated EF in the behavioural categories. There were, however, students with elevated levels of executive functioning that do not exhibit behaviour problems. Conversely, there were students within the normal range of executive functioning exhibiting behaviour problems.

Table 8

Cross-Tabulation of Two-Step Cluster Analysis Group by Behaviour Group (N)

	NORM	EXT	INT	COMB
Normal Range	456	8	39	2
% within behaviour group	84%	14.5%	46.4%	5.9%
Elevated	82	47	45	32
% within behaviour group	15.2%	85.5%	53.6%	94.1%

Discussion

Both executive functioning and behaviour problems are important constructs in and outside of the classroom. Early deficits in EF have been linked to factors such as lower levels of academic achievement (Lubin et al., 2016) and poorer emotional functioning (Espy et al., 2011). EF problems in early childhood are also predictive of EF problems later in life, and these deficits can become larger over time if not addressed (Diamond, 2012). Behaviour problems can impede learning and social opportunities (Ogundale, 2018) and predispose children to future psychopathology (Blanken et al., 2017). Furthermore, behaviour problems in young children have been linked to lower levels of school adjustment and school readiness, alongside negative long-term academic and social outcomes (Graziano et al., 2016). Early emergence of behaviour problems also tend to be predictive of future adolescent behaviour problems (Janus, 2009). These associations suggest that providing a complete picture of how these variables interact at a young age is integral to promoting positive future outcomes for youth. The objective of the present study was to further investigate the relationships across EF, adaptive skills, and behaviour problems in young children in order to gain a more thorough understanding of the etiology of behaviour problems, and to therefore inform targeted early intervention practices. This study addressed the current gaps in research in relation to how these variables interact in younger children and in the typical classroom. The study was also the first to explore how adaptive skills and various EFs are related to each of the four behaviour groups identified in the literature through both person and variable oriented perspectives.

Results showed that all four behaviour groups presented with different levels of EF and adaptive skills. As expected, the COMB group possessed the highest levels of EF deficits alongside the lowest levels of adaptive skills, whereas the NORM group had the lowest EF deficits and the highest levels of adaptive skills, solidifying a clear relationship across deficits in EF, adaptive skills, and behaviour group membership in young children. Additionally, the EXT group had higher inhibition and working memory deficits compared to INT group, and the INT group had higher levels of shifting deficits in comparison to the EXT group. These results were the first in this study to suggest a relationship between shift and internalizing behaviour problems, and inhibition and externalizing behaviour problems.

Univariate analyses indicated that all EFs, age, sex, and adaptive skills were each individually predictive of behaviour group membership. Specifically, boys were approximately two times more likely to be placed in the EXT group and were 36% more likely to be placed in the COMB group in comparison to girls. This is in line with previous research suggesting that boys exhibit more externalizing behaviour problems in comparison to girls (Raaijmakers et al., 2008; Schoemaker et al., 2013). Sex also remained a predictor of group membership for the EXT and COMB group even when taking into account differences in EF, suggesting that there were other factors beyond EF that contribute to boys exhibiting more externalizing behaviour problems in comparison with girls. As previously discussed, this may be due to socialization differences between males and females, wherein females typically engaging in covert aggression that may go unnoticed by teachers, versus males typically engaging in overt aggression, which is more noticeable to teachers. This may therefore create a stronger relationship between males and externalizing problems (Crick et al., 1997, as cited in Spann & Gagne, 2016). Additionally, in the univariate analysis, students aged four-to-five were 47% less likely to be in the INT group compared to those aged six-to-seven. This is consistent with previous research stating that internalizing behaviour problems tend to increase with age, as opposed to externalizing behaviour problems (Korhonen, 2014).

In the final model, both inhibition and shift remained predictors of group membership. For the EXT group, inhibition predicted group membership, wherein for each one-unit increase in inhibition deficit, the likelihood of children being in the EXT group increased by 28%. Shift no longer predicted EXT group membership, suggesting that a large proportion of the previous impact of shifting on behaviour group can be explained by the impact of inhibition. In the initial model, working memory had an inverse relationship with EXT group membership, wherein for each one-unit increase in working memory deficit, the likelihood of children being in the EXT group decreased by 8%. Possible reasons for this inverse relationship are discussed further below.

