# The Role of Screen Media in Early Childhood Development and Parental Influence on Children's Screen Exposure and Use


Maria Corkin

The University of Auckland


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## Abstract

The over-arching goals of this thesis were to investigate parental influences on preschool children's screen exposure and to investigate the role of screen media in early childhood development. Studies 1 and 2 investigated the predictors of total screen time on a weekday for children when they were 2 years and 4.5 years of age. Higher screen time at 2 years was significantly associated with higher TV exposure, viewing adult-directed content, having no screen time rules, ethnicity, and not attending non-parental childcare. Parent always co-viewing with their child was negatively associated with 2-year-olds' screen time. Higher screen time at 4.5 years was significantly associated with higher TV exposure, TV at meal-times, symptoms of inattention/hyperactivity, and ethnicity, while having screen time rules and reading to the child daily were negatively associated with screen time. As six of the significant predictors of screen time identified in Studies 1 and 2 are media parenting practices, and modifiable, this information may benefit parents wishing to reduce their preschool children's screen time.

Study 3 identified relationships between TV at meal-times at 4 years and poorer cool executive functions at 4.5 years, and high TV exposure at 2 years and poorer hot executive functions at 4.5 years. Neither hot nor cool executive functions were significantly associated with screen time. Study 4 investigated associations between key markers of high-quality parent-infant interactions (parental responsiveness, scaffolding, directiveness, and co-ordinated joint attention), infant vocabulary, and "technoference", which is distraction from interpersonal activities due to use of mobile screen devices. Using SEM, the frequency of audible notifications negatively predicted infant vocabulary, and this relationship was fully mediated by parental directiveness. This novel finding indicates that there may be a "carryover" effect whereby parents' habitual use of mobile technology may affect parent-child interactions even when parents are not using their phones.

Overall, this thesis highlights the pivotal role that parents play in creating the media environment that may facilitate or constrain their preschool child's access to screens, and suggests that in today's media environment, environmental screen media may be more important to the development of executive functions and vocabulary than screen time.

# Acknowledgements

I know everyone says this, but it has been a long journey. However, those who know me and have helped me along the way, can attest that mine has been a particularly arduous journey. It is perhaps ironic that now that I have completed my thesis, things finally seem to have calmed down! But this is a wonderful blessing, as I forge ahead into my next projects and make plans to continue with my research in the field of children's screen media use.

Now I begin my thank yous. Above all, God should be thanked. I know I am blessed to have the privilege of undertaking doctoral study. Not everybody has this opportunity and I hope that through this work, I have made good use of the talents God has given me.

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# Co-Authorship Forms

**School of Graduate Studies**
AskAuckland Central
Alfred Nathan House
The University of Auckland
Tel: +64 9 373 7599 ext 81321
Email: postgradinfo@auckland.ac.nz

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## CO-AUTHORS

| Name | Nature of Contribution |
|---|---|
| Elizabeth Peterson | Oversight and mentorship of the research activity planning and execution, critical review and editing, and Co NI for design and collection of dataset used for analyses. |
| Annette Henderson | Oversight and mentorship of the research activity planning and execution, critical review and editing, contribution to the design and assessment materials for the longitudinal study. |
| Amy Bird | Mentorship of the initial planning, critical review and editing, and NI for design and collection of dataset used for analyses. |
| Karen Waldie | Critical review and editing, and Co NI for design and collection of dataset used for analyses. |
| Elaine Reese | Critical review and editing, NI for design and collection of dataset used for analyses. |
| Susan Morton | PI of the over-arching study, design and evaluation of tools used for data collection and preparation of data sets for analyses throughout the longitudinal study, review of text. |
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## Certification by Co-Authors

The undersigned hereby certify that:

*Last updated: 19 February 2021*

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and
- that the candidate wrote all or the majority of the text.

| Name | Signature | Date |
|---|---|---|
| Elizabeth Peterson | EPeterson | 3.6.2021 |
| Annette Henderson | | 3/6/2021 |
| Amy Bird | | 3-6-2021 |
| Karen Waldie | | 3/6/2021 |
| Elaine Reese | J E Reese | 3-6-21 |
| Susan Morton | | 07/06/2021 |
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| Extent of contribution by PhD candidate (%) | 90% |

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❖ that the candidate wrote all or the majority of the text.

| Name | Signature | Date |
|---|---|---|
| Elizabeth Peterson | E Peterson | 3/6/2021 |
| Annette Henderson | [illegible] | 3/6/2021 |
| Karen Waldie | [illegible] | 3/6/2021 |
| Elaine Reese | J E Reese | 3-6-21 |
| Susan Morton | [illegible] | 07/06/2021 |
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❖ that the candidate wrote all or the majority of the text.

| Name | Signature | Date |
|---|---|---|
| Elizabeth Peterson | E Peterson | 3/6/2021 |
| Annette Henderson | [illegible] | 3/6/2021 |
| Karen Waldie | [illegible] | 3/06.2021 |
| Elaine Reese | J E Reese | 3-6-21 |
| Susan Morton | [illegible] | 7/06/2021 |
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| Extent of contribution by PhD candidate (%) | 90% |

## CO-AUTHORS

| Name | Nature of Contribution |
|---|---|
| Annette Henderson | Mentorship of the research activity planning and execution, co-developing research protocols and instrument construction, development of the original coding scheme, and critical review and editing of manuscript. |
| Elizabeth Peterson | Mentorship of the research activity planning and execution, input into instrument construction, critical review and editing of manuscript. |
| Siobhan Kennedy-Costantini | Co-created the research design for the larger research project, led data collection, and reviewed the final manuscript. |
| Holly Sharplin | Contributed to the refinement of the behavioural coding scheme, assisted with data collection, and reviewed the final manuscript. |
| Sam Morrison | Contributed to the design of data collection procedures, co-led data collection, and reviewed the final manuscript. |
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| Name | Signature | Date |
|---|---|---|
| Elizabeth Peterson | | 3/6/2021 |
| Annette Henderson | | 3/6/2021 |
| Sam Morrison | | 3/6/2021 |
| Holly Sharplin | | 3/6/2021 |
| Siobhan Kennedy-Costantini | | 10/6/2021 |
| | | |
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# Chapter 1. General Introduction

## 1.1 Why Study Screen Exposure During the Preschool Years?

The early childhood years are viewed as a critical period in childhood development, and environmental influences play a key role in shaping developmental trajectories (Bronfenbrenner, 1979). For the vast majority of preschool children and infants, screen media are becoming an increasingly prominent part of the microsystems in which they develop (Barr, 2019; S. L. Golden et al., 2020). Hence, there is a pressing need for research into the role of screen media in early childhood development and parental influences on children's screen exposure and use. The research conducted in the course of completing this thesis adds to a growing body of research addressing these issues.

