The interplay between screen time and outdoor play on preschool children's cognitive and social-emotional development

by

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ABSTRACT

Objective: 1) identify distinct profiles (i.e., subgroups) of screen time (ST) and outdoor play (OP) in a sample of preschool children, and 2) examine the mean differences in specific domains of cognitive and social-emotional development between these profiles.

Method: Baseline data from the Technology and Development in Early Childhood (TECH) study were used. Participants were 352 preschool children (3–4 years) and their parents living in Western Canada. ST (television (TV)/video viewing and video/computer games) and OP for both weekdays and weekend days were parent-reported. Social-emotional development outcomes (emotional, cognitive, and behavioral self-regulation) and demographic covariates were assessed via questionnaire. Cognitive development outcomes (language, response inhibition, working memory, self-control) were assessed via four short games played during a recorded virtual meeting. Latent profile analysis was conducted.

Results: Four profiles were identified: 1) low ST/medium-high OP (optimal ST-OP), 2) high TV/high OP, 3) medium ST/low OP, and 4) high ST/medium-high OP. Profile 1 was selected as the reference group. For response inhibition, the medium ST/low OP (M=10.3, SE=2.0; p=0.03) and high ST/medium-high OP (M=2.8, SE=3.7; p<0.01) profiles scored significantly lower than the reference group (M=15.3, SE=1.0). For self-control, the high TV/high OP (M=65.5, SE=3.2; p=0.03) and medium ST/low OP (M=63.8, SE=4.8; p<0.05) profiles scored significantly lower than the reference group (M=74.2, SE=2.1). For behavioral self-regulation, the high TV/high OP (M=3.6, SE=0.1; p<0.01) profile scored significantly lower than the reference group (M=3.9, SE=0.04).

Conclusion: Children with the most optimal combination of lower ST and higher OP had more advanced cognitive and social-emotional development for some outcomes.

Preface

We received ethics approval from the University of Alberta Research Ethics Board for the Technology and Development in Early Childhood (TECH) study (Ethics ID: 00121809). I helped with data collection, analyzed and interpreted the data, and was the lead writer in the manuscript presented in this thesis.

The manuscript in Chapter 3 “The interplay between screen time and outdoor play on preschool children's cognitive and social-emotional development” is formatted using guidelines from the Journal of Developmental and Behavioral Pediatrics, where it was submitted for publication. This manuscript uses baseline data from the TECH study, which was created and designed by Dr. Valerie Carson, Dr. Sandra Wiebe, Dr. Christina Rinaldi, and Dr. Yao Zheng. Madison Boyd (Predy) led participant recruitment and data collection. She was assisted by many research assistants during data collection including myself (Ramiah Moldenhauer), Morgan Potter, Joshua Li, Shohreh Hassanzadeh, Jasmine Rai, Kyla Dorn, Olivia Harris, Victor Han, Jayleen Hills, Terri Ciavardini, Jeslin Tijo, Debadrita Chowdhury, Leenah Qureshi, and Aditi Sharma. Yeongho Hwang taught me about the statistical analyses (such as latent profile analysis) in Mplus and assisted with the interpretation of the findings. Dr. Yao Zheng assisted in guiding me through the Bolck Croon Hagenaars (BCH) 3-step approach to achieve robust results. Dr. Valerie Carson assisted with the interpretation of findings and the writing of the manuscript. All authors revised the paper critically for important intellectual content as well as read and approved the final version of the manuscript prior to being submitted for publication.

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Chapter 1: Introduction

1.1 General Introduction

The cognitive, social-emotional, and physical development that occurs during early childhood, or the first five years of life, is important for life-long health and well-being (Schor, 2007). The preschool age group (3-4 years) may be a particularly important age group to focus on because at the time of entry into kindergarten, future educational success seems to be well established as well as patterns of response to emotional and physical stressors (Schor, 2007). Therefore, understanding and targeting early life experiences is important to positively impact healthy development for current and future generations. Specifically, the trends of increasing screen time and decreasing outdoor play in children requires further study, given the growing evidence on potential detrimental impacts on healthy development and the major evidence gaps that exist regarding this trend (Madigan et al., 2020; Foreman et al., 2021; Tremblay et al., 2015).

According to the Canadian 24-hour Movement Guidelines for the Early Years, which were released in 2017, it is recommended that preschoolers have no more than 1 hour of sedentary screen time per day (Tremblay et al., 2017a). However, only 24.4% of preschoolers in Canada met this recommendation (Chaput et al., 2017). Similar trends have been observed in other countries, such as Australia and South Africa (Hinkley et al., 2013; Tomaz et al., 2020). During the COVID-19 pandemic, larger increases in screen time were observed in young children and exposure has remained high (Patel et al., 2023). This trend is concerning as detrimental associations have been reported between screen time and cognitive and social-emotional development outcomes in this age group (Carson et al., 2015; Madigan et al., 2020; Poitras et al., 2017). Since the current generation of children are living and growing in a society where screen technology is integrated in everything they do, mobile devices must also be taken into consideration. However, the majority of screen time research in preschool children has focused on traditional screen devices, such as television, highlighting a major gap in this area.

While screen time has increased, generational decreases have been observed in the amount of time children spend outdoors and connected to nature, despite the known health benefits (Oswald et al., 2020; Moss, 2012). Factors such as increased parental perceptions of traffic risk, stranger danger, and overscheduled lifestyles have all contributed to the decline in outdoor play across generations (Moss, 2012). The Canadian 24-hour Movement Guidelines for the Early Years recommend replacing indoor time with outdoor time for healthy development (Tremblay et al., 2017a) because outdoor time can give children further opportunity to explore, imagine, and play (Oswald et al., 2020), while being physically active (Rosiek et al., 2022). Additionally, when children are outdoors, they are typically not engaging with screens. A recent scoping review stated that further research is needed on the associations between children's outdoor play and cognitive and social-emotional development domains as physical health has been the most examined outcome (de Lannoy et al., 2023).

1.2 Knowledge Gaps

In a recent scoping review on the psychological impacts of screen time and green time (e.g., outdoor play) in children and youth <19 years of age, several major evidence gaps were noted that limit our understanding of how increased screen time and reduced outdoor play are impacting children's healthy development (Oswald et al., 2020). First, no studies in this review considered the interplay between screen time and outdoor play. Novel statistical analysis methods that are person-centred, such as latent class or latent profile analysis, can be used to better understand the interplay between these two behaviours. Second, only two studies in the review considered time spent on mobile devices for young children. As previously noted, the prevalence of mobile screen device use in young people is high and increasing over time (Oswald et al., 2020). Third, only 14 of the 186 studies focused on preschool children, which as previously noted is a key period of healthy development (Almli et al., 2007). This thesis will address all of these gaps to further our understanding regarding the interplay between screen time, including mobile devices, and outdoor play and the mean differences between profiles for multiple developmental domains, including cognitive and social-emotional development in preschool children. Findings will help inform interventions and initiatives that target these early life experiences in order to support children in achieving their full potential.

1.3 Objectives

The overall objective of this thesis is to address major evidence gaps regarding screen time and outdoor play in preschool children. The specific objectives of this thesis are to: 1) identify distinct profiles (i.e., subgroups) of screen time (ST) and outdoor play (OP) in a sample of preschool children, and 2) examine the mean differences in specific domains of cognitive and social-emotional development between these profiles.

1.4 Hypothesis: Preschoolers who have a profile of lower screen time combined with higher outdoor play will have more advanced development than those of other profiles.

1.5 Definition of Key Terms

Preschoolers: For this thesis, preschoolers will be defined as 3- and 4-year-olds in line with the Canadian 24-hour Movement Guidelines for the Early Years (Tremblay et al., 2017a).

Sedentary behaviour: The Sedentary Behaviour Research Network (SBRN) defines sedentary behaviour as: "any waking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Sedentary Behaviour Research Network, 2011; Tremblay et al., 2017b). Screen time is often considered one type of sedentary behaviour (Tremblay et al., 2017a). SBRN defines screen time as the: "time spent on screen-based behaviours" (Stamatakis et al., 2011, Anderson et al., 2008 as cited in Tremblay et al., 2017b). Though it is noted that screen time can occur when children are sedentary or physically active (Tremblay et al., 2017b), the majority of screen time that children engage in is sedentary (Tremblay et al., 2017a). The Canadian Paediatric Society has also defined screen time as: "the duration of time that the child watches television, videos, or DVDs on a television, computer, or portable device" (Ponti, 2023). For this thesis, the duration of time that children engage with various screen devices will be used as a measure of screen time.

Outdoor play/time: According to the Play, Learn and Teach Outdoors Network (PLaTO-Net), play is the: "voluntary engagement in activity that is fun and/or rewarding and usually driven by intrinsic motivation" (Lee et al., 2022) and outdoor play is: "a form of play that takes place outdoors". PLaTO-Net also defines outdoor time as: "time spent outdoors" (Lee et al., 2022). The terms outdoor play and outdoor time are often used interchangeably in the literature (Lee et al., 2021). Given the measure used in this thesis captures the time children spend playing outdoors, outdoor play will be the term used in this thesis.

Development: Development can be separated into three domains: physical (e.g., body size, physical capabilities, physical health), cognitive (e.g., attention, problem solving, language, memory), and social-emotional (e.g., self-understanding, interpersonal skills, moral reasoning and behaviour) development (Berk, 2013). Cognitive and social-emotional development will be the main focus for this thesis.

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Chapter 2: Literature Review

2.1 Early Childhood

Early childhood is an important period in child development, and it is characterized by rapid brain and body development which begins prior to birth and continues until the age of 8 (American Academy of Pediatrics, n.d.). During this critical period, there are many developmental milestones that children should reach as they grow (American Academy of Pediatrics, n.d.). For preschool children, these include age-appropriate language, fine motor skills, gross motor skills, and social skills (McArthur et al., 2021). Therefore, early childhood is an important age group to target for supporting children in reaching their full potential. This thesis will focus on the preschool years of early childhood.

2.2 Settings

Preschool children learn and grow in various settings including home, neighbourhood/community, and childcare. The home setting includes both dwelling and the immediate surrounding areas, such as the backyard, driveway, and immediate sidewalks. Parents have a major influence on children in the home setting (Lee et al., 2018). The neighbourhood/community setting includes parks, recreation centres, playgrounds, and neighbourhood sidewalks (Villanueva et al., 2022). However, given the age of preschool children, they usually require an adult to access these settings. The childcare setting includes indoor space with the addition of outdoor play areas. This setting is important because over half of children under the age of 6 attend childcare (Statistics Canada, 2022). The focus of this thesis will primarily be the home and neighbourhood/community settings with data being collected from parents.