As shifting no longer predicted EXT membership, results suggest that, of the EFs measured, only inhibition deficits increased the likelihood of EXT group membership. This is consistent with previous research indicating a strong relationship between inhibition and externalizing behaviour problems across youth populations (Spann & Gagne, 2016; Utendale & Hastings, 2011). Being male also remained a significant predictor of EXT group membership, wherein males were approximately three times more likely to be in the EXT group in comparison to females in the final model, even when accounting for differences in EF and adaptive skills.

For the INT group, a shifting deficit was the only EF predictor of group membership, wherein for each one-unit increase in shifting deficit, the likelihood of being in the INT group increased by 12%. This relationship aligns with Mocan et al.'s (2014) results wherein a relationship was found between internalizing behaviour problems and cognitive flexibility in older children and adds to the mixed and scarce literature in relation to shifting and internalizing behaviour problems in young children. In the final model, age and sex were no longer predictors of INT group membership, suggesting that the previous impact these variables had on group membership could be accounted for by the differences in shifting ability associated with each age/sex.

Both inhibition and shift remained predictors of the COMB group membership. Based on the predictors of INT and EXT group membership, shift as a predictor may be due to the relationship with internalizing behaviour, whereas inhibition as a predictor may be due to the relationship with externalizing behaviour. In the final model, sex was no longer predictive of COMB group membership. Overall, univariate, multivariate, and z-score regression results all pointed to the strong relationship that shift possessed with internalizing behaviour problems, and that inhibition possessed with externalizing behaviour problems. These findings add new information to the literature surrounding young children and point to potential areas of targeted early intervention for youth with at-risk-to-clinical levels of behaviour problems.

When examined on its own, working memory deficits lead to increased likelihood of EXT, INT, and COMB group membership. As discussed above, when examined in the initial model alongside inhibition and shift, however, working memory being inversely predictive of EXT, INT, and COMB group membership, wherein for every one-unit increase in working memory deficit, the likelihood of being in the EXT, INT, and COMB group decreased by

8%, 3%, and 8%, respectively. For the INT group, this relationship was approaching significance (p = .053), and, when outliers were removed, this relationship became significant (p = .029). This inverse relationship may be due to a measurement error based on the high collinearity of working memory and inhibition, as, when inhibition was taken out of the model, working memory deficits were again associated with increased likelihood of behaviour problems. This finding further suggests that working memory and inhibition may not be distinct enough to be measured separately in this model. This finding is in line with Garon's (2008) model of EF development. In this review, a model of EF development in preschoolers is proposed wherein each EF component is dependent and built upon earlier developing EFs. Specifically, the model proposes that working memory is the first EF to develop, followed by inhibition; both skills are then integrated into shifting (or set-shifting). Therefore, the high correlation between inhibition and working memory may capture a developmental period wherein inhibition development is still highly dependent on and therefore related to working memory development.

All analyses additionally indicated a relationship between adaptive skills and all three behavioural group memberships. Specifically, results suggested that increases in adaptive skills lead to decreases in likelihood of behaviour problems in young children. Adaptive skills used in this analysis included social skills, functional communication, adaptability, study skills, and leadership; therefore, early interventions focused on these skills may lead to decreases in behavioural problems and, in doing so, may lead to more positive future outcomes for young children.

Cluster analysis results produced a two-cluster solution in relation to EF groups: 1) a group with elevated levels of all three EFs and 2) a group within the normal range for all three EFs. Working memory was the strongest predictor of cluster group membership, followed by inhibition and, lastly, shift. These results were also consistent with the development of EF in normally developing preschoolers put forth by Garon et al. (2008) discussed above.

There is an ongoing debate regarding whether three distinct EF components can be found at the preschool age. On one side of the debate, studies find distinct EF constructs at this age (Schoemaker et al., 2013). Memisevic & Biscevic (2018), for example, found that inhibition and cognitive flexibility (or set shifting) were two distinct features of EF during the preschool period. Conversely, other studies have found one unitary executive construct during the preschool years (Hughes, 2011), which then divides into three components in later childhood.

ANOVA and regression results support the former theory, wherein behaviour groups had unique differences across each of the EFs, and each EF differentially predicted group membership. Furthermore, although the three EFs were correlated with each other, with inhibition and working memory having the strongest correlation, VIF and tolerance scores indicated that they had enough distinction to be measured separately at this age. Overall, regression analyses eventually supported the presence of at least two distinct EFs at this age (inhibition and shift).