In modern society, screen technology is all-pervading, and today's generation of preschool children are almost invariably exposed to a range of screen-based devices, including television (TV), computers and laptops, tablets, and smartphones (Ralph & Petrina, 2019). While the traditional medium of TV remains popular during the preschool years (Kostyrka-Allchorne et al., 2017b; Neumann, 2015; Tena et al., 2019), the introduction of small, interactive, mobile technologies such as smartphones and tablets has broadened the way in which young children can use screen technology, as they need only perform tapping and swiping gestures on the screen to operate such devices (Geist, 2012; Neumann, 2015). The expansion of screen-based technologies accessible to preschool children has, not surprisingly, corresponded to an increase in the time that children spend using screens (Paus-Hasebrink et al., 2019). There is now concern not only about children's viewing of TV (Neumann, 2015) but also the potential effects of newer digital screen technologies (Ey, 2015). As screen exposure is essentially inescapable in modern society (Hepp & Hasebrink, 2018), and children are engaging in higher levels of screen time than ever before (Paus-Hasebrink et al., 2019), it is important to learn as much as we can about the potential impacts of screen time on preschool children in today's society, in order to maximise the benefits and prevent negative effects wherever possible. This may be particularly important for preschool children, who are undergoing a period of rapid neurological development (Conway & Stifter, 2012; Kolb & Fantie, 2009) and have less ability to comprehend screen media (Moser et al., 2015; Nikken & Schols, 2015) compared to older children. It is also important that research takes account of the different ways in which families may allow their preschool children to interact with screens, so that findings are as relevant and useful as possible (Lauricella et al., 2015).

There is now an abundance of research into the risks and benefits of TV viewing (Radesky & Christakis, 2016), with many studies finding associations between TV viewing or exposure during the preschool years and poorer developmental outcomes (Haughton et al., 2015). However, the speed with which the media landscape is changing means that it is extremely difficult for the research to keep up with new developments (Troseth et al., 2016). This is a critical consideration, because even before the introduction of digital technologies such as tablets and smartphones, S. Lee et al. (2009) demonstrated that research findings related to TV viewing were not necessarily applicable to newer technologies available at that time, e.g., gaming consoles and computers. This highlights the limitations of research that focuses on only one device (Livingstone & Local, 2017; Paus-Hasebrink et al., 2019), as such research risks becoming obsolete in a short space of time (Christakis, 2014; Troseth et al., 2016). Research that can be "generalized to multiple platforms" (Troseth et al., 2016, p. 60) may be the best approach, particularly as different forms of media converge (Peil & Sparviero, 2017).

Concerns have been raised in the research community that the "overuse" of newer digital technologies might be associated with risks to children's development (Ey, 2015). Although use of the terms "over-use" or "excessive" may be problematic, as there is unlikely to be a specific amount of screen time at which all negative outcomes occur (Royal College of Paediatrics and Child Health, 2018), there is nevertheless an acknowledgement that children can have more screen time than is good for them (UNICEF, 2017). Parents also have questions about the amount of screen time their children should have, and are eager for trustworthy information about the risks and benefits of the new media landscape their young children are experiencing (Canadian Paediatric Society, 2017; Ralph & Petrina, 2019). This highlights the need for research-based evidence that parents can consider when making informed decisions about their pre-school children's screen use (Ferguson, 2018). It is also important that the research identifies modifiable variables associated with screen time so that parents are able to decrease their children's screen time (Hoyos Cillero & Jago, 2010) - if they wish.

There is a need for more research investigating the links between the contextual aspects of children's media use and developmental outcomes (Alper et al., 2016). Characteristics of media use that may impact on children's development include content (e.g., Ostrov et al., 2006); context and connections (Blum-Ross & Livingstone, 2016); whether screen media is developmentally appropriate (Anderson & Hanson, 2010); or mediated by parents or others (Connell et al., 2015). Research in this field extends beyond a narrow focus on the quantity of media consumed by children to focus more on the quality of children's screen time (Blum-Ross & Livingstone, 2016). Such research may provide parents with a wider range of strategies for supporting and mentoring their children as they encounter the challenges and opportunities of living in a media-saturated world (Blum-Ross & Livingstone, 2016).

Most research in this field has been conducted in the United States (U.S.) (Lemish, 2019; Livingstone & Franklin, 2018). Consequently, there is far less research into the screen media use of preschool children living in other non-European nations or in minority groups (Asplund et al., 2015; Jago et al., 2012). Although recent publications now appear to include a substantial number conducted outside of the U.S. (e.g., B. Chen et al., 2020; Felix et al., 2020; Leppänen et al., 2020; Rodrigues et al., 2020; Yang, 2020), this trend needs to continue so as to build a better understanding of preschool children's screen exposure across different societal and cultural contexts (Barr, 2019).

More research needs to be conducted to investigate the *long-term* effects of media exposure during the preschool years (Pappas, 2020; Troseth et al., 2016). As yet, there is little evidence that use of interactive touch screen devices during early childhood has long-term implications for children's development (Nathanson & Beyens, 2018; Troseth et al., 2016). Much of the research to date has been correlational in nature (Gottschalk, 2019), which precludes making inferences about causality (Hinkley et al., 2010). In addition, although there is a greater body of research into the effects of TV or video viewing (Radesky & Christakis, 2016), these findings have not always formed a consensus (Courage & Howe, 2010). Nevertheless, as Courage and Howe (2010) point out, these findings have cumulatively advanced the understanding of how young children might be affected by screen exposure, and researchers identified a range of factors that could influence the outcomes of TV viewing for this age group, such as whether parents co-viewed with their child, and whether the material was designed for adults or children (Courage & Howe, 2010). A similar process needs to continue today to uncover the possible effects of screen media use on the preschool children who inhabit a media landscape comprised of both traditional and newer screen-based technologies.

Past research identified background TV as a source of distraction that can impair the quantity and quality of parent-child interactions (Kirkorian et al., 2009). In today's media context, mobile technologies can also distract people's attention from others who are physically present with them at the time, a phenomenon that has been labelled "technoference" (McDaniel & Coyne, 2016). There is a growing body of evidence to show that parents' use of mobile technology can distract their attention from the children in their care, making them less likely to interact and respond to their children's bids for attention (e.g., Hiniker et al., 2015; Radesky et al., 2014a; Radesky et al., 2015a). However, there is no research investigating the implications of routinely high levels of technoference on key dimensions of parent-child interactions and developmental outcomes. This is an important question to explore as parents' use of mobile screen media in the "background" becomes increasingly prevalent in children's lives.

## 1.2 Definitions Related to Screen Media Use

### *1.2.1 Defining Screen Time in Today's Media Context*

Screen time is defined here as a period of time during which a person uses any screen-based device, including, but not limited to: TV, laptops, computers, tablets and smartphones (Downing et al., 2017; Wiberg & Wiberg, 2019). For the purposes of research, a daily or weekly total can be computed (e.g., Birken et al., 2011; Cliff et al., 2018; Wiecha et al., 2001; Xu et al., 2016). Children's screen time is often separated into TV use versus use of computers and mobile technologies (Leppänen et al., 2020).