2.3 Development in Preschoolers

Physical, cognitive, and social-emotional development in the early years are important prerequisites for future success in school, work, and the community (Center on the Developing Child, 2007; Robinson et al., 2017). This thesis will focus on cognitive and social-emotional development.

2.3.1 Cognitive Development

The basic structure of the brain continually changes from the prenatal period into adulthood (Center on the Developing Child, 2007). This means that early childhood experiences can affect the quality of the brain structure for learning, behaviour, and health that follow (Center on the Developing Child, 2007). In addition to early childhood experiences, the environments in which children live can also impact brain structure through altering gene expression and affecting long-term neural development (Sigman, 2017). As the brain matures, it starts to lose its ability to reorganize and adapt to unexpected challenges (Center on the Developing Child, 2007). This can pose a problem if a weak structure has been established through poor early childhood experiences and environments (Center on the Developing Child, 2007).

There are several domains of cognitive development. Two important domains of cognitive development that will be measured in this thesis are language and executive function. Language is defined as a set of shared rules that gives people the opportunity to engage with each other in a meaningful way such as expressing ideas (National Institute of Deafness and Other Communication Disorders, n.d.). There are many language milestones that children should be reaching by the time they are 3 to 4 years, including answering questions using the 5 Ws (e.g., who, what, where, when, why), talking about activities, using sentences with four or more words, and speaking easily without repeating syllables or words (National Institute of Deafness and Other Communication Disorders, n.d.). Executive function is a key cognitive development domain in the preschool years because executive function skills emerge at the age of 3. Specific aspects of executive function include working memory, inhibitory control, and cognitive flexibility (Hughes, 1998; Scionti et al., 2020). Working memory is holding information in the brain with the opportunity to mentally manipulate it (Scionti et al., 2020). Inhibitory control can be defined as the ability to control the desire to engage in impulses, distractions, and habits (Scionti et al., 2020). Cognitive flexibility is switching between multiple thoughts and demands as appropriate (Scionti et al., 2020).

2.3.2 Social-emotional Development

The preschool years are an important period for social-emotional skills to develop, such as building the ability to manage stress and forming positive relationships with family and friends (Wolf et al., 2021). Specific domains of social-emotional development include emotional competence, social competence, behaviour problems, and self-regulation (Halle & Darling-Churchill, 2016). In early childhood, emotional competence skills include: identification and expression of emotions, regulation of emotions as well as behaviours, and perspective taking (Campbell et al., 2016). For social competence, early childhood skills include: picking up on social cues, settling conflicts, and cooperating (Campbell et al., 2016). Behaviour problems in early childhood can include internalizing behaviours such as anxiety, depression, and emotional difficulties, and externalizing behaviours such as aggression, deviance, and hyperactivity (Nikstat & Riemann, 2020).

This thesis will focus on the self-regulation domain of social-emotional development. Self-regulation is an important domain of social-emotional development because it is a contributing factor to school readiness (Howard et al., 2022), and it is highly predictive of later development (Howard & Melhuish, 2016). It can be defined as the control of one's thoughts, behaviours, emotional reactions, and social interactions (Howard & Melhuish, 2016). Self-regulation quickly develops during the early years for most children (Montroy et al., 2016). Self-regulation can be further sub-divided into: behavioural, cognitive, and emotional. Behavioural self-regulation involves motor and verbal control (Montroy et al., 2016). Cognitive self-regulation is the ability to control one's thinking processes and it is more advanced than the reactive behaviours that young children sometimes display (Montroy et al., 2016). Emotional self-regulation involves managing emotions and it is typically developed prior to behavioural self-regulation (Montroy et al., 2016).

2.4 Screen Time in Preschoolers

2.4.1 Prevalence

Many children are introduced to screen time during early childhood. In an American sample, it was found that approximately 40% of children regularly engage in screen time by 3 months and by 24 months, 90% regularly engage in screen time (Zimmerman et al., 2007). Screen time habits established in early childhood appear to track over time which makes early childhood a key period to develop healthy habits (Trinh et al., 2020; Jones et al., 2021).

The Canadian 24-hour Movement Guidelines for the Early Years: An Integration of Physical Activity, Sedentary Behaviour, and Sleep include screen time recommendations. Specifically, it is recommended that preschoolers engage in no more than one hour per day of sedentary screen time (Chaput et al., 2017). Based on a nationally representative sample of 803 preschoolers, only 24.4% were reported to meet this recommendation (Chaput et al., 2017). Internationally, a recent meta-analysis indicated that only 35.6% of children aged 2-5 met the screen time recommendation of one hour or less per day (McArthur et al., 2022). The pandemic only served to further increase screen time in young children (Patel et al., 2023). For young children aged 0 to 5 years old, it was reported in a systematic review and meta-analysis that total screen time increased by an average of 0.6 hours per day during the COVID-19 pandemic, primarily during the initial lockdowns (Trott et al., 2022). It was found in one study in Ontario, Canada that children less than 5 years old had a greater increase in screen time during the first and second lockdowns and a lower decrease in the second reopening than children over the age of 5 (Patel et al., 2023). Therefore, research focusing on this increased screen time and its impact on young children's development is very timely (Hedderson et al., 2023).

2.4.2 Generational Changes

Since the 1930s when TV entered American homes, the number of programs for children has increased, leading to entire channels for entertaining children at all hours of the day by the 1980s (Wolf et al., 2018). In the 1970s, children regularly watched TV by the time they were 4 years old, but today children are exposed to screen time when they are just a few months old (Christakis, 2017; Wolf et al., 2018; Zimmerman et al., 2007). Generational increases in screen time can be explained by cultural changes where screens are more often used as a parenting strategy to manage children (Chen et al., 2020). For example, in 2017, nineteen percent of children less than 8 years old used devices in restaurants and fourteen percent used screens while eating meals, which is a trend that is becoming increasingly more popular to control children's behaviour (McCarthy, 2017). More recent correlational evidence showed that dysfunctional parenting styles, low parent self-efficacy for managing behaviours, and screen time-related child behaviour problems are several reasons why young children are given access to excessive screen time (Halpin et al., 2021).

Generational increases in screen time can also be explained by advances in technology. Screen time research in early childhood has mainly examined traditional screen time devices such as television. However, mobile devices, such as tablets and mobile phones, are a large part of the increasing trend of screen time. As a result, a child no longer needs to be at home or at a movie theatre to engage in screen time. The first iPhone was released in 2007. In the United States, children under the age of 8 spent about 5 minutes per day using a mobile device in 2011, but they spent approximately 1 hour per day using a mobile device in 2017 (McCarthy, 2017). In addition, parents often model the use of screen time devices and internet addiction behaviour, which is demonstrated by their increased use of mobile devices especially at home (Dennis et al., 2022).

2.4.3 Health Implications

Unhealthy behaviours during early childhood, including the preschool years, such as higher screen time have potential long-term implications on health. As mentioned earlier, the three domains of development are physical, cognitive, and social-emotional. Cognitive and social-emotional development will be the main focus in this section.

There have been six systematic reviews exploring the impacts of screen time on cognitive development and/or socio-emotional development in young children over the last 10 years (Hinkley et al., 2014; Carson et al., 2015; Poitras et al., 2017; Madigan et al., 2020; Arabiat et al., 2020; Mallawaarachchi et al., 2022). The first systematic review by Hinkley and colleagues showed that sedentary behaviour which was assessed via screen time measures was negatively associated with psychosocial well-being (Hinkley et al., 2014). Two reviews that were published in 2015 and 2017 focused on sedentary behaviour but included specific findings related to screen time. Specifically, in the 2015 review, it was reported that higher screen time and adult-specific TV content was largely detrimentally associated with cognitive development (Carson et al., 2015). Similarly, in the 2017 review, it was reported that associations between screen time and cognitive development and psychosocial health were mostly unfavourable or null (Poitras et al., 2017).

A fourth review was published in 2020 on children ≤12 years that specifically focused on language skills. It was reported that more screen time was associated with lower language skills; however, educational screen time programs and co-viewing were associated with better language skills (Madigan et al., 2020). It was also reported that children were more likely to have better language skills if they start using screens at a later age (Madigan et al., 2020). A fifth systematic review, also published in 2020, in children 7 years or younger found that the use of digital devices was negatively correlated with executive function and language, but interactive digital technology was positively correlated with executive function and ability to understand language (Arabiat et al., 2020). A sixth systematic review and meta-analysis was published in 2022, examining the associations between smartphones and psychosocial and cognitive health in early childhood. Findings from the meta-analysis indicate a significant detrimental association between smartphone and tablet use with child development health outcomes. However, the effect size was considered weak. Specifically, seven of the eleven studies that focused on preschoolers found that smartphone and/or tablet use resulted in poor psychosocial development including problem behaviours, poor self-regulation, and bad temperament, but the same conclusion cannot be made for cognitive development (Mallawaarachchi et al., 2022). More research is needed for smartphone and tablet use in several areas, including self-regulation, social skills, and cognitive development, such as language (Mallawaarachchi et al., 2022).

Since the last review published in 2022, which captured articles until November 2020, there have been additional key studies published on the topic of screen time and cognitive and social-emotional development. When focusing on longitudinal evidence, there has been three key studies published. First, using data collected pre-COVID-19, Liu and colleagues found that screen time by six months of age was a risk factor for emotional problems and hyperactivity when the child turned 4 years old, and screen time by 4 years of age was a risk factor for several social-emotional outcomes such as total difficulties, conduct problems, peer problems, hyperactivity, and prosocial behaviour (Liu et al., 2021). Taylor and colleagues who followed children from the age of one to five pre-COVID-19 found those that consistently met screen time recommendations had better mental health, such as lower anxiety and depression (Taylor et al., 2021). Finally, using data from multiple time-points, Li and colleagues reported that higher amounts of screen time for Canadian 0-5-year-olds during the pandemic was correlated with higher levels of conduct problems and hyperactivity/inattention (Li et al., 2021).

When focusing on additional studies that did not solely focus on television viewing, there has been two key studies published. Specifically, in a pilot study that informed the study this thesis will focus on, certain content such as educational screen time was positively associated but total screen time was negatively associated with certain measures of cognitive development (Rai et al., 2023). This evidence is supported by a second recent study showing young children who exceed screen time recommendations were more likely to be vulnerable in the following areas: social competence, emotional maturity, language and cognitive development, and communication skills (Kerai et al., 2022).

2.4.4 Measurement

Subjective measures, such as parent-reported screen time, is a common way to record how much time a child engages with screens. Duration of screen time is typically captured through a parental questionnaire (Carson et al., 2017; Burdette et al., 2004). A more detailed measurement of screen time can be captured by parents filling in a screen time diary for a period of time (e.g., 2 weeks). A diary can capture not only the duration, but patterns of screen time (e.g., type, device, content, context) (Rai et al., 2023). Advantages of using subjective measures include low cost, ease of administration, and the ability to collect data from a large sample. However, limitations of subjective measures include recall bias and social desirability bias. Furthermore, few subjective screen time measures have established psychometric properties. For example, a recent systematic review in children 0-6 years old revealed that less than 15% report any psychometric properties, such as reliability, validity, or both (Byrne et al., 2021). Of note, all studies included in the review used subjective measures.