The two-cluster solution, however, is consistent with the latter theory, suggesting that during the preschool period there is one unitary executive construct, which then divides into three components in later childhood. Together, results may be presenting a transition period in EF development, as our sample was largely (80%) children ages four-to-five. Specifically, results may be capturing an age where EF is divided enough to produce separate constructs, but still share enough commonality to naturally cluster into a unitary solution, wherein the child either has a general EF deficit or does not. This could also explain why the quality of the cluster solution was 0.6 out of a possible 1.0, as this is a time period where EFs are beginning to separate. These results are consistent with the developmental literature suggesting that EFs start as a single, unity function in the early years of life and differentiate into distinct, diverse concepts with age, beginning prior to the preschool years (Karr et al., 2018).

The results of this study therefore provide support for the unity/diversity model put forth by Miyake et al. (2000), wherein cluster analysis supported a unitary EF, and regression results support the presence of at least two EFs that were able to differentially predict behaviour. As previously stated, these results also align with Memisevic & Biscevic's (2018) findings that shift and inhibition represent distinct EF concepts at the preschool age, as well as Goran's (2008) model of EF, wherein working memory is the foundation of EF development during the preschool years. Together, these results capture both the unity and diversity of EF at a young age.

Lastly, when examining the relationship between EF and behaviour from a person-oriented view, 90% of children who had EF levels within the normal range were also not displaying behaviour problems. Approximately 40% of those who had elevated levels of EF, however, were not exhibiting high levels of behaviour problems, and approximately 10% of those within the normal range for EF were displaying high levels of behaviour problems. These results show a similar pattern in comparison to the variable-oriented results, wherein EF is largely predictive of behaviour group membership, but does not solely account for the variance in relation to group membership.

Sensitivity and specificity results also further illustrate this finding, wherein a large proportion of variability still remained in relation to predicting group membership. Specifically, prediction rates were particularly low in relation to accurately predicting those in the COMB group, in the INT group, and those not in the NORM group. These results further suggest that other variables beyond those addressed in this study may account for the unexplained variance in behaviour group membership. As previously discussed, behaviour problems are multiply determined and have various risk and protective factors; other variables that may account for these behavioural challenges include, but are not limited to, temperament (Delgado et al., 2018; Gartstein et al., 2012), adverse or challenging environments (Ogundele, 2018), negative care-giver traits, peer victimization in school (Reijntjes et al., 2010), and/or having a highly stressed parent at home (Keyser et al., 2017).

Implications

Results of this study suggest that behavioural measures of EF can provide valuable information in relation to possible areas of intervention for internalizing and externalizing behaviour problems in young children. Furthermore, the results of this study provide information regarding the unity/diversity of EF, the etiology of internalizing and externalizing behaviour problems, and therefore suggestions for targeted early intervention practices for young children. EFs during this stage of life may still share a strong commonality, as shown through our cluster analysis results. In line with previous literature, this suggests that interventions targeting overall EF may be beneficial for students with high levels of behavioural problems; however, different EFs are distinct enough to differentially predict behaviour in young children. Early behaviour-based interventions may therefore have more success by emphasizing interventions targeting inhibition for young children with at-risk to clinical levels of externalizing behaviour problems only. Furthermore, inhibition and working memory were closely related at this age, indicating that interventions targeting both of these EFs may be beneficial for externalizing behaviour problems.

For young children with at-risk-to-clinical levels internalizing behaviour problems, an intervention focused on shifting may be most appropriate. Lastly, for young children with at-risk-to-clinical levels of both internalizing and externalizing behaviour problems, a more comprehensive intervention that targets various EFs may be most appropriate. Additionally, targeting adaptive skills such as functional communication, social skills, adaptability, leadership, and study skills may also lead to decreased likelihood of young children displaying elevated levels of both internalizing and externalizing behaviour problems.

EFs are malleable and responsive to intervention, can be stimulated by “high quality, structured care experiences, and need to be a target of early learning and intervention” (Son & Chang, 2018, p.1). Furthermore, studies surrounding various curricula and curricula add-ons have shown that EF can be improved by teachers in classroom settings (Diamond & Lee, 2011). Computer-based training, traditional martial arts, two-school curricula, yoga, mindfulness, and aerobics have all been associated with increased levels of EF in children (Diamond, 2012). Teaching tae kwon do and curricula such as Tools of the Mind and the Chicago School Readiness Program have been shown to specifically increase levels of inhibition (Diamond, 2012), suggesting that activities such as these may be best suited to students with externalizing behaviour problems. Conversely, a social-emotional program entitled the First Friends program produced increases in set-shifting but not inhibition in kindergarten children (Randall, 2013), suggesting this program may be more useful for young students with internalizing behaviour problems. Lastly, task-switching computerized games have shown to improve both inhibition and task-switching (a common indicator of shifting ability), suggesting these interventions may be best suited for children with combined internalizing and externalizing behaviour problems. A complete guide to EF interventions is beyond the scope of this study; see Diamond and Lee (2011) for a more thorough review of interventions that may improve separate EFs in children.