Screen use refers to a non-quantified period of time during which screen-based devices are employed for a certain activity or purpose (Kaye et al., 2020). For the purposes of this study, "excessive use" will be interpreted to mean: "a significant amount of time is spent using digital technology, but without quantifying how much time this implies in practice" (Kardefelt-Winther, 2017, p. 11). Screen media exposure refers to both "foreground" and "background" media, i.e., screen-media that a person is using themselves, compared to screen media being operated in the person's environment, even if they are not directly paying attention to it (Anderson & Pempek, 2005). The term "digital media" incorporates screen-based devices that can access and transmit content and information using the internet (Canadian Paediatric Society, 2017). It can also include applications (apps), games and websites that can be used or created online (Plowman, 2016).

### *1.2.2 Screen Time as a Parent Behaviour for Preschool Children Aged 0–5*

During the preschool years, children have little autonomy compared to older children (Davies & Gentile, 2012) and are dependent on others, predominantly their parents, to manage their daily lives (DeCaro & Worthman, 2007). Parents choose the types of media equipment available in the home, which they may or may not allow their young child to access (Jago et al., 2013; Kostyrka-Allchorne et al., 2017b; Lundtofte, 2020). Due to their children's young age, parents are also able to control the amount of screen media their children are exposed to (Barr, 2019; Duch et al., 2013). Whilst family members other than parents may also provide pre-school children with opportunities to use screen media, parents can choose to guide and regulate the amount of screen time that occurs in the family setting (Maniaci et al., 2019), or take a "laissez faire" approach (Livingstone et al., 2017). Thus, the screen exposure of preschool children can be described as a parenting behaviour (Ansari & Crosnoe, 2016), as it reflects parental decisions about the opportunities for media use afforded to their child, and the extent to which they facilitate or constrain their children's access to screens (Lauricella et al., 2015).

### *1.2.3 Parental Mediation of Preschool Children's Screen Time*

Parental mediation refers to strategies parents use to regulate their children's screen use, in order to promote positive outcomes and prevent negative outcomes (Domoff et al, 2019; Nikken & de Hann, 2015). One type of mediation involves putting restrictions on children's screen use, including the amount of time children can spend using screens, or the content children have access to. Co-use or co-viewing are strategies whereby parents watch, use, or play with screen media with their child, whereas active mediation involves instructive and critical comments aimed at helping children understand and learn from the content of the screen media they engage with (Livingstone et al., 2017; Nikken & Jansz, 2014).

## 1.3 Perspectives on the Role of Parents in Preschool Children's Exposure to Screens

In this doctoral research, I consider the influence of parents on their preschool children's screen time and screen use, and potentially on their child's developmental outcomes via the screen media environment they provide for their child. It is important to turn first to the literature to gain some insight into how parents in today's media environment might view their preschool children's screen use in relation to their role as parents. I have also considered wider societal perspectives on these issues, as these may influence parents' media parenting decisions.

### *1.3.1 Parents' Perspectives on their Preschool Children's Use of and Exposure to Screen Media*

A range of factors may lead parents to promote or restrict preschoolers' use of screen media in the family setting. Many parents perceive screen use as being educational (A. Brown & Smolenaers, 2018; De Decker et al., 2012) or entertaining for their child (Tena et al., 2019); useful for occupying their child while they carry out household tasks or other work (Beyens & Eggermont, 2014; He et al., 2005); as a means of facilitating bedtime, mealtimes and family time (Elias & Sulkin, 2019); and necessary to prepare their child for a future where technological skills will be essential (Livingstone & Franklin, 2018; Plowman & McPake, 2013). Parents may also utilise screens as a means of calming their child when upset (De Decker et al., 2012); or as a reward for desirable behaviour (Cingel & Krcmar, 2013; Wartella et al., 2014). Parental willingness to allow their children to use screen devices and view certain content can also vary depending on the age of the child (Vandewater et al., 2005b); type of activity (e.g., video chatting with grandparents versus using screens for entertainment) (J. O'Connor & Fotakopoulou, 2016); type of device (e.g., interactive screen use versus passive viewing of TV); the child's (Nikken & Schols, 2015) or the parent's competence at using screen devices (Rideout & Katz, 2016); the parent's own childhood experience of screen media (S. G. O’Connor et al., 2017), the role screen media plays in managing and organising their family life (Elias and Sulkin, 2019; Vittrup et al., 2016), and societal norms (E. Clark & Dumas, 2020).

Many parents are ambivalent about allowing their young children to use screens (J. O’Connor & Fotakopoulou, 2016). Despite potential benefits, parents may worry about health and developmental effects, whether their child can become dependent on screens, ensuring that their child is not exposed to unsuitable content (J. O’Connor & Fotakopoulou, 2016) and whether their child’s use is excessive (Kervin et al., 2018). However, parents can experience multiple barriers to reducing or monitoring their children’s screen time, including societal pressure for ownership of new technologies; obstacles to outdoor play, e.g., poor neighbourhood safety, and bad weather conditions; needing a break from their children; as a chance to get other work done; children enjoying and wanting to use screens, being calmed by screens, or preferring using screens to other leisure activities; and older siblings enabling preschool children to access screen activities and content (Carson & Janssen, 2012; E. Clark & Dumas, 2020; He et al., 2005; Radesky et al., 2016). Obstacles such as these may reduce “barrier self-efficacy for limiting screen time” for some parents (E. Lee et al., 2018, p. 4).

Warnings that screen media exposure may carry risks for preschool children are frequently directed towards parents (Carson et al., 2014), who are urged to restrict screen time for their pre-schoolers to relatively low levels. For instance, New Zealand (Ministry of Health, 2017), Australian (The Australian Government, Department of Health, 2019), Canadian (Tremblay et al., 2017) and World Health Organization screen time guidelines (WHO, 2019) advise parents to restrict screen time to one hour per day for their preschool children aged 2 years and above. However, it is not uncommon for preschool children to exceed two hours of screen time per day (see e.g., Berglind & Tynelius, 2018; Bernard et al., 2017; Madigan et al., 2019), which suggests that some parents may be unaware of these time guidelines (Hinkley & McCann, 2018; Miguel-Berges et al., 2019), consider them inappropriate for their own child or family circumstances (Nabi & Krcmar, 2016), or are not, in general, concerned about the amount of screen time their children accrue (He et al., 2005). While some parents acknowledge recommended screen time guidelines as an "ideal" (A. Brown & Smolenaers, 2018) and feel guilty when their child exceeds them (Carson et al., 2014), others view such guidelines as "unrealistic" (Ferguson, 2018). Some parents may resent the implication that their child's screen time is excessive if they do not adhere to official recommendations or guidelines (He et al., 2005).