Screen time can also be measured objectively by using wearable devices or cameras, tracking programs via computer or mobile devices, or direct or video observation (Perez et al., 2023). Advantages of these tools are they overcome the biases associated with subjective measures and may be more accurate in capturing amount of screen time, compared to subjective measures. However, objective measures have limitations preventing them from being more widely used, especially in early childhood. Some of these limitations include privacy and participant burden (Saunders & Vallance, 2017). Also, tracking programs may capture time on television or smartphones, but they would not capture time on other devices. This is important as young children receive screen time in many forms. Another systematic review examining validated subjective and objective assessment tools for screen time included 29 articles with only four articles focusing on samples of preschool children (Perez et al., 2023). These four articles each used a different form of measurement, including (1) parent-report, (2) passive-sensing mobile application, (3) various TV measurements (e.g., parent-reported, accelerometry, and an electronic TV power meter), and (4) a tool using a questionnaire, diary, and passive sensing application with unknown psychometric properties (Anderson et al., 1985; Radesky et al., 2020; Mendoza et al., 2013; Barr et al., 2020).

As new technology evolves, new measures are being developed. For example, the Language Environment Analysis, also known as LENA, showed good reliability between computed scores by LENA and those that are parent-reported (Xu et al., 2009; Brushe et al., 2023). The technology provides automated counts of children's exposure to electronic noise, and these audio segments are later coded as screen exposure (Brushe et al., 2023). However, the technology is used via a vest or t-shirt with the digital language processor being stored in the front pocket along with LENA software (Brushe et al., 2023). In this study, the child was only required to wear the clothing one day every six months (Brushe et al., 2023), which is likely because of participant burden. Although the study by Brushe et al. (2023) suggests good reliability, a longitudinal pilot study found that agreement between objective and caregiver self-reported phone use was poor (Parker et al., 2022). Another limitation of LENA technology is that the type, content, or context of screen time are not considered, which as previously noted can be captured via a diary (Rai et al., 2023). In other words, although objective measures are being developed for capturing screen time, they are not yet at the stage for widespread use in research (Perez et al., 2023).

2.5 Outdoor Play in Preschoolers

2.5.1 Prevalence

A systematic review based on 85 studies showed that children between the ages of 3 and 12 spend between 60 to 165 minutes per day engaged in outdoor play (Lee et al., 2021). Of the 21 studies focusing on the preschool age group, outdoor play ranged between 45 and 191 minutes per day, with the most commonly reported duration being 60 minutes per day (Lee et al., 2021). Similar to screen time, the COVID-19 pandemic had an impact on outdoor play in preschool children. For example, in an international study of 14 countries, children were outside 81 minutes per day less on weekdays during the initial COVID-19 lockdown compared to pre-COVID-19. A similar pattern was observed on weekends, where 105 minutes per day of lower outdoor time was observed, greatly reducing opportunities for outdoor play (Okely et al., 2021). In the Canadian context, larger decreases in outdoor play during certain periods of the pandemic were observed in younger Canadian children (< 5 years) compared to older children (≥ 5 years) in Ontario (Patel et al., 2023).

2.5.2 Generational Changes

Generational decreases have been observed in the amount of time children, including preschoolers, spend outdoors and connected with nature (Oswald et al., 2020; Clements, 2004; Moss, 2012; Brussoni et al., 2015). For example, in 2004, 70% of American mothers of young children reported playing outdoors daily when they were young, compared to only 31% of their children (Clements, 2004). In addition, the majority of mothers would stay outside for three hours or more at a time as children, compared to only 22% of their children (Clements, 2004). It should be noted there was also a difference in not just the amount of outdoor play, but also the types of activities children engaged in. In previous generations, chasing and fleeing games, imaginative play, and street games (e.g. jump rope) were played on a regular basis (Clements, 2004). However, a small portion of the current generation appear to engage in these regularly because organized youth sport and adult-structured activities have become the norm (Clements, 2004).

Parents' perceptions associated with preschoolers' risky outdoor play seems to be a main contributing factor for the generational decline in outdoor play (MacQuarrie et al., 2022). Some of these parent perceptions included their child's poor ability to self-assess, the need for companions and supervision during play, and the higher expectations of today's society in avoiding injury during child play over time (MacQuarrie et al., 2022). Many parents have also been limiting outdoor play for their children in recent years based on their perception of how safe or unsafe they think their neighbourhood is (such as downtown core versus suburbs) and many parents also mentioned that their own low tolerance for cold weather/season affects their children's outdoor play (MacQuarrie et al., 2022). In young and school-aged children, parents are increasingly worried about child safety and preventing injuries compared to previous generations, which has resulted in decreased opportunities for risky outdoor play (Brussoni et al., 2015). Other contributing factors include the increase of entertainment indoors via multiple screen-based opportunities, the increase in traffic, and many parents' greatest fear, which is stranger danger (Moss, 2012). In recent generations, children of all ages may be at risk of "Nature Deficit Disorder" leading to poor health outcomes (Moss, 2012).

2.5.3 Health Implications

The Position Statement on Active Outdoor Play states that despite the associated risks, having access to active play both within nature and outdoors is required for healthy child development. Therefore, the statement recommends that society should strive to increase children's opportunities for self-directed outdoor play in all settings including home, school, childcare, and community (Tremblay et al., 2015). More outdoor time will give children additional opportunity to explore, imagine, and play (Oswald et al., 2020).

A systematic review by Brussoni et al. (2015) that informed the position statement states that children including preschoolers should be encouraged by parents to participate in more risky outdoor play opportunities because of the benefits for children's health and development, including social and mental health. However, none of the included studies focused solely on the preschool age group. Another systematic review found that unstructured nature play is important for development in early childhood, such as cognitive play behaviours (Dankiw et al., 2020); however, the authors concluded that there is a need for standardized measures of children's play behaviours and a universal outdoor play definition in order to come to a more confident conclusion (Dankiw et al., 2020).

Recent smaller studies, not included in the above mentioned reviews, have shown that outdoor play may be important for cognitive development. First, in a small sample of 3–5-year-old children, both boys and children of low socio-economic status showed greater on-task behaviour when they were allowed to engage in outdoor play prior to learning compared to no outdoor play prior to learning (Lundy & Trawick-Smith, 2020).

It has also been shown that outdoor play benefits social-emotional development, though the context may matter. For example, outdoor natural environments with loose parts were found to lead children to have higher levels of social interaction and peer play compared to indoor and outdoor environments lacking loose parts (Flannigan & Dietze, 2017).

2.5.4 Measurement

Similar to screen time, outdoor play can be measured both subjectively and objectively. Subjective measures include questionnaires, surveys, and interviews (Bates & Stone, 2015). A common subjective measurement is a proxy report, such as parents reporting their child's outdoor play (Burdette et al., 2004). Similar advantages and disadvantages exist for outdoor play subjective measurements as was discussed in section 2.4.4 for screen time.

Objective measures of outdoor play include accelerometry (i.e., activity monitors), global positioning systems (GPS), and direct observation (e.g., a researcher observing a child's outdoor play) (Bates & Stone, 2015). Some advantages include good precision and accuracy, but some disadvantages include cost, wearability, and time.

Scoping review evidence in children and youth shows that more studies use subjective measurement methods than objective measurement methods for outdoor play (de Lannoy et al., 2023). Some studies choose to use both subjective and objective measurements in their research, which may result in better quality data by capturing the multiple components of outdoor play (e.g., physicality and experiences) (de Lannoy et al., 2023). However, with large sample sizes and participants from different areas of the country, accelerometry and researcher observations become much less feasible. One proxy report measure that has been commonly used due to its feasibility and psychometric properties is the Burdette proxy report, which uses parent recall (Burdette et al., 2004). This tool will be used in this work.

2.6 Interplay between Screen Time and Outdoor Play

The generational increases observed for screen time have coincided with the generational decreases in outdoor play. Therefore, it is important to consider the interplay between these two behaviours when understanding associations with children's development. The scoping review by

Oswald et al. (2020) mentioned in the introduction of this thesis sought to assess the associations between screen time, contact with nature (green time), and psychological outcomes such as mental health and cognitive development in any age group between preschoolers to adolescents. A total of 186 studies were included in the review on this topic. Overall, the authors concluded that green time may buffer the negative effects of high screen time on psychological well-being (Oswald et al., 2020). However, several gaps in the literature were identified in the review that impede our understanding of how screen time and outdoor play are affecting children's healthy development. This thesis will address these gaps. First, this thesis will use latent profile analysis, where participants can be categorized into underlying profiles (e.g., higher screen time and lower outdoor play) based on both continuous screen time and outdoor play variables. This is in contrast to most other studies in the review that examined screen time and outdoor time separately. Specifically, only 14 studies included in the review measured both screen time and green time (Dadvand et al., 2017; Gopinath et al., 2012; Janssen, 2016; Kim et al., 2016; Khouja et al., 2019; McHale et al., 2001; Greenwood & Gatersleben, 2016; Mutz et al., 2019; Richardson et al., 2017; Rosen et al., 2014; Hinkley et al., 2018; Aggio et al., 2017; Markevych et al., 2014; Verburgh et al., 2016 as cited in Oswald et al., 2020). Of note, these studies looked at the independent associations with psychological outcomes and not the interplay between screen time and green time. Second, this thesis will capture mobile devices, an important form of screen time for this age group. For the preschool age group, only 2 of the 14 studies or 14% considered mobile devices (Nathanson & Beyens, 2018; Plitponkampim et al., 2018 as cited in Oswald et al., 2020). Third, this thesis will focus on preschool children. Less than 7% of the studies included in the scoping review focused on preschool children either in the area of screen time or green time (Agostini et al., 2018; Brussoni et al., 2017; Duch et al., 2013; Largo-Wright et al., 2018; McDonald et al., 2018; McEachan et al., 2018; Mendelsohn et al., 2010; Nathanson & Beyens, 2018; Plitponkampim et al., 2018; Radesky et al., 2014; Tomopoulos et al., 2010; Zhao et al., 2018; Schutte et al., 2017 as cited in Oswald et al., 2020). Only 1 of the studies with preschool samples focused on both screen time and green time in the same study (Hinkley et al., 2018 as cited in Oswald et al., 2020). While Oswald and colleagues assessed the psychological outcomes of poor and positive mental health (including self-regulation), cognitive functioning, and academic achievement, this thesis will specifically examine self-regulation which is an important part of social-emotional development (Howard & Melhuish, 2016), and language, response inhibition, working memory, and self-control, which are important aspects of cognitive development (Howard & Melhuish, 2016; Ponitz et al., 2008; Thorell & Wåhlstedt, 2006; Wiebe et al., 2011; Schoemaker et al., 2011). Finally, only 17 of the 186 or 9% of the studies were conducted in Canada (Oswald et al., 2020), and only two Canadian studies focused on preschoolers (Brussoni et al., 2017; McDonald et al., 2018 as cited in Oswald et al., 2020).