Interventions targeting adaptive skills such as social skills, functional communication, adaptability, study skills, and leadership may provide additional benefits alongside EF interventions. These results support the evidence that targeting EFs alone is not as effective as targeting EF alongside social, emotional, and character development (Diamond, 2012). Various social-emotional programs that have produced increases in EFs alongside social-emotional skills exist, with most social-emotional learning programs being successfully implemented at the classroom level (see CASEL, 2013; Schonert-Reichl, 2015).

Limitations

Findings associated with this study should be considered within the context of certain limitations. Firstly, EF scores were derived from teacher ratings, creating two separate limitations. The first being that EF scores were based solely on subjective teacher ratings as opposed to using multi-informant information, including objective child assessment tools; this creates a limitation as subjective teacher ratings may be prone to biases based on factors such as gender, ethnicity, and English Language Learner (ELL) status (Garcia, Sulik, & Obradović, 2018). Secondly, teachers' filling out EF and behaviour measures for the children in their classroom produces inherent clustering of data. This creates a violation of the assumption of independence of observations for both variable-oriented analyses conducted in this study and should be considered when interpreting the results of this study.

Future Directions

In line with the limitations discussed above, future research should use multi-informant information to assess the relationships among various EFs and behaviour problems. A study by Dekker et al. (2017), for example, examined the relationships among teacher, parent, and cognitive measures of child EF and concluded that although correlations between behavioural and cognitive measures of EF exist, these measures tend to capture "different aspects of EF across different situations and under variable conditions" (p. 8). Future analyses should also address the independence of observation assumption violation by using multilevel modeling, and could examine how classroom and school level factors such as teacher experience and classroom makeup may affect these relationships. Future research should also examine how various EFs and adaptive skills are related to specific behaviour problems (i.e. aggression versus hyperactivity), as this could provide further specificity in relation to intervention research. Lastly, longitudinal analyses of the relationship across various EFs and behaviours would provide valuable insight into when these constructs separate, and how this relationship may change throughout the lifespan.

Contributions

The present study added to the literature surrounding the unity and diversity of EF and the etiology of internalizing and externalizing behaviour problems in young children. Specifically, person-oriented analysis supported an overall unified EF, while regression analysis supported two EFs that differentially predict behaviour problems in young children. Results add to the literature in relation to early intervention practices, wherein emphasizing shifting may be more effective for young children with internalizing problems and emphasizing inhibition may be more effective for young children with externalizing problems. Results also suggest that increasing adaptive skills may decrease the likelihood of young children experiencing high levels of both internalizing and externalizing behaviour problems.

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Appendix A

Letter of Initial Approval

Western Research

Research Ethics

Western University Non-Medical Research Ethics Board
NMREB Full Board Initial Approval Notice

Principal Investigator: Dr. Claire Crooks
Department & Institution: Education\Faculty of Education,Western University

NMREB File Number: 108218
Study Title: Mind UP for Young Children

NMREB Initial Approval Date: October 15, 2016
NMREB Expiry Date: October 15, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Western University Protocol	Received October 15, 2016	
Instruments	Appendix A - School Personnel Demographic Information Form	2016/10/15
Instruments	Appendix B - ARTIC Items - Received June 29, 2016	
Instruments	Appendix C - Emotional Exhaustion and Personal Achievement Items	2016/06/28
Instruments	Appendix D - BASC - Received June 29, 2016	
Instruments	Appendix E - SRISI Items	2016/06/28
Instruments	Appendix F - MindUP Session Tracking Sheets	2016/06/28
Instruments	Appendix G - MindUP Satisfaction Survey	2016/06/28
Instruments	Appendix H - Focus Group Questions	2016/06/28
Other	Appendix I - Timeline and Participant Procedures - Received for Information Only	2016/06/28
Letter of Information & Consent	Appendix L - Parent	2016/10/13
Letter of Information & Consent	Appendix M - School Personnel	2016/10/15
Instruments	Appendix N - Parent Demographics Questionnaire	2016/10/15
Other	Appendix O - Research Assistant Agreement - ECEs - Received October 14, 2016	2016/09/14
Other	Appendix P - Research Assistant Agreement - Teachers - Received October 14, 2016	2016/09/14
Other	Appendix Q - Letter of Support - LDCSB - Received for Information	2016/01/11
Other	Appendix R - Letter of Support - Merrymount - Received for Information	2015/01/11
Other	Appendix S - LDCSB Meeting Outline	2016/09/14
Other	Appendix T - Research Assistant Agreement - Combined Teacher/ECE Role - Received October 14, 2016	