More restrictive media parenting practices are frequently encouraged by policy makers, parent organisations and medical professionals (E. Clark & Dumas, 2020; P. I. Dong, 2018) and promoted on both societal and cultural levels (A. Brown & Smolenaers, 2018), including online forums (e.g., S. Brown, 2019; Margalit, 2016) and news sources (e.g., Mazmanian & Lanette, 2017; Russell, 2020). Parents may internalise societal norms about screen media parenting practices and consequently feel ashamed when they fail to meet these expectations (Blum-Ross & Livingstone, 2018; Liss et al., 2013). Alternatively, parents may feel pressure to "justify and validate" the choices they make with regard to their children's screen use (Kervin et al., 2018, p. 126). Further, parents who do not meet societal standards and expectations may, to some extent, be judged as remiss in their parenting duties (Green, 2015). "Screen-time shaming" may occur, when parents are criticised for the amount or type of screen exposure they allow their children to have, even by other parents (Nwoko, 2017).

Despite proscriptions against screen time during early childhood, most parents believe that children's use of screen media provides opportunities for learning and creativity (Kucirkova & Zuckerman, 2017; Rideout, 2017), and view their preschool children's use of screen technology as largely positive (Vittrup et al., 2016). Parents who hold positive views tend to have children who accrue more screen time (Vittrup et al., 2016), but they are also more likely to co-use screens with their child and mediate their child's exposure to screens, compared to parents who hold more negative views (Nikken & Schols, 2015). While some parents are aware that the way they manage their preschool child's screen time could be improved (Hesketh et al., 2012; Kervin et al., 2018), developing media practices suited to the needs of their family is often seen as more important than adhering to guidelines (Hinkley & McCann, 2018).

### *1.3.2 Societal Perspectives*

Western society has historically met the introduction of new media, whether radio, movies or TV, with a combination of openness and apprehension (Wartella & Jennings, 2000). Hence, even as screen media is assimilated into our daily lives (Maurer & Taylor, 2012) and may proffer a myriad of "social and educational benefits" (Wartella & Jennings, 2000, p. 31), there are fears that its use will lead to undesirable behaviours and undermine society (Harley et al., 2018). As preschool children are often seen as more vulnerable to the effects of screen media (Harley et al., 2018), their engagement with the screen technologies available today is a controversial subject (Kervin et al., 2018). Two "opposing public discourses" have arisen (Kucirkova & Radesky, 2017, p. 23), one that highlights the potential benefits for children's development and future prospects, and one that focuses on the risks (Plowman & McPake, 2013).

Concerns about preschool children's use of screen time may be due in part to a nostalgic idealisation of childhood, whereby childhood is seen as a time of innocence, free play and closeness to nature (Burman, 2017), during which children should be protected from the concerns of the adult world (Higonnet, 1998). Societal norms prescribe the sorts of adults most valued in specific societies and cultural groups, and the role of parents is to form their children into good quality adults over the course of their childhood (Burman, 2017). Western societies are known to value "intensive parenting", whereby parents are expected to pour their time, energy and resources into optimising their children's development (Burman, 2017; Wall, 2010). Screen time can be seen as an unnatural and artificial imposition into the realm of childhood (Cordes et al., 2004), an obstacle to children's play instead of another context in which to play (Scott, 2018), an appropriation of the role of parents and a threat to children's optimal development (Cordes et al., 2004).

Research into preschool children's screen use has been greatly influenced by the risk discourse (Courage, 2017). In line with this, and as previously noted, guidelines from official bodies directed at parents typically promote a precautionary and restrictive approach (Blum-Ross & Livingstone, 2016) and warnings about the effects of media on children are disseminated in news headlines (Mazmanian & Lanette, 2017), magazines and other media outlets (Livingstone & Blum-Ross, 2020). Societies that endorse intensive parenting practices often also ascribe to the neo-liberalist view that parents should not be autonomous in their parenting but should be informed by external input on what constitutes good parenting and optimal child development (Burman, 2017). An example of this was arguably provided by the Australian screen guidelines for preschool children, which were previously prefaced on the webpage from which they could be downloaded by the following statement: "These recommendations are for *all* children aged Birth to 5 years who have not yet started school, *irrespective* of cultural background, gender or ability" (Australian Department of Health, n.d., Section 2) (emphasis added)[1]. Having established societal norms around children's screen time, members of society may then scrutinise parents for the choices they make regarding their children's screen time (Livingstone & Blum-Ross, 2020). Groups of parents whose children are less likely to meet recommended screen time limits, e.g., sole parents or parents with lower socio-economic status (SES), may be depicted as deficient in fulfilling their parenting duties (Alper et al.,

[1] This webpage has now been updated as of May 6, 2021.

2016) and targeted with interventions designed to help them reduce their children's screen time (Rodrigues et al., 2020).

Diverging from the risk discourse is an opportunity-focused view in which screen media provide opportunities for children to "learn, connect and create" (Blum-Ross & Livingstone, 2016, p. 6). Embedded in this discourse is a perception that children can use screen media in ways that enhance their childhood learning and prepare them for a digital future (J. O'Connor & Fotakopoulou, 2016). There is less emphasis on parental restriction of children's media use and elimination of risk (Blum-Ross & Livingstone, 2016) and greater emphasis on parents helping children to develop media literacy (Calvert et al., 2005). There is a perception that even very young children can start developing their media literacy by learning how to operate screen technology, making decisions about their media use, creating media and communicating with others via media. This can occur through observations of parents' use, parental scaffolding and guidance, and exploration (Gillen et al., 2018). Hence, in the opportunities-focused discourse, parents can serve as "resources" for their children as they themselves embrace and explore new technologies and media and help their children do the same (Blum-Ross & Livingstone, 2016, p. 12).

In line with the intensive parenting discourse, parents may be viewed as having a responsibility to develop the skills to protect themselves and their families from harmful effects of screen media, to educate their children about screen media (Wallis & Buckingham, 2013), and to actively monitor their children's activities (Faircloth, 2014). However, parents and families differ in the amount of time and resources they can invest in this task, e.g., equipment, internet access, or parental expertise, which means some preschool children may have fewer or inferior opportunities to engage with screen media compared to others (Rideout & Katz, 2016). From an opportunities-focused perspective, this may impede children's future academic and employment success in a digitally-mediated world (UNICEF, 2017).

## 1.4 Patterns of Screen Use in Preschool Children

Here I provide an overview of the amount of time preschool children spend using screens, frequencies of using different types of screen devices, and age of introduction to screen use. Note that these statistics are broadly indicative of preschool children's media usage trends on an international level as they are based on data from multiple countries including the U.S. (Hish et al., 2020; Rideout, 2011), US and UK (Ribner & McHarg, 2021), Spain (Tena et al., 2019), Singapore (Bernard et al., 2017), China (Xie et al., 2020) and Japan (Horiuchi et al., 2020).