Some recent studies in preschoolers that were not included in the Oswald and colleagues review have examined both screen time and outdoor play. A cross-sectional study from Australia reported that rules discouraging outdoor play was positively correlated with preschool children's screen time (Wiseman et al., 2019). Similar findings were reported in Ireland where limiting outdoor play was associated with higher TV viewing for preschoolers in the home environment (Bassul et al., 2021). Another study examined outdoor play as a mediator. The authors found that screen time at 2 years old was negatively associated with communication skills at 4 years old, but it was not mediated by amount of outdoor play (Sugiyama et al., 2023). Conversely, screen time was also negatively associated with daily living skills, and a small part (18%) of this association was mediated by outdoor play (Sugiyama et al., 2023). Lastly, it was found that outdoor play, but not screen time, was associated with socialization in young children (Sugiyama et al., 2023). Overall, limited research has considered the interplay between these two behaviours in preschoolers and no study has used a person-centered approach, such as latent class or latent profile analysis to examine the potential impacts on development.

2.7 Latent Profile Analysis

Latent Profile Analysis (LPA) is a statistical "person-centred" method for cross-sectional data that allows for the identification of underlying unobserved profiles in a sample by grouping similar people together based on personal and/or environmental attributes, referred to as indicators (Nylund-Gibson & Choi, 2018; Spurk et al., 2020; Sinha et al., 2020). Group membership is based on a certain degree of probability (Spurk et al., 2020). LPA belongs to larger group of latent variable techniques called mixture models (Nylund-Gibson & Choi, 2018). Latent Class Analysis (LCA) is also a "person-centred" approach, and it is similar to LPA in that it is a mixture model for cross-sectional data (Sinha et al., 2020). However, LPA is used for continuous variables whereas LCA is used for categorical variables (Bauer, 2022). In contrast, factor analysis is not a "person-centred" approach, rather it is a variable-centered approach because it groups items and often arbitrary cut-offs are used (Nylund-Gibson & Choi, 2018). Therefore, this thesis will use LPA because continuous variables are being collected. For LPA, each person can only have membership in one of the latent profiles created (Nylund-Gibson & Choi, 2018). To decide on the number profiles, it is recommended that multiple model fit indices, model testing, and content characteristics are considered (Spurk et al., 2020; Sinha et al., 2020).

2.8 Summary

Growing evidence indicates screen time is on the rise and outdoor play is declining but how these behaviours are interacting to impact development during the critical preschool years is unclear. This thesis will bridge the evidence gaps on the interplay between screen time and outdoor play. Specifically, it will examine the mean differences in specific domains of cognitive and social-emotional development between the screen time and outdoor play profiles. Therefore, this novel work will generate new knowledge on this important topic. Furthermore, findings will help inform future research, including interventions and potentially public health initiatives, to help children reach their full potential.

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Chapter 3: The interplay between screen time and outdoor play on preschool children's cognitive and social-emotional development

ABSTRACT

Objective: 1) identify distinct profiles (i.e., subgroups) of screen time (ST) and outdoor play (OP) in a sample of preschool children, and 2) examine the mean differences in specific domains of cognitive and social-emotional development between these profiles.

Method: Baseline data from the Technology and Development in Early Childhood (TECH) study were used. Participants were 352 preschool children (3–4 years) and their parents living in Western Canada. ST (television (TV)/video viewing and video/computer games) and OP for both weekdays and weekend days were parent-reported. Social-emotional development outcomes (emotional, cognitive, and behavioral self-regulation) and demographic covariates were assessed via questionnaire. Cognitive development outcomes (language, response inhibition, working memory, self-control) were assessed via four short games played during a recorded virtual meeting. Latent profile analysis was conducted.

Results: Four profiles were identified: 1) low ST/medium-high OP (optimal ST-OP), 2) high TV/high OP, 3) medium ST/low OP, and 4) high ST/medium-high OP. Profile 1 was selected as the reference group. For response inhibition, the medium ST/low OP (M=10.3, SE=2.0; p=0.03) and high ST/medium-high OP (M=2.8, SE=3.7; p<0.01) profiles scored significantly lower than the reference group (M=15.3, SE=1.0). For self-control, the high TV/high OP (M=65.5, SE=3.2; p=0.03) and medium ST/low OP (M=63.8, SE=4.8; p<0.05) profiles scored significantly lower than the reference group (M=74.2, SE=2.1). For behavioral self-regulation, the high TV/high OP

($M=3.6$, $SE=0.1$; $p<0.01$) profile scored significantly lower than the reference group ($M=3.9$, $SE=0.04$).

Conclusion: Children with the most optimal combination of lower ST and higher OP had more advanced cognitive and social-emotional development for some outcomes.

Key Terms: Early childhood, Preschool, Development, Screen time, Outdoor play

INTRODUCTION

The current generation of children are growing up in a world dominated by screens. Consequently, young children (≤ 5 years) have been engaging in increased amounts of screen time (ST)[1]. National and international guidelines recommend that preschool children (3–4 years) engage in no more than one hour of sedentary ST per day[2]. However, many young children worldwide are exceeding these guidelines[1]. This is a concerning trend because growing research indicates that ST may have detrimental and long-lasting impacts across the major domains of development: physical, cognitive, and social-emotional[3,4]. These impacts are the result of ST largely being a sedentary behavior as well as the direct impacts that screens can have on the developing brain structure through overstimulation[3,4]. Young children may also be missing fundamental opportunities for practicing and mastering interpersonal, motor, and communication skills, which are essential for optimal growth and development[4].

At the same time, young children have been engaging in less outdoor play (OP) than previous generations. OP is thought to be essential for healthy child development not only through benefits associated with increased physical activity compared to indoor activities[5], but through the opportunities it provides children to explore, imagine, play, and relieve stress[6]. In particular, having access to green space to play can enhance the mental well-being of children[7]. However, less research has focused on the benefits of outdoor play in young children[8]. The concerning trend of decreased OP is thought to be due in part to parental perceptions regarding both the need for companions and supervision during play and the higher expectations of today's society in avoiding injury during children's play over time[9] as well as increased access and use of screens[1].

Many studies have focused on ST or OP in regards to children's development, but few studies have considered both ST and OP. A recent scoping review on the psychological impacts of ST and green time (e.g., OP) in children and youth (aged ≤ 18 years) highlighted major evidence gaps in the literature[6]. For example, no studies in this review considered the interplay between ST and OP, only two studies in the review considered time spent on mobile devices for young children, and only 14 of the 186 studies focused on preschool children, which is a key period of healthy development and establishing healthy behavioral habits[2,6,10]. Therefore, the objectives of this study were to: 1) identify distinct profiles (i.e., subgroups) of screen time (ST) and outdoor play (OP) in a sample of preschool children, and 2) examine the mean differences in specific domains of cognitive and social-emotional development between these profiles. We hypothesized that preschool children who have a profile of lower ST combined with higher OP will have more advanced development than those of other profiles.

METHODS

Study Design and Participants

Baseline data from the TECH project were used for this cross-sectional study. Participants included preschool children aged 3, 3.5, and 4 years and their parent(s) recruited from Western Canada (British Columbia, Alberta, Saskatchewan, or Manitoba) from October 2022 to December 2023. Participants were recruited through ads on social media. The University of Alberta Research Ethics Board provided ethics approval for the TECH project (ID: 00121809). Parents provided written consent via the online data capture tool REDCap[11] and verbal consent prior to the recording of a virtual session described further below.

Inclusion criteria consisted of a parent having a preschool child aged 3, 3.5, or 4 years (±2 weeks) living in Western Canada. Exclusion criteria consisted of children born preterm (< 37 weeks), born underweight (< 2.5 kg), or diagnosed with a disorder that may affect neurocognitive development as well as families uncomfortable with English, and without technology required for the study.

Procedures

The procedures described in this section are specific to this study and do not include all TECH project procedures. At baseline, an eligible parent completed a consent form and questionnaire via REDCap[11] that included information on screen time (ST), outdoor play (OP), social-emotional development, and demographic information. Cognitive development was assessed via four games played during a virtual Zoom meeting (~35-50 minutes). A second virtual meeting was scheduled if a child did not finish all games in the first meeting and was willing to meet again. Stickers and a sticker chart were sent to the families ahead of time and used to maintain child's interest throughout the meeting. At baseline, as part of the cognitive development virtual meeting(s) portion of the project, parents were eligible for a $10 electronic gift card.

Measures

Indicator Variables. Average weekday and weekend screen time (ST) including television (TV)/video viewing and video/computer games and weekday and weekend outdoor play (OP) in the last month were parent-reported. TV/video viewing included watching TV, videos, or DVDs on a TV, computer, or portable device. Video/computer games included playing on a learning laptop, LeapFrog® Leapster® (LeapFrog Global Headquarters, Emeryville, California, USA), computer, laptop, tablet, cell phone, PlayStation™ (Sony, San Mateo, California, USA), or Xbox (Xbox Game Studios, Redmond, Washington, USA) devices. Consequently, there were six continuous exposure variables: weekday TV/videos, weekend TV/videos, weekday video/computer games, weekend video/computer games, weekday OP, and weekend OP. The parent-reported measures of ST and OP have established psychometric properties[12,13]. Specifically, the 1-week test re-test reliability has been previously reported for combined ST measures in a sample of toddlers (intra-class correlation [ICC]: 0.819)[12]. The OP measure was previously found to be significantly correlated with accelerometer-derived physical activity ($r = 0.20$; $p = 0.03$) in a sample of preschool children[13].

Outcome Variables. One domain of social-emotional development, self-regulation, was assessed because it is highly predictive of later development[14]. It can be defined as the control of one's thoughts, behaviors, emotional reactions, and social interactions[14]. Parents completed a portion of the Child Self-Regulation and Social Behavior Questionnaire (CSBQ) from the Early Years Toolbox. Specifically, parents were asked 17 statements and responded whether each statement was not true, partly true, or very true regarding their child[14]. Specific items were reverse-coded and then averages were calculated to create three self-regulation outcomes: emotional, cognitive, and behavioral self-regulation. For participants (n=7) who were missing one item for either emotional or cognitive self-regulation subscales, averages were calculated with remaining items for these subscales. For the CSBQ subscales used in this study, internal consistency (Cronbach's α) ranged between 0.83–0.87, and convergent validity (*r*s) with the Strengths and Difficulties Questionnaire ranged between 0.69–0.78 in a previous sample of 2.5–5 year olds[14]. In the present study, internal consistency (Cronbach's α) ranged from 0.63 to 0.75.