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the above named study, as of the NMREB Initial Approval Date noted above.

NMREB approval for this study remains valid until the NMREB Expiry Date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario.

Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Appendix B

Letter of Approval: BRIEF Amendment

Western Research

Research Ethics

Western University Non-Medical Research Ethics Board
NMREB Amendment Approval Notice

Principal Investigator: Dr. Claire Crooks
Department & Institution: Education\Faculty of Education,Western University

NMREB File Number: 108218
Study Title: Mind UP for Young Children

NMREB Revision Approval Date: August 22, 2017
NMREB Expiry Date: October 15, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Recruitment Items	Appendix VV	2017/07/26
Letter of Information & Consent	Appendix UU	2017/07/26
Other	Appendix TT	2017/07/26
Instruments	Appendix SS	2017/07/26
Assent	Appendix RR	2017/07/26
Data Collection Form/Case Report Form	Appendix QQ	2017/07/26
Letter of Information & Consent	Appendix PP	2017/07/26
Recruitment Items	Appendix MM	2017/07/26
Other	Appendix OO	2017/07/26
Assent	Appendix NN	2017/07/26
Letter of Information & Consent	Appendix LL	2017/07/26
Recruitment Items	Appendix KK	2017/07/26
Instruments	Appendix JJ	2017/07/26
Instruments	Appendix II	2017/07/26
Revised Letter of Information & Consent	Appendix Z	2017/07/26
Other	Appendix T	2017/07/26
Recruitment Items	Appendix S	2017/07/26
Revised Letter of Information & Consent	Appendix M	2017/07/26
Revised Letter of Information & Consent	Appendix L	2017/07/26
Revised Study End Date	Appendix I	2017/07/26
Data Collection Form/Case Report Form	Appendix A	2017/07/26
Revised Western University Protocol		2017/07/26

The Western University Non-Medical Science Research Ethics Board (NMREB) has reviewed and approved the amendment to the above named study, as of the NMREB Amendment Approval Date noted above.

NMREB approval for this study remains valid until the NMREB Expiry Date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario.

Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Curriculum Vitae

Name Melissa Read

Education

Master of Arts, School and Applied Child Psychology — 2017 – 2019 (May)
Western University, London, ON
Masters Thesis Supervisors: Dr. Karen Bax and Dr. Claire Crooks

ABQ Social Science (Senior): Psychology — May 2016 - June 2016
University of Windsor, Windsor, ON

ABQ Health and Physical Education (Intermediate) — May 2015 - June 2015
University of Windsor, Windsor, ON

Bachelor of Education (Major: Primary/Junior) — 2013 - 2014
University of Windsor, Windsor, ON

Bachelor of Arts (Honours B.A), Criminology and Psychology — 2009 - 2013
University of Windsor, Windsor, ON

Awards and Scholarships

Park Davidson Award for best student poster at the Banff International Conference on Behavioural Science — 2019

Graduate Student Internal Conference Travel Grant — 2018
Western University, London, ON

Graduate Student Entrance Scholarship — 2017 – 2019
Western University, London, ON

Related Work Experience

Making Mindfulness Matter (M3) Co-Facilitator — 2017 – 2019
London, ON

Research Consultant for the Vanier Parent and Infant Relationship (PAIR) Clinic Program Evaluation — 2018 - 2019
Mary J. Wright Research and Education Centre

Research Assistant at the Centre for School Mental Health — 2018
Western University

Teach Resiliency Research and Development Team — 2017 – 2019
Western University

Research Assistant at the Mary J. Wright Research and Education Centre 2017-2019
Western University

Year 3 Teacher 2017
London, UK

Health and Social Care Teacher 2016
London, UK

Academic Tutor 2016
Windsor, ON, CA

Youth Mental and Physical Health Program Leader 2014-2016
Windsor, ON, CA