In 2011, only 10% of infants under the age of one had been introduced to mobile technologies (Rideout, 2011). However, more recent figures indicate a marked decrease in age of first use, with the majority of infants (75%) now being introduced to mobile devices by 4 months and 85% by 14 months (Ribner & McHarg, 2021). Early exposure of infants to TV is not a new phenomenon, e.g., Rideout (2011) identified 9 months as the average age at which children were introduced to TV, while more recently Hish et al. (2020) found that 85% of infants aged 6 months and under had been introduced to TV. TV remains the preferred screen medium for preschool children, followed by touchscreen devices. For example, Tena et al. (2019) found that children aged 0–6 years mostly used TV (94.5%), followed by tablets (69.9%) and mobile phones (60.9%); Bernard et al. (2017) found that 2-year-old infants spend more time per day viewing TV ($M$ = 1.6 hr, $SD$ = 1.6) than using mobile devices ($M$ = 0.7 hr, $SD$ = 1.0); and Xie et al. (2020) found that the screen time of preschool children aged 3–6 years consisted primarily of TV viewing (45%, 38.25 min) followed by use of tablets or smartphones (30%, 25.5 min). Horiuchi et al. (2020) found that at 18 months, 77% of children viewed TV, 22% used a smartphone and 10% used a tablet, and at 42 months, 84.5% viewed TV, 46% used a smartphone and 19% used a tablet.

Together these findings suggest that use of touchscreen devices tends to increase over the preschool years while still not exceeding frequency or amount of TV viewing.

## 1.5 The Potential Effects of Screen Time on Preschool Children

As part of my doctoral research, I conducted two studies to investigate the effects of screen media on the development of children aged 0–5 years, and to consider how parents' screen media parenting practices might also influence developmental outcomes (Chapters 4 and 5). Here I provide an overview of what is known on this topic, including the effects of screen time, content and context of use; mechanisms by which screen media might influence developmental outcomes; and whether parental mediation can improve outcomes of screen time.

### *1.5.1 Background to Research Addressing the Effects of Screen Time During the Preschool Years*

The first five years of life are a period of accelerated cognitive, physical and social development (Irwin et al., 2007; Willumsen & Bull, 2020), largely attributed to the period of heightened neuroplasticity children experience at this time (Conway & Stifter, 2012; Kolb & Fantie, 2009). For this reason, preschool children and infants may be more susceptible to any potential effects of media exposure or use (Christakis, 2009). The question of how much screen time preschool children should have has been contentious, particularly as the results of different studies addressing the same developmental outcome do not always concur, the quality of the evidence has been questioned (Gottschalk, 2019) and studies examining longitudinal associations are lacking (Pappas, 2020).

As previously outlined, one perspective is that there are risks associated with higher levels of screen time during the preschool years, and research investigating potential associations between screen time and developmental outcomes is needed (e.g., Haughton et al., 2015). In contrast, some researchers believe that the research should be less focused on screen time and more on how children use screen media (Blum-Ross & Livingstone, 2018; Guernsey & Levine, 2016). For instance, considering the content and context of media use, and whether children's media exposure facilitates or impedes children's interpersonal relationships (Blum-Ross & Livingstone, 2016). Given what is at stake, my opinion is that the amount of screen time needs to be considered alongside other factors that might potentially impact on children's development.

There is a preponderance of research investigating the role of TV viewing in children's lives, spanning several decades (Dorr & Rabin, 1995). However, children living in contemporary society routinely use a range of screen technologies, not just TV, and results that have focused solely on TV viewing may not be generalisable to a modern media context (Valkenburg & Peter, 2013). Accordingly, in my discussion of potentially adverse effects of screen *time* below, I will focus on the findings of research that has employed comprehensive measures of screen time. Specifically, screen time measures that encompass children's use of TV plus other screen technologies available today.

My literature review suggests there are no benefits to be gained by simply allowing children to have higher levels of screen *time* in general. Nevertheless, screen *use* during the preschool years has been linked to multiple benefits (Canadian Paediatric Society, 2017). These benefits are mostly linked to the content of screen media, and also activities carried out using screen technologies. Context of media use may also influence the outcomes of screen technology use, a consideration that will partially be addressed in the following sections, but explored in greater depth when I examine the evidence that parental mediation may help promote beneficial effects of screen use in Section 1.6. Below, I also address the detrimental effects of screen media associated with the content or context of screen media use, including in this section studies that have focused exclusively on TV, DVD or apps, as well as studies that have examined composite measures of screen time.

When considering potential outcomes of screen measures, I primarily address findings that compare screen use to no screen use or a non-digital equivalent, rather than comparing one form of screen use or content to another. Possible explanations for significant associations between screen use and developmental outcomes are explored in Section 1.5.5.

### *1.5.2 Detrimental Effects of Comprehensive Screen Time*

There are now several studies that have investigated the relationships between screen time and cognitive, behavioural, socio-emotional, physical and health outcomes using a comprehensive measure of screen time. Collectively, their results suggest higher levels of screen time are associated with poorer developmental outcomes for preschool children.

**1.5.2.1 Cognitive, Behavioural and Socio-Emotional Outcomes, and General Developmental Progress.** Higher levels of screen time at 24 and 36 months of age have been associated with poorer scores at 36 months on the Ages and Stages Questionnaire, a screening tool to assess developmental progress (Madigan et al., 2019). Similarly, infants whose screen time was in the top quartile between 6 months and 2 years scored lower at 2 years on a composite measure of development based on four subscales of the Mullen Scales of Early Learning, i.e., fine motor, visual reception, receptive language, and expressive language (Supanitayanon et al., 2020). Higher screen time at 28 months has also been associated with poorer expressive language at 34 months (Dynia et al., 2021).

Executive functions (EFs), including executive attention, develop and build on each other during childhood, and are critical to the execution of purposeful, independent goal-directed behaviours (Jurado & Rosselli., 2007). There is evidence that higher levels of screen time may jeopardise the development of EFs, a term often used interchangeably with self-regulation and effortful control (Nigg, 2017), and attention. For instance, higher screen time at 2 years has been associated with poorer self-regulation at 4 years (Cliff et al., 2018). Similarly, in a cross-sectional study of children aged 4.5 years, an inverse association between screen time and effortful control was identified (Leppänen et al., 2020). Tamana et al. (2019) found that children whose screen time exceeded 2 hr per day at 3 years and 5 years had higher externalising problem scores, including inattention, at 5 years, as well as higher scores for internalising and total behavioural problems, compared to children who had less than 30 min screen time per day. In a cross-sectional study, children aged 3–6 years who exceeded 1 hr of screen time per day had higher behavioural problem scores, including inattention, compared to children who had less than 1 hr of screen time per day (Xie et al., 2020). The relationships between EFs, attention, and screen media use will be examined closely in Chapter 4.