Two domains of cognitive development, language and executive function, were assessed because the groundwork for language and cognition are being established from birth until the age of six[15]. Language has also been associated with school readiness[14]. Children engaged in four established short games[14-17] administered during a virtual meeting. The four cognitive development outcomes measured through the games were: language, response inhibition, working memory, and self-control. The feasibility and reliability of the virtual delivery of these games were established via pilot testing[18]. Specifically, for inter-rater reliability, ICC ranged between 0.94–1.00 in a sample of 44 3-year-olds[18]. Inter-rater reliability for the cognitive development outcomes was calculated for two raters, with 10% of the sample randomly selected.

Language was assessed using the expressive vocabulary game from the Early Years Toolbox[14]. This game consisted of 45 pictures that children had to name. If children answered incorrectly six consecutive times, the task ended. A higher score indicates more advanced expressive vocabulary, and a score of 45 points was the maximum. In a previous sample of 2.5–5 year olds, convergent validity with existing measures ($r = 0.60$) were reported[14]. In the present study, the ICC for inter-rater reliability was 1.00.

Response inhibition was assessed using the Head Toes Knees Shoulders (HTKS) task[15]. In this game, children were instructed to do the opposite (e.g., touch head when research assistant says toes). Part one included head and toes, whereas part two included head, toes, knees, and shoulders. Scoring included two training, four practice, and 10 test items for part one, and 10 test items for part two. Children only moved on to part two if they got five or more correct responses during the 10-item test for part one or if they had started kindergarten. If children did the wrong movement, self-corrected, or did the correct movement, they received 0, 1, or 2 points, respectively, for a maximum score of 52 points. A higher score indicates more advanced response inhibition. In a previous study, among a sample of 445 3-6 year olds, convergent validity for HTKS compared to an existing test was reported ($r = 0.15$-0.47; $p<0.05$)[15]. In the present study, the ICC for inter-rater reliability was 0.98.

Working memory was assessed with forward and backward word span[16]. Children were instructed to repeat words back starting with 2-word span. Forward word span was always completed prior to attempting backward word span. Children can receive a maximum score of 10 points in total for forward and backward span. For both forward and backward word span, the game ended when children got all three sets of words in a series incorrect. Forward and backward span scores were summed to get a total score, with a higher score indicating more advanced working memory. This game has previously been validated in a sample of 800 5–12 year olds, but has been successfully used in younger children[16,19]. In the present study, inter-rater reliability was an ICC of 0.99 and 1.00 for forward and backward word span, respectively.

Self-control was assessed with the modified Snack Delay Task[17]. Following a 10-second practice trial, a 4-minute test trial was conducted where children were instructed to be frozen like a snowman for the test duration with snacks placed within their reach. If the snacks were eaten early, the trial ended. Parents were instructed to leave the room for a specific portion of time. Scoring was broken into five second increments. Each increment was scored out of three based on hand movement, body movement, and speaking. The child could receive a maximum of 144 points in this game. Higher scores indicate more advanced self-control. In the present study, the ICC for inter-rater reliability was 0.85.

Covariates

Children's and parental demographic characteristics were measured via a parental questionnaire. The demographic characteristics used as covariates in this study were children's age (years), children's sex (male, female), and parental education (below Bachelor's degree, Bachelor's degree, above Bachelor's degree). The above covariates were selected due to their inclusion in similar research[20].

Statistical Analysis

Statistical analyses were performed in Stata 18 and Mplus 8.7. Median Absolute Deviation (MAD) method was used to detect outliers for TV/video viewing and outdoor play (OP)[21]. Outliers were winsorized to the highest percentile (i.e. 90^{th}, 95^{th}, or 99^{th}) in which the value of the percentile was below the MAD-determined outlier cut-off point. For video/computer games, the MAD method could not be used because of the large number of children (56.3%) who did not play video/computer games. However, outliers were winsorized to the 99^{th} percentile based on visual inspection. Descriptive statistics were conducted for participant characteristics, ST, OP, and cognitive and social-emotional development. Latent profile analysis (LPA) using the manual BCH 3-step approach was conducted. Compared to other methods, BCH is found to be the most robust for continuous outcome variables[22]. For step 1, the correct number of profiles for LPA was chosen by using: Akaike information criterion (AIC), Bayesian information criterion (BIC), and sample-size adjusted BIC (saBIC) values, *p*-values for the Lo-Mendell-Rubin adjusted Likelihood Ratio Test (LMR LRT) and Bootstrapped Likelihood Ratio Test (BLRT), entropy, and interpretability[23]. Profiles were explored to determine the optimal behavioral profile (e.g., lower ST and higher OP) to serve as the reference group for planned contrasts. For step 2, individuals were assigned to the identified profiles and the classification error probability was calculated. For step 3, mean differences in each cognitive and social-emotional development outcome were compared between profiles, considering the classification error probability due to imperfect classification. Participants who had complete ST/OP measurements and complete data on covariates were included in all statistical analyses. Participants with missing cognitive and/or social-emotional outcomes were included for step 1 and 2. For step 3, the BCH 3-step approach uses complete case analysis for each outcome. Sensitivity analyses were conducted by excluding participants with missing outcome data for each of the cognitive development outcomes and re-running the BCH 3-step approach. Statistical significance was set at $p<0.05$.

RESULTS

Of the 362 preschool participants, five were excluded for missing screen time (ST)/outdoor play (OP) data and five were excluded for missing covariate data, leaving a total sample size of 352. Completion rates for the outcome variables were 97.4% (n=343) for language, 86.9% (n=306) for HTKS, 89.8% (n=316) for word span, 95.7% (n=337) for snack delay, and 100% for emotional, cognitive, and behavioral self-regulation. Participant characteristics including parent-reported ST and OP are listed in Table 1. Children's mean age was 3.5 (±0.4) years and there was an even split of male and female children.

For latent profile analysis (LPA), a 4-profile solution (Figure 1) was selected because of low AIC, BIC, and saBIC values. Additionally, the 4-profile solution was supported by a significant *p*-value for LMR LRT and BLRT, a reasonably high entropy, and high interpretability[23] were observed. The fit indices for 2- to 5-profile models are shown in Table 2. The four profiles identified were: 1) low ST/medium-high OP (low ST, medium weekday/high weekend OP), 2) high TV/high OP (high TV, low games, high OP), 3) medium ST/low OP (medium ST, low OP), and 4) high ST/medium-high OP (high ST, medium weekday/high weekend OP). There were 60%, 24%, 13%, and 3% of participants in each of the profiles, respectively.

Profile 1 (low ST/medium-high OP) was considered the optimal behavioral profile and selected as the reference group for planned contrasts. Table 3 shows outcome means adjusted for covariates for each profile as well as overall unadjusted means for the full sample. For response inhibition, children in the medium ST/low OP (M=10.3, SE=2.0; p=0.03) and high ST/medium-high OP (M=2.8, SE=3.7; p<0.01) profiles scored significantly lower than the reference group

(*M*=15.3, *SE*=1.0). For self-control, children in the high TV/high OP (*M*=65.5, *SE*=3.2; $p=0.03$) and medium ST/low OP (*M*=63.8, *SE*=4.8; $p<0.05$) profiles scored significantly lower than the reference group (*M*=74.2, *SE*=2.1). For behavioral self-regulation, children in the high TV/high OP (*M*=3.6, *SE*=0.1; $p<0.01$) profile scored significantly lower than the reference group (*M*=3.9, *SE*=0.04). Regarding the other profiles, compared to the high ST/medium-high OP profile, the high TV/high OP profile scored significantly higher for response inhibition ($p=0.02$), but significantly lower for cognitive self-regulation ($p<0.05$; data not shown).

DISCUSSION

This study identified underlying distinct profiles of screen time (ST) and outdoor play (OP) in a sample of preschool children and examined mean differences in specific domains of cognitive and social-emotional development between the ST and OP profiles. Preschool children classified in the behavioral profile with low ST and medium-high OP, compared to those classified in less optimal behavioral profiles, had more advanced cognitive and social-emotional development for some outcomes. Specifically, response inhibition was more advanced compared to the medium ST/low OP and high ST/medium-high OP profiles, self-control was more advanced compared to the high TV/high OP and medium ST/low OP profiles, and behavioral self-regulation was more advanced compared to the high TV/high OP profile. Effect sizes for these associations ranged from medium for response inhibition (Cohen's d=0.46) to small for self-control and behavioral self-regulation (Cohen's d=0.18 and d=0.20 respectively). A number of null differences were also observed.

Several meta-analyses and systematic reviews have synthesized research on the association between ST and development in isolation among young children. One such meta-analysis, in which 35 of the 42 studies were conducted with children with a mean age of five years or younger, showed that a higher ST duration was associated with lower receptive and expressive language skills[3]. Furthermore, a systematic review by Poitras and colleagues showed that associations between ST and cognitive and psychosocial health were primarily unfavorable or null[4]. Even a null association can be concerning if screen time is replacing time that could be spent in activities known to support development (e.g., reading with a caregiver)[4].

Although there is a general consensus that OP supports child development[5,6], in comparison to the screen time literature, few studies have examined the associations between OP and cognitive and social-emotional development in preschool children. For example, in a systematic review examining the associations between risky OP and health, beneficial associations were observed for social health and behaviors, but none of the included studies in the review focused solely on the preschool age group[8]. A systematic review focusing on 2- to 12-year olds showed that unstructured nature play is beneficial for cognitive play behaviors, but authors noted that there is a need for standardized measures of children's play behaviors and a universal outdoor play definition in order to come to a more confident conclusion[24]. Other smaller studies show short-term cognitive and social-emotional development benefits of outdoor play among preschool children. Though these benefits were observed with certain demographics (e.g., children of lower socio-economic status)[25] or in certain context-specific benefits (e.g., outdoor natural environments with loose parts)[26], in both studies the sample sizes were quite small (< 30 participants).