Associations between preschool children's total screen time and their socio-emotional skills, wellbeing, or behaviour have also been investigated. In a sample of more than 20,000 children aged 3–4 years, negative associations were found between higher levels of screen time and psychosocial wellbeing, as measured by children's Total Difficulties and Pro-social scores on the Strengths and Difficulties Questionnaire (SDQ) (Zhao et al., 2018). Similarly, employing a sample close to 9,000, X. Wu et al. (2017) found that children aged 3–6 years old who exceeded 2 hr of screen time per day had poorer scores on all subscales of the SDQ and higher Total Difficulties scores; plus increased symptoms of autism on the Clancy Autism Behaviour Scale (CABS). In another large study ($N$ = 29,461), screen time at 4 years was positively associated with symptoms of autism, measured on the Autism Behavior Checklist (ABC) (J. Chen et al., 2020).

**1.5.2.2 Health, Physical and Physiological Outcomes.** A number of studies suggest that higher levels of screen time are associated with poorer health, physical or physiological outcomes. Higher screen time has been associated with poorer manual dexterity at 3–4 years (Webster et al., 2018) and poorer scores on the General Motor Quotient at 4–6 years, although this latter effect was mitigated by longer nocturnal sleep duration and taking daily naps (Felix et al., 2020). Both Hiltunen et al. (2021) and M. Khan et al. (2020) found that screen time was negatively associated with sleep duration of children aged 3–6 years, while Zhang et al. (2021) found that for every 1 min increase in daily screen time across a 6-month period, there was a decrease in nocturnal sleep of 0.19 min per day for children aged 19–35 months. Less optimal levels of sleep may impact on preschool children's development, as duration and quality of sleep during early childhood are associated with improved cognition and language ability (Dearing et al., 2001) and reduced incidence of behavioural and emotional problems (Sivertsen et al., 2015). Schwarzfischer et al. (2020) found that higher levels of screen time between the ages of three and six predicted higher zBMI at 6 years. There is also evidence from the GUSTO longitudinal study ($N$ = 1,171) that higher screen use in the early childhood years (ages 2 to 3) is associated with lower levels of sleep and moderate-to-vigorous physical activity at 5.5 years (B. Chen et al., 2020).

Higher levels of screen time at 3–4 years may be associated with increased levels of non-HDL cholesterol, a novel finding that suggests the need for further research into possible associations between preschool children's total screen time and cardiovascular risk (Sivanesan et al., 2020). In another interesting finding, Hutton et al. (2020) used diffusion tensor imaging (DTI) to show that the white matter tracts related to literacy development and language in the brains of 3- to 5-year-old children exhibited poorer structural integrity as scores on the ScreenQ increased (indicating screen use in excess of American Academy of Pediatrics' (AAP; 2016) screen guidelines of a maximum of one hour per day). In addition, higher ScreenQ scores were associated with poorer performance on measures of rapid object naming, emergent literacy skills, and expressive language.

Screen time may be associated with the development of vision problems in young children, perhaps due to children maintaining a set focal distance for sustained periods of time (Yang et al., 2020) or straining ciliary muscles if viewing screens at close distances (Huang et al., 2020). In line with this, Yang et al. (2020) found that introduction of screens during infancy was associated with increased risk of myopia for preschool children aged 3–7 years participating in the Longhua Child Cohort Study (*N* = 26,433), even if their parents did not have myopia, and higher screen time levels during early childhood increased the risk. Using a sample from the same study, Huang et al. (2020) found that preschool children who were introduced to screens during infancy or had higher levels of screen time during early childhood were at greater risk of astigmatism.

#### *1.5.3 Detrimental Effects Associated with Content and Context of Screen Media Use*

Certain types of media content have been associated with detrimental outcomes for preschool children. A study conducted by Fitzpatrick et al. (2014) showed that exposure to TV programmes with "lots of violence in them" (p. 293) at 41 months was associated with numerous detrimental outcomes in second grade, including antisocial behaviour, inattention, emotional distress, poorer child-rated academic motivation and self-concept, and poorer teacher-rated academic achievement. Similarly, viewing of shows with violent content in them at 2–5 years, including aggressive language, has been associated with antisocial behaviour for boys at 7–10 years (Christakis & Zimmerman, 2007). Viewing of violent media at 4 years was associated with increased levels of teacher-rated and observed physical, verbal and relational aggression for boys and increased verbal aggression for girls, measured 4 months later (Ostrov et al., 2006). Fast-paced and fantastical content has also been associated with adverse effects on EFs and attention (Lillard et al., 2015a; Zimmerman & Christakis, 2007). The relationships of different forms of media exposure with EFs and attention will be further addressed in Chapter 4.

Several studies have identified links between viewing of adult-directed TV content during infancy and poorer developmental outcomes. Tomopolous et al. (2010) found that 6-month-olds who were exposed to adult- or older-child-directed programming were at greater risk of poorer cognitive and language scores at 14 months, while Chonchaiya et al. (2015) found that infants exposed to adult-directed TV at 6 months were more likely to experience pervasive developmental problems, aggression, emotional reactivity, and externalising behaviours at 18 months. Increasing exposure appeared to exacerbate the effects, as infants whose exposure to adult-directed TV increased between 6 months and 18 months had even higher levels of developmental problems and oppositional defiant behaviours at 18 months.

One context of screen exposure involves children's experience of screens in their environment that they themselves are not using. Examples of this include the aptly named "background TV", as well as screen devices in use by people around them, typically mobile devices. The latter can contribute to a phenomenon called "technoference" (McDaniel & Coyne, 2016), which will be described in Section 1.8 and explored in depth in Chapter 5.

Background TV during the preschool years has been linked with several adverse developmental outcomes (Pempek & Lauricella, 2017). For instance, infants whose parent-child dyadic play occurred more frequently with TV on in the background at 13 and 17 months had lower expressive vocabularies at 17 months (Masur et al., 2016). For children aged 4–7 years, hours of background TV were negatively associated with several aspects of school readiness, including literacy and language and self-regulation. Self-regulation mediated the relationships between background TV, literacy and language (Ribner et al., 2020).

### *1.5.4 Beneficial Effects of Screen Time*

Due to the constant advances in digital screen technologies, their effects on preschool children's development are, to a great extent, unknown (Haughton et al., 2015; Radesky et al., 2015b). However, it is undeniable that newer screen technologies and media are great enablers (Stephen & Edwards, 2018); for instance, allowing preschool children to collaborate with others on the same tasks (Nikken & Schols, 2015), hear a story read to them even if an adult is not available (Kelley & Kinney, 2017), collect and store information for later use, e.g., taking photos (Genc, 2014; Plowman, 2016), and communicate with others who are not physically present with them, thus building relationships with distant friends and relatives (Horgan & Poehlmann-Tynan, 2020).

Past research has shown that viewing certain educational TV programmes, such as Sesame Street, Barney & Friends and Blues Clues, can also promote positive learning outcomes for preschool children, including school readiness, literacy and numeracy skills, expressive language, and prosocial behaviours (Kirkorian et al., 2008; Linebarger & Walker, 2005; Mares & Woodard, 2005; Rice et al, 1990). Some of these benefits are long-term and persist even after children enter school (Kearney & Levine, 2015). The introduction of newer digital technologies and screen media has been welcomed by researchers and educators as a means to further enhance learning during the preschool years (W. Clark & Luckin, 2013). Anecdotally, children appear to be motivated to engage in learning using these devices (W. Clark & Luckin, 2013), which is important as higher levels of engagement can support learning (Hirsh-Pasek et al., 2015).

Although the research linking newer screen technologies with preschool children's learning has yielded mixed results (Hassinger-Das et al., 2020), some promising findings are starting to emerge. Griffith et al. (2020) conducted a comprehensive systematic review of studies that have investigated associations between interactive apps designed for educational purposes and preschool children's developmental outcomes. Their review uncovered a growing body of evidence that educational apps can support children's learning. In particular, in the domain of mathematics, where seven out of twelve randomised control studies and three out of three quasi-experimental studies showed greater gains on mathematical knowledge and skills for children in the intervention condition compared to the control condition. In the language domain, three of the seven randomised control studies and three of the four quasi-experimental studies found that children in the intervention group made greater gains on letter knowledge, phonological awareness, letter writing, or vocabulary compared to children in the control group. However, Griffith et al. remark that the results of the studies to date should be "interpreted with caution", due to a lack of "rigorously designed RCTs" (p. 4). Further, as Arnold et al. (2021) point out, more attention needs to be paid to investigating the beneficial effects of preschool children's mobile technology use in the home.

Using a RCT design, Arnold et al.'s (2021) study showed that preschool children can indeed learn from educational apps in the home setting, even when using them alone most (>80%) of the time. Twenty-five 4- and 5-year-old children who were assigned to the treatment group used a Khan Kids literacy APP for 10 weeks, averaging 14 min of use per day, while 24 children who were assigned to a comparison group used educational apps focusing on music and art. At the completion of the intervention period, children in the treatment groups showed greater gains on emergent literacy skills compared to children in the comparison group.

There is evidence that the use of Electronic books (E-books) may be beneficial to preschool children's language and vocabulary development. For example, 4- to 5-year-old children who read an interactive E-book independently in eight 12-min sessions administered over a 2-week period learned on average 28% more words ($n$ = 12) than children in a control group who played mathematics games for the same amount of time (Smeets & Bus, 2015). Similarly, 4- to 5-year-old children exposed to E-books for 15 min per day for 8 weeks showed greater increases on emergent literacy, print awareness, vocabulary, alphabet knowledge, and phonological awareness compared to children read to from a print version of the same book (Ihmeideh, 2014).

### *1.5.5 Potential Explanations for the Effects of Screen Use*

Although multiple studies indicate that screen time, use and exposure can impact on children's development in the first five years of life, there are no simple answers as to why or how this may occur. A starting point is to consider the age and developmental stage of the child (Kucirkova & Radesky, 2017). Infants may be most susceptible to environmental stimuli such a screen media, as there is heightened synaptic proliferation during this period (Kolb & Fantie, 2009). Although screen media such as TV will typically be in the "background" for very young children, in the sense that they may not understand it (Ribner & McHarg, 2021), they do pay attention to screens (Courage & Howe, 2010). As their ability to exert executive attention (EA) (i.e., deploy their attention voluntarily) is still developing (Nigg, 2017; Ruff & Rothbart, 1996), their attention may be drawn to salient features of screen media such as light, sound and movement (Christakis, 2009; Lillard et al., 2015b). These incoming stimuli are potentially "overstimulating" for the infant's brain at this critical stage of development (Christakis, 2009).

Further, children less than two years of age appear to have difficulty transferring learning from a 2-D medium to a "real-life" 3-D equivalent (Russo-Johnson et al., 2017). This is postulated to be due to a "video deficit", a phenomenon attributed to infants' perceptual and conceptual immaturity (Anderson & Hanson, 2010; Troseth & DeLoache, 1998). However, scaffolding provided by a parent or dyadic partner may ameliorate the effects of the video deficit (Moser et al., 2015) and support learning (Troseth et al., 2016), a point that will be explored in Section 1.6 when I address whether parental mediation can affect relationships between screen media use and developmental outcomes.

Another sensitive period of cognitive development occurs between the ages of 3 and 5 years, as EFs begin to emerge (Conway & Stifter, 2012; Diamond & Taylor, 1996; Kerr & Zelazo, 2004; Zelazo & Müller, 2011). Like infancy, this also is a period of heightened neuroplasticity, during which children's development may be more vulnerable to the effects of external factors including their media environment (Christakis, 2009; Conway & Stifter, 2012). Although children aged 3–5 years comprehend screen media better than toddlers and infants (Anderson & Hanson, 2010), engagement with certain types of media may be problematic, e.g., fantastical or unrealistic media content may be more difficult to process than realistic content, as it is at odds with children's existing schemas of reality (Lillard et al., 2015a). This may place higher demands on children's cognitive resources as they attempt to process this information (Nathanson & Fries, 2014). Hence, children's cognitive resources may be depleted and their neuropsychological functions compromised (A. Lang, 2000; Nathanson & Fries, 2014). In line with this, some studies have found negative relationships between viewing fantastical content and subsequent utilisation of EFs (e.g., Lillard et al., 2015a; Lillard & Peterson, 2011).

Background TV (or video) may distract preschool children from other activities they are engaged in, due to the light and sounds of TV drawing their attention (Christakis, 2009). Cognitive resources must be allocated to process this sensory information, which depletes the cognitive resources that can be allocated to the focus activity (A. Lang, 2000). In particular, children's language development can be affected, as parents and children interact and speak less to each other when background TV is playing (Kirkorian et al., 2009); and parents are less responsive to their child, and use less varied language (Masur et al., 2016). All of these factors have an important role to play in preschool children's language development (Hart & Risley, 1992; Tamis-Lemonda et al., 2001). Alternatively, there is evidence that background TV is associated with poorer EFs (Linebarger et al., 2014), which again may affect language development (Ribner et al., 2020). Background TV may also distract children from their play (Schmidt et al., 2008), which has been linked to developmental outcomes such socio-emotional competence (Radesky et al., 2016).

Some researchers have hypothesised that some negative effects of screen media may be due to "displacement", which occurs when screen time or use displaces time spent in activities that are more beneficial to children's development (Christakis, 2009). This could include time spent verbally interacting with parents or peers, or reading books, both of which support children's language development (Hart & Risley, 1992; Taylor et al., 2018). If screen time reduces opportunities for quality parent-child interactions, there may be negative effects on children's socio-emotional development (Radesky et al., 2016).