This study was novel in that we used latent profile analysis (LPA) to examine the interplay of ST and OP in early childhood, specifically mean differences in specific domains of cognitive and social-emotional development between the profiles created. In a scoping review of 186 studies on the associations between ST, OP, and psychological well-being (i.e., cognitive functioning such as executive function and working memory, mental health, academic achievement) in children and youth aged ≤ 18 years, no studies considered these behaviors together[6]. Within the review, there were 14 studies with samples of preschool children and two of these included both ST and OP but did not examine their combined associations with domains of cognitive and social-emotional development. For instance, Hinkley and colleagues found that when both ST and OP were included in a regression model, high ST (including mobile devices) and lower OP were independently associated with poorer social skills in preschool children[27]. In a second study, high ST at two years was positively associated with lower communication scores at age four, but OP was not a mediator[28]. It is difficult to compare our findings to previous evidence, given that our study used a novel person-centred approach, whereas previous research used traditional variable-centred approaches. For some outcomes, the profile with higher ST and lower OP had more advanced developmental outcomes than profiles that included medium to high OP or high OP. These findings could indicate that higher OP and lower ST may have additive associations with cognitive and social-emotional development in this age group.

Future research is needed to both confirm and extend the findings of the present study. Some considerations for future research are higher-quality study designs and examining other cognitive and social domains (e.g., spatial, social competence, emotional competence, behaviour problems). Experimental evidence could shed light on the acute effects of ST/OP on child development. More longitudinal research is needed to better understand the temporality of longer-term associations between ST/OP and development[29]. Additionally, the use of direct measures of OP through GPS and accelerometry as well as direct measures of ST through technological measurement advances would provide further confidence in findings[24,30]. Furthermore, it is important that future ST measures include mobile devices, given the high accessibility and increased use of these devices by young children[29]. The current study included mobile devices within our TV/video viewing and video/computer games measures, but we did not specifically look at these devices. Finally, novel person-centred analysis methods, such as LPA, should continue to be used, so the interplay of these behaviors on health can be better understood.

A major strength of the current study was the use of LPA and the robust BCH 3-step approach. Furthermore, though a convenience sample was used, generalizability from this study was increased by including preschool children from across Western Canada. A key limitation is that this study is cross-sectional, so causation cannot be established. Furthermore, the parental-report measures of ST, OP, and social-emotional development are prone to recall and social desirability biases, though all ST, OP, and development measures used in the study had established psychometric properties. Finally, due to the sample size and the complexities of the models, we were only able to include three relevant covariates. Therefore, it is possible that findings were impacted by residual confounding.

CONCLUSION

To address major evidence gaps in the literature regarding screen time (ST) and outdoor play (OP) in preschool children, we performed latent profile analysis (LPA) to better understand the interplay between these two behaviors and potential impact on development in preschool children. Findings suggest that interventions targeting both behaviors to increase OP and also reduce ST may support optimal developmental outcomes in the early years and beyond. Given the study design and the limited research in this area, future research is needed to confirm and build on this work.

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Table 1 Participant Characteristics including Screen Time (ST) and Outdoor Play (OP) (n = 352)

Variables	Mean/category (SD/percent)
Children’s age (months)	3.5 (± 0.4)
Children’s Sex	
Male	179 (50.1%)
Female	178 (49.9%)
Parent education	
Less than Bachelor’s degree	75 (21.1%)
Bachelor’s degree	134 (37.8%)
Above Bachelor’s degree	146 (41.1%)
Children’s Screen Time (min/day)	Median (IQR)
Total ST	90 (48–150)
Total weekday	60 (30–120)
Total weekend	120 (60–180)
Total TV/videos	90 (45–135)
Total weekday	60 (30–120)
Total weekend	90 (60–180)
Total Video/computer games	0 (0–24)
Total weekday	0 (0–17.5)
Total weekend	0 (0–30)
Children’s OP (min/day)	
Total Outdoor Play	105 (60–180)
Total weekday	90 (60–150)
Total weekend	120 (60–180)

Table 2 Fit Indices for Latent Profile Analysis (n = 352)

Model	AIC	BIC	saBIC	LMR LRT *p*	BLRT *p*	entropy	% per profile
2-profile	22332.152	22405.561	22345.285	0.0143	0	0.984	87/13
3-profile	21978.376	22078.83	21996.348	0.1785	0	0.976	83/14/3
4-profile	21816.673	21944.173	21839.484	0.0029	0	0.906	60/24/13/3
5-profile	21734.343	21888.888	21761.992	0.5921	1	0.861	43/22/19/13/3

AIC = Akaike information criterion. BIC = Bayesian information criterion. saBIC = sample-size adjusted BIC. LMR LRT = Lo-Mendell-Rubin adjusted likelihood ratio test. BLRT = Bootstrapped likelihood ratio test. *p* = *p* value

Table 3 Outcome Means for ST/OP (screen time/outdoor play) profiles

	Profile 1 (low ST, medium/high OP)	Profile 2 (high TV/ high OP)	Profile 3 (medium ST/ low OP)	Profile 4 (high ST, medium/high OP)	Overall (unadjusted)
	mean (SE)	mean (SE)	mean (SE)	mean (SE)	mean (SE)
Language (n = 343)	23.2 (0.5)	23.0 (0.9)	21.6 (1.1)	21.8 (2.5)	22.9 (0.5)
Response Inhibition (n = 306)	15.3 (1.0)[c,e]	13.0 (1.8)	10.3 (2.0)[c]	2.8 (3.7)[e]	13.7 (0.9)
Working Memory (n = 316)	2.0 (0.1)	1.8 (0.1)	1.9 (0.2)	1.1 (0.5)	1.9 (0.1)
Snack delay (n = 337)	74.2 (2.1)[a,d]	65.5 (3.2)[a]	63.8 (4.8)[d]	67.8 (6.9)	70.7 (1.6)
Emotional SR (n = 352)	3.4 (0.1)	3.3 (0.1)	3.3 (0.1)	3.7 (0.2)	3.4 (0.0)
Cognitive SR (n = 352)	3.6 (0.1)	3.5 (0.1)	3.7 (0.1)	3.9 (0.2)	3.6 (0.0)
Behavioural SR (n = 352)	3.9 (0.0)[b]	3.6 (0.1)[b]	3.8 (0.1)	3.8 (0.3)	3.8 (0.0)

SR = self-regulation; SE = standard error
Means (SE) for profiles 1-4 are adjusted for children's age, children's sex, and parental education
Means (SE) for the overall sample are unadjusted
[a,b] Significant difference between profile 1 and 2
[c,d] Significant difference between profile 1 and 3
[e] Significant difference between profile 1 and 4

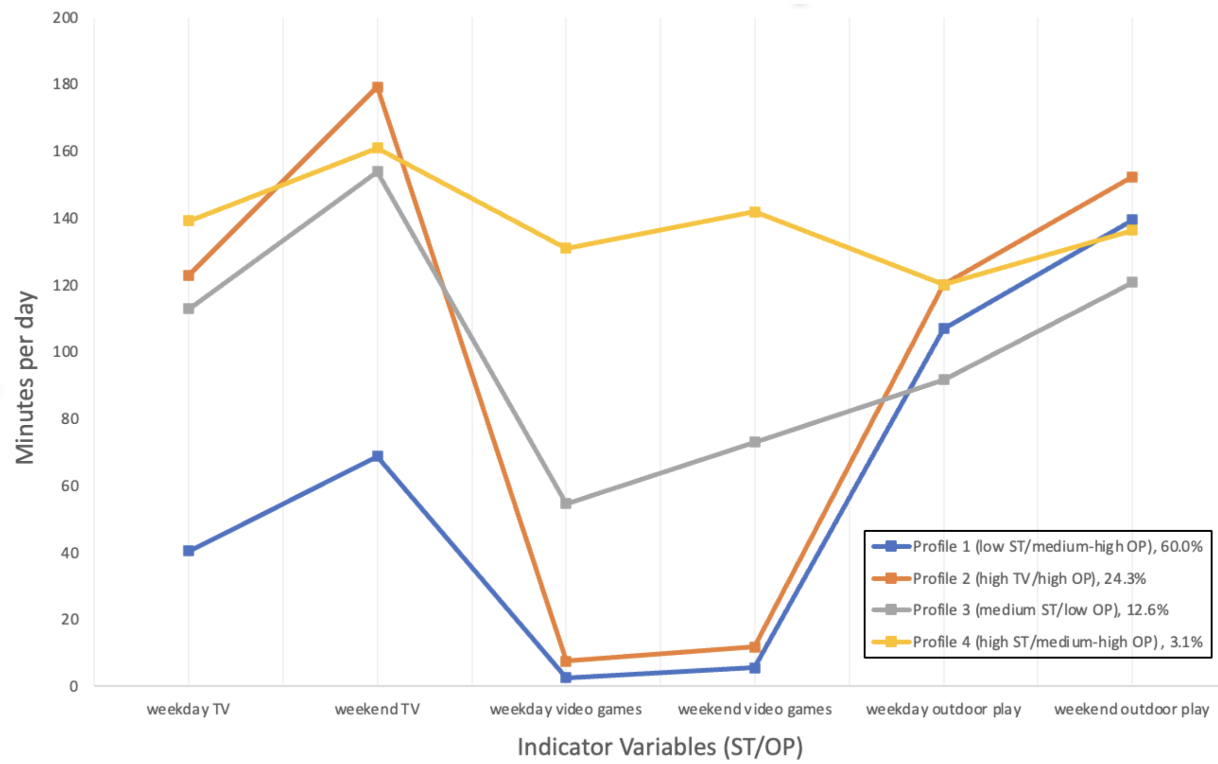

Figure 1 4-profile plot for screen time (ST) and outdoor play (OP)

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Chapter 4: Conclusion

4.1 Overview

This thesis addressed important evidence gaps in the literature. Specifically, no previous studies in children and youth have combined screen time and outdoor play to examine differences in specific domains of cognitive and social-emotional development. This thesis focuses on preschool children as this is a critical time period of development and establishing healthy patterns of behaviours (Almli et al., 2007; Tremblay et al., 2017). Specifically, novel, person-centered, latent profile analyses (LPA) were used to: 1) identify distinct profiles (i.e., subgroups) of screen time and outdoor play in a sample of preschool children, and 2) examine the mean differences in specific domains of cognitive and social-emotional development between these profiles.

4.2 Summary of Key Findings

It was hypothesized that preschoolers who have a profile of lower screen time combined with higher outdoor play would have more advanced development than those of other profiles. Findings from this thesis confirmed this hypothesis for some outcomes. Specifically, compared to the optimal behavioural profile (low screen time/medium-high outdoor play), children in all other profiles scored significantly lower for at least one outcome: response inhibition (medium screen time/low outdoor play, high screen time/medium-high outdoor play), self-control (high television/high outdoor play, medium screen time/low outdoor play) and behavioural self-regulation (high television/high outdoor play). Effect sizes were medium for the response inhibition outcome, and small for the self-control and behavioural self-regulation outcomes, suggesting findings are practically significant.

4.3 Directions for Future Research

There are several areas for future direction of this research, including the use of more rigorous study designs, measuring the patterns of screen time and context of outdoor play, measuring other domains of cognitive and social-emotional development, and improving generalizability. First, the present study used a cross-sectional design. This study design produces lower quality of evidence because temporality of associations cannot be observed (Caruana et al., 2015). The current study used baseline data from the Technology and Development in Early Childhood (TECH) project. For the TECH project, 6-month and 12-month time-points are being collected. Therefore, the current study could be expanded in the future, utilizing data from the TECH project, to examine longitudinal differences in outcomes by using latent transition analysis. Following the same cohort of children over time is advantageous as it provides information on the temporality of associations between combined screen time and outdoor play and development. Observational research is more susceptible to internal validity threats (Grimes & Schultz, 2002). Experimental research designs provide the highest quality of evidence because they are able to establish cause and effect. Therefore, if the results observed in the present work are confirmed in additional observational research, targeted interventions may be another important avenue for future research. Specifically, targeting families whose preschool children do not have optimal patterns of screen time and outdoor play and measuring development through short and longer-term follow-up periods would add important evidence to this area.

Although this thesis used screen time as duration only, the TECH project also uses a screen time diary to capture patterns of screen time, including type of screen time (e.g., game, show, etc), device used (e.g., TV, tablet, etc), content (e.g., educational, entertainment, adult, etc), and context (e.g. who watched with the child). Though it was beyond the scope of this work, screen time patterns are important to consider for future work because not all screen time may be equal in terms of its associations with development. For example, children playing an educational electronic game while interacting with a parent may have different associations with development than a child passively watching a television show, independently (Rai et al., 2023). Although not asked in the TECH project, it may also be interesting to explore the context of outdoor play, such as the location (e.g., nature versus urban area), who children are playing with (e.g., solo versus parents or peers), and what children are playing while outdoors (e.g., active versus sedentary play). This contextual information is important because previous research suggests it may be important for development (MacQuarrie et al., 2022). For instance, systematic review evidence in children and youth <18 indicates that access to a green space is associated with improved mental well-being and cognitive development (McCormick et al., 2017). Therefore, incorporating measures that capture patterns of screen time and contextual information regarding outdoor play should be considered for future research.

Using direct measures of screen time and outdoor play could help provide more information on patterns of screen time and contextual information regarding outdoor play. Furthermore, direct measures could help confirm our current findings by eliminating some of the potential biases associated with indirect measures, such as parent-report (Bates & Stone, 2015; Perez et al., 2023). For example, for outdoor play, utilizing accelerometers (i.e., activity monitors), global positioning systems (GPS), and diaries has been found to result in more accurate estimates of outdoor play in older children along with capturing contextual information, such as companions, locations, and activity levels (Klinker et al., 2014). It is important to note that, in comparison to the questionnaire that was used in the present study, this combination of measures would also result in increased participant burden and the feasibility in young children is unknown. Currently, no direct measure of screen time is widely used in early childhood research but technology is continuing to advance in this area (Perez et al., 2023). It will be important that future direct measures include television as well as mobile devices, as was done in the current study, because of the increased popularity and high accessibility of these devices in today's society by young children (Mallawaarachchi et al., 2023). Future technology development will need to consider the fact that young children often watch videos or play games on their parent's phone to keep them occupied in settings outside of the home, such as at restaurants or in the car (Ponti et al., 2023).

Along with measurement considerations for screen time and outdoor play, there are also considerations for the measurement of development outcomes in future research. Given this study utilized data from the TECH project, only specific domains of cognitive development and social-emotional development that were included in the TECH project could be included in the current study. In terms of social-emotional development, only one domain was included; therefore, future research examining the combined impacts of screen time and outdoor play should include the domains of emotional competence, social competence and behaviour problems (Halle & Darling-Churchill, 2016). Furthermore, for cognitive development, spatial and memory domains may be important to examine (Carson et al., 2016).

To further improve generalizability, future studies may also want to include children born preterm (<37 weeks) or underweight (<2.5 kg), as well as children with physical and developmental disabilities and a variety of health conditions (e.g., children with congenital heart defects) to produce evidence that can support all children in achieving their full potential. For now, current research can likely be applied to these children until future, more specific studies are conducted. Overall, this study will hopefully provide a stepping stone to inspire future research in this area.

4.4 Directions for Future Practice

Casual inferences cannot be made from this work. If findings from this study are supported by future research noted in the previous section, this body of work could inform future directions for practice across home, neighbourhood/community, and childcare settings, including public health initiatives, environmental changes, and policy. This study focused on the home and neighbourhood/community setting because parents are important gatekeepers for children's health behaviours (Lee et al., 2018; Villanueva et al., 2022). Public health initiatives could be one strategy to reach parents by promoting the importance of regular outdoor play and minimal screen time, especially screen time of low quality (e.g., passive screen time) for optimal development in early childhood. The preschool years is one of the best times to work on healthy screen use because high screen time is much harder to reduce once it has become a habit (Morawska et al., 2023). However, research suggests that parents need to be armed with more than just knowledge in order to implement health-promoting behaviours, especially for screen time (Morawska et al., 2023). For instance, previous qualitative research in Canadian parents found that parents wanted realistic strategies on how to meet screen time recommendations that overcome common barriers, such as weather and the demands of raising a family (Carson et al., 2014). Therefore, public health initiatives should not be education only, but also offer practical ideas for parents and families to manage family demands without screens and engage in outdoor play across seasons and weather conditions.

In regards to environmental changes, communities and municipal governments should support changes to the environment to ensure children and families have access to safe and desirable outdoor play spaces across seasons. In particular, outdoor play has been found to be lower in colder seasons in Canada and other locations in the northern hemisphere (Carson, 2009).

Therefore, environmental changes to support families in enjoying outdoor play in the community during the winter could include the development of permanent (e.g., buildings) or temporary infrastructure (e.g., heat lamps, warming domes) as well as family-oriented outdoor winter festivals.

In terms of policy, municipalities should consider public policy to ensure every community has access to green space. This may be easier to achieve for new developments but creative solutions could be implemented in more established communities, such as creating walking trails for easier access to community green space. Access to green space is important because previous systematic review evidence indicates that access to green space is associated with lower mental and behavioural problems in children and youth (0-18 years). Furthermore, within the childcare setting, which serves a large proportion of preschool children (Statistics Canada, 2022), provincial and childcare level policy development should also be considered regarding reducing or eliminating screen time from this setting. In the province of Alberta, approximately half of childcare centers were found to provide screen time for preschoolers (Predy & Carson, 2022). Across Canada, 71% of childcare centres had no written screen time policy and those who did mainly focused on amount of screen time (Ott et al., 2019), not other important considerations such as type and context. In terms of provincial policy, British Columbia and Quebec were the only two provinces to have policies that addressed screen time (Vercammen et al., 2020). In terms of outdoor play, centre-level and provincial policy regarding duration and frequency of outdoor play as well as outdoor space requirements for outdoor play are also important directions for future practice. In Alberta, most (94.2%) childcare centres have an outdoor play policy, but 12.1% had less than three policy components (e.g., total amount of outdoor play, guidelines for unsuitable weather, etc) (Predy, 2019). For provincial policy, all Canadian provinces and territories indicated time in outdoor play is required daily by childcare centres, but only three provinces further specified the requirements (e.g., number of outdoor play periods) (Vanderloo & Tucker, 2018; Vercammen et al., 2020).

4.5 Conclusions

It is important to understand the developmental implications of the increasing screen time and decreasing outdoor play trends of children in today's society. This study addressed major evidence gaps by performing LPA and found that children with the optimal behavioural profile (low screen time/high outdoor play) showed advanced development for some outcomes compared to children in the other profiles. There were no significant findings in which children in the non-optimal behavioural profiles outperformed children in the optimal behavioural profile. Future research, such as longitudinal research and targeted interventions, will be needed to confirm study findings and expand on this topic.

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Appendix 1:

Original Project

This thesis used baseline data from the Technology and Development in Early Childhood (TECH) project. To address several substantial evidence gaps, the overall objectives of the TECH project are to examine: 1) screen time patterns (e.g., time of day, device, type, content, context), 2) the associations between screen time patterns and cognitive development overtime (1 year), 3) the quality of parent-child interactions during different screen-based tasks (i.e., television viewing, game app) and a control task (i.e., reading), and 4) the influence of parent-child interaction quality on the association between screen time patterns and cognitive development. Each cohort (3, 3.5, and 4 years) is being followed up at 6 and 12 months after enrollment to represent data for ages 3 through 5 years of age.

Cognitive tasks/games

Language was assessed using the expressive vocabulary game from the Early Years Toolbox (Howard & Melhuish, 2016). This task consists of 45 powerpoint slides that are shown to the child via the share screen function on Zoom. The research assistant asks the child "What is this?" The child receives one point for each correct answer. However, they are not told how many they have answered correctly. Positive reinforcement remains throughout the task even if they do not know the answer or provide the incorrect answer. For answers that are close, the research assistant provides up to 3 prompts, such as "What else could you call this?" Once the child answers 6 vocabulary words incorrectly in a row, the task ends. The child is then praised for playing the game and told that they can add a sticker to their sticker chart. This shows them that they only have three games left until they get their prize. A higher score in this game indicates the child has a better vocabulary, and a score of 45 points is the maximum. It is important to note that this test is for English speakers. If the child says the vocabulary word in a language other than English, they are encouraged to say it in English. If they say it in English, it counts as a point. If not, then no point can be given, and we can move onto the next word.

Response inhibition was assessed using the Head Toes Knees Shoulders (HTKS) task (Ponitz et al., 2008). The parent is asked to position the camera so the research assistant can see the child from head to toe. Part one begins by the research assistant telling and showing the child how to touch their head and toes with the child imitating them. The child is then instructed to do the opposite of what the research assistant says. They are given some training and practice in which the research assistant is allowed to re-explain the instructions up to three times if the child is doing the incorrect movement. Once the 10-item test begins, the research assistant can no longer re-explain, and the child is not told whether they are performing correctly or not. If the child gets five or more of the items correct or if they have started kindergarten, they can proceed to part two. If not, they will add a sticker to their chart and move on to the next game.

Part two begins in a similar way to part one, but they will be touching their shoulders and knees this time. The child is then instructed to do the opposite of what the research assistant says, and the training and practice occur in the same manner as part one. During the 10-item test in part two, the child is told that we are putting all the parts together. In other words, if they are asked to touch their head, they will touch their toes, and if they are asked to touch their knees, they will touch their shoulders, and so on. At the end of the test (either part one or two depending on part one score), they are told they did a great job, and they are thanked for playing. The HTKS task is scored by giving 0 points for an incorrect movement, 1 point if they self-correct (i.e., they reach for their toes and then realize that they are actually supposed to reach for their head), and 2 points for a correct movement. Part two training and practice do not count towards the total score which is a maximum of 52 points. A higher score indicates that the child has better response inhibition.