Compared to older children, preschool children are less likely to have developed the critical thinking skills needed to evaluate what they see onscreen, making them more likely to be influenced by messages conveyed by screen media content and emulate behaviours displayed by onscreen characters (Vittrup et al., 2016). Depending on the content they are exposed to, children may be "primed" to exhibit certain behaviours (Parkes et al., 2013). For instance, children are more likely to feel angry after watching aggressive content, and more likely to show aggression (Parkes et al., 2013). Longer term effects may be due to vicarious reinforcement, whereby children watch on-screen characters model certain behaviours that are ultimately rewarded. An example is when a "goodie" has to fight a "baddie" and so aggression may seem justified (Savina et al., 2017). Children who habitually view violent media content may begin to see aggression as a justifiable strategy and become desensitised to the suffering of victims of violence, which may make them more likely to exhibit aggressive behaviours themselves (Savina et al., 2017; Singer et al., 1998). Through viewing different types of media content, children may also develop schemas that shape their perception of what behaviours and responses are appropriate in given situations (Cole & Bernstein, 2016; Ostrov et al., 2006). For instance, Gorn et al. (1976) found that white children who viewed children of different ethnicities interacting onscreen were more likely to identify children of different ethnicities to themselves as potential playmates.

As discussed in Section 1.5.4, there is evidence that educational video content and apps have the potential to facilitate preschool children's learning. However, in order to be effective, the design of the "educational" media that children are exposed to needs to be based on a sound understanding of how children learn (Hassinger-Das et al., 2020) and the content must be developmentally appropriate (Kucirkova & Radesky, 2017; Linebarger et al., 2014). It should incorporate techniques known to support learning in "real-life" contexts

(Hassinger-Das et al., 2020). For instance, learning is typically promoted when children are provided with a supportive framework that will enable them to achieve learning outcomes that are just within their reach with support (Wasik & Jacobi-Vessels, 2017). Vygotsky (1997) labelled this "distance" between what children can do now and what they can do with support their "zone of proximal development" (ZPD; Vygotsky, 1997, p. 32). Interactive educational media that utilise children's previous input to individualise feedback and subsequent tasks may promote children's learning by working within their ZPD. This is the case with many educational apps, where feedback is often provided immediately and clearly linked to children's responses, e.g., "Well done, you chose the red ball!" (Troseth et al., 2016). This effect can also be achieved to an extent with pseudo-interactions between children and on-screen characters, e.g., Steve in Blue's Clues inviting children to respond to questions, and then affirming their (expected) responses (Gaudreau et al., 2020; Linebarger & Walker, 2005). Educational media may also promote learning if they provide children with multiple opportunities to engage with target content and to practise skills, as this gives children a chance to consolidate their learning (Hirsh-Pasek et al., 2015).

## 1.6 Can Parental Mediation Improve the Outcomes of Screen Time?

For very young children, parental mediation determines the circumstances and degree to which children engage with screen media, typically with the intention of promoting positive effects and minimising negative effects (T. M. O'Connor et al., 2013). Media parenting practices can be viewed as falling into three broad categories: restrictions, co-viewing and co-use, and active mediation (Livingstone et al., 2017; Nikken & Jansz, 2014). These parenting behaviours are not unique to parental mediation, but are examples of parenting practices commonly exhibited by parents that can exert an influence on preschool children's development (T. M. O'Connor et al., 2013). Children's ability to self-regulate their behaviour develops progressively throughout the preschool years, so it is commonplace for parents to place restrictions on their young children's behaviour, in order to protect them from harm (Gralinski & Kopp, 1993). Co-viewing or co-using screen media are examples of "passive joint engagement" and "coordinated joint engagement", where parent and child focus their attention on the same object, and in addition, for coordinated joint attention (CJA), alternate their attention between the object and their social partner (Bakeman & Adamson, 1984; Barr et al., 2008). In both forms of joint attention, young children will intermittently look towards their parent (Bakeman & Adamson, 1984). Scaffolding refers to a range of strategies that parents use to help their children learn and develop new skills that are within their reach with support (Carr & Pike, 2012; Vygotsky, 1997; Wasik & Jacobi-Vessels, 2017). Active mediation is a form of scaffolding, as it involves the parent interacting with the child to help them understand, interpret and evaluate content (Nikken & Jansz, 2014; Zaman et al., 2016) and learn the technical skills needed to use digital technologies effectively (Zaman et al., 2016). Effective scaffolding behaviours such as asking children questions about content, and labelling or expanding on content (Wasik & Jacobi-Vessels, 2017) are examples of scaffolding practices that parents can use to mediate their children's engagement with screen media and promote learning (Barr, 2008). Parents may employ more than one form of mediation (S. T. W. Wu et al., 2014). For instance, co-use and co-viewing frequently occur in conjunction with active mediation (Zaman et al., 2016). However, as Barr et al. (2008) observe, co-viewing alone may serve to scaffold children's interactions with media, as children may be cued to pay attention to content that will facilitate their understanding of screen media. For instance, by following parents' eye gaze and non-verbal signals (Barr et al., 2008; Demers et al., 2013). In the following section I discuss the associations between parental mediation strategies and preschool children's developmental outcomes. Co-viewing, co-use and active mediation are discussed together as these are often conflated in the literature. To avoid confusion, restrictive mediation will be referred to as "restrictions" or "rules".

### *1.6.1 Potential Impacts of Co-Viewing, Co-Use and Active Mediation on Developmental Outcomes During the Preschool Years*

**1.6.1.1 Children Aged 2 Years and Under.** Children aged 2 years and under are very limited in their ability to comprehend and learn from screen media compared to older preschool children (Anderson & Hanson, 2010; Moser et al., 2015). However, parental co-viewing of children's screen use during early childhood may increase the odds of beneficial effects and mitigate negative effects for this age group. For instance, Mendelsohn et al.'s (2010) longitudinal study of 253 mothers from a low socio-economic background and their 6-month-old infants found that higher levels of verbal interaction during the child's viewing of educational screen media had a positive effect on children's language scores at 4 years. Further, verbal interactions protected against the negative effects of general screen media exposure that were observed in children whose mothers did not interact with them verbally during viewing. Using a sample of approximately 5,000, Jackson et al. (2018) found that lower levels of co-viewing at 2 years of age were associated with increased risk of children experiencing difficulties interacting with peers at age five. Fender's et al.'s (2010) study of 64 children aged 12–25 months found that children succeeded in learning more target words from video if parents demonstrated higher levels of scaffolding while co-viewing (talking about the target words and other aspects of the DVD) compared to medium or low scaffolding (talking less about target words).

**1.6.1.2 Preschool Children Aged 3–5 Years.** Between the ages of three and five, there is a marked improvement in children's ability to comprehend the formal features of screen media (e.g., transitions between scenes, cuts, and "point-of-view sequences") and understand narrative (Anderson & Hanson, 2010, p. 251). Research suggests that as preschool children become increasing proficient at engaging with screen media, parental mediation has a valuable role to play in promoting desirable learning outcomes and mitigating the potentially