Working memory was assessed with forward and backward word span (Thorell & Wåhlstedt, 2006). To make this task more interesting, a puppet is used for each part of the game. For forward span, the child is instructed to repeat the words after the puppet. After a 2-word example and a 2-word practice are completed, the test trials begin. There are three sets of words in a series. If the child gets the first two correct, the research assistant can skip to the next level. The research assistant tells the child each time the game is going to get harder by saying "Now [name of puppet] is going to say three words so make sure you listen to all three before you say them back." The series start at two words and go all the way up to six words. If the child gets all three sets of words incorrect, the forward word span game ends.

The child receives a check mark on the score sheet each time they repeat a set of words correctly. If they get 0/3, 1/3, 2/3, or 2/2 correct, they get 0, 0.33, 0.67, or 1 point, respectively, for each of the series. These numbers are summed to get a final score, with a maximum of 10 points (5 forward, 5 backward). Backward span is similar to forward span except that there is a 2-word and 3-word example followed by three 2-word practices because children find backward span more confusing than forward. For backward span, the child is instructed to repeat the words after the puppet in the reverse order. The test trials and scoring are the same as forward span. It is important to note that children continue onto backward span in this game no matter how they score on forward span. A higher score in the game indicates the child has a better working memory.

Self-control was assessed with the modified Snack Delay Task (Wiebe et al., 2011; Schoemaker et al., 2011). Parent are asked to get some small snacks and place them under a clear cup or container. They are then asked to position the camera so that the research assistant can see the child from head to toe from the side. The game instructions for the parent are emailed to them the day before and posted in the Zoom chat box for a quick review before starting the game. These instructions include timing the trial, staying in the room while working on a chore away from the child until 2 minutes, telling the child at that time that they need to go check something and to stay frozen, then returning at 3 minutes and 30 seconds and encouraging the child to keep going until time is up. The time from approximately 2:15 to 3:15 minutes represents the actual delay of the snack delay test. The child is told to stand still and be silent like a frozen snowman, to place their hands on the table in front of their treats, and that when they hear the bell ring, they can have their treats. The research assistant starts a 10-second practice trial. When the bell rings, the child eats the treats. The parent may need to check to see if there are still treats under the cup or if they need to add more.

The test trial is 4 minutes long and the research assistant tells the child that they will be doing some paperwork off-screen while they wait for the bell to ring. The test trial ends when the child eats the snack early or when time is up (i.e. the bell rings). During this 4-minute test trial, the research assistant acts or plays different cues at specified times out of camera view. These include dropping a pencil, clearing their throat, knocking twice on the table, playing audio of email notification, playing audio of dog barking, and playing audio of bell at 15, 30, 45, 60 (1 minute), 90 (1:30 minutes), and 240 (4 minutes) seconds, respectively. For scoring, the Snack Delay Task is broken into 5 second increments. Each increment is scored out of 3, which is based on 3 categories. Because there are 48 5-second epochs, the child can receive a maximum of 144 points in this game. Higher scores indicate better performance on the task (i.e., better self-control). The child loses up to 3 points during each increment for the following: hand movement, body movement, and speaking. This means that to achieve full points per epoch, the child must not move their hands from table, stand still and not make any large movements, and not speak or make sounds. Examples of when a child may lose points is provided in the TECH protocol manual.

Appendix 2: Letter of information and informed consent

PARTICIPANT CONSENT FORM

Title of Study: Screen technology, parent-child interactions, and cognitive development in early childhood

Project Leads:
Dr. Valerie Carson, 1-149 Van Vliet Complex, University of Alberta, Edmonton, AB, T6G 2H9; vlcarson@ualberta.ca; 780-492-1004

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Research/Study Coordinator: Madison Predy, 1-167 Van Vliet Complex, University of Alberta, Edmonton, AB, T6G 2H9; perbel@ualberta.ca; 780-492-2931

You are being invited to take part in a research study. Before you take part, a member of the research study team is available to explain the project. If there is anything you do not understand, you are free to ask them questions. You will be emailed a copy of this form for your records.

Why am I being asked to take part in this research study? You are being asked to be in this study because you have a preschool-aged child. The preschool years represent a significant period of cognitive development. This study will help us better understand the role new screen technology plays in preschool children's cognitive development.

What is the reason for doing the study? Today screens play a large role in the daily lives of families. Research has not kept pace with the technological and cultural changes. Therefore, many questions remain on how young children's engagement with this new screen technology relates to cognitive development outcomes. Additionally, it is unclear how parents can best support optimal cognitive development in regards to screen time. This study will address these evidence gaps.

What will I be asked to do? This study takes place over the course of 1 year with study measures occurring at three time-points: baseline, 6 months and 12 months later. Each time-point includes three main tasks: 1) completing an online questionnaire, 2) attending 2 virtual meetings conducted by a trained research staff with your child, and 3) recording your child's screen time in a daily diary for 14 consecutive days. The total time commitment at each time-point is about 2-2.5 hours spread across 2 weeks. Therefore, the total time commitment of the entire study is about 6-7.5 hours over the 1-year period.

Task 1: Before virtual meeting # 1, you will be asked to complete a short online questionnaire through a secure web application called REDCap. The questionnaire should take about 15-20 minutes to complete.

Task 2: During virtual meeting # 1, you and your child will complete three activities together, including watching a brief video, reading a new storybook that we send you, and playing a free app game that you will download on your personal smartphone. At virtual meeting # 2, your child will complete 4 games to assess cognitive development such as working memory, response inhibition, self-control, and vocabulary. For one of the games, we will ask you to provide a desirable snack for your child. If needed, we can arrange a third virtual meeting to allow your child to complete any remaining games. All virtual meetings will be conducted through Zoom and recorded for later analysis. The virtual meetings will last about 30 minutes each.

Task 3: After virtual meeting # 1, we will ask you to complete a daily diary measuring your child's screen time patterns for 2 weeks. Diaries include reporting the time(s) your child engaged in screen time (e.g., 9:00-9:30 am), the device used (e.g., iPad, TV), type of screen time (e.g., movie, game), content (e.g., program name), context (e.g., watched with Mom) as well as some questions about the day (e.g., nap, childcare). You will complete the daily diaries online through a secure web application called REDCap. If your child spends time outside of your care during the day (e.g., daycare, kindergarten) we will also provide you with a paper-copy of the diary to share with their educator and/or teacher. The diaries should take approximately 5 minutes/day to complete.

What are the risks and discomforts? There are no anticipated risks. All tasks have been used in previous research with young children. It is not possible to know all of the risks that may happen in a study, but we have taken all reasonable safeguards to minimize any known risks to you.

What are the benefits to me? You and your child may not directly benefit from participating in the study. However, findings from this study will have important implications on updates to national screen-time recommendations, health promotion initiatives, and future interventions, which may benefit preschool children and their families in the future.

Do I have to take part in the study? Participating in this study is your choice. You should not feel obliged to answer any survey or diary questions you do not wish to. If your child does not want to participate in some or all of the virtual meeting tasks, they do not have to. Even if you agree to participate in the study, you can change your mind and stop participating in the study at any time. To withdraw from the study please contact the research coordinator Madison Predy (perbel@ualberta.ca; 780-492-2931) or the principal investigator Dr. Valerie Carson (vlcarson@ualberta.ca; 780-492-1004). Whether you remain in the study or not, you may choose to withdraw some or all of your data by contacting Madison Predy within one month of completing the questionnaires, diary, or Zoom sessions. We are unable to remove your data after that time because knowledge translation activities will have likely begun.

Will I be paid to be in the research? At the end of each of the three time points, you will receive an electronic gift card worth up to $48. Specifically, you will receive up to $20 for the 2-3 virtual meetings and up to $28 ($2 per daily entry) for the 2-week daily diaries. If you contact us to let us know that you are choosing to stop participating in the study, you are still entitled to the gift card or a portion of the gift card based on the timing of when you stopped participating in the study. At each time point, you will also receive a free children's storybook, valued at about $10, to use during the virtual meeting as well as a prize (e.g, stickers, small toy) for your child. If you choose to stop participating in the study, you will still be able to keep any storybooks and prizes that have already been sent to you.

Will my information be kept private? During this study we will do everything we can to make sure that all information you provide is kept private. No information relating to this study that includes your name will be released outside of the research team or published by the researchers unless you give us your express permission. In a rare situation, by law, we may be required to release your information so we cannot guarantee absolute privacy. However, we will make every legal effort to make sure that your information is kept private. In instances where research staff are working remotely, Zoom recordings from the virtual meetings will be downloaded to research staff's personal computer/laptop (not the cloud) and uploaded to a password protected research drive. The research coordinator will then download the video data to a password protected U of A lab computer. Once it is confirmed the video data is on the research drive and lab computer, the video data will be deleted permanently from personal computers/laptops. This will be done as quickly as possible to limit the amount of time participants video data is stored on personal computers.

What will happen to the information or data that I provide? All data collected will be kept confidential. Only the research team will have access to it. The study data will be kept in a secure place for a minimum of ten years. Any physical data (i.e., paperwork) will be stored in locked cabinets in secure lab spaces. Electronic data will be stored on password protected U of A computers and research drives. If the data is to be used for other studies, ethics approval will be obtained. We will publish study findings in professional journals and present the study findings at scientific conferences, but any such publications and presentations will be of general (group-level) findings and will never breach individual confidentiality. Should you be interested, you are entitled to a copy of the findings at the end of the study.

What if I have questions? If you have any questions about the research now or later, please contact the research coordinator Madison Predy (perbel@ualberta.ca; 780-492-2931). You can also contact the project lead, Dr. Valerie Carson (vlcarson@ualberta.ca; 780-492-1004). If you have any questions regarding your rights as a research participant, you may contact the University of Alberta Research Ethics Office at reoffice@ualberta.ca and quote Ethics ID Pro00121809. This office is independent of the study investigators.

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role in the design of the study, the collection, analysis, and interpretation of the data, and the knowledge translation of study findings.

How do I indicate my agreement to be in this study?

By signing below, you understand:

- That you have read the above information and have had anything that you do not understand explained to you to your satisfaction.
- That you will be taking part in a research study.
- That you may freely leave the research study at any time.
- That you do not waive your legal rights by being in the study.
- That the legal and professional obligations of the investigators and involved institutions are not changed by your taking part in this study.

NAME AND SIGNATURE OF STUDY PARTICIPANT

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Name of Child Participant

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Name of Parent Participant

_________________________________ _____________________

Signature of Parent Participant Date

NAME OF PERSON OBTAINING CONSENT

_________________________________ _____________________

Name of Person Obtaining Consent Contact Number

You will be emailed a copy of this form for your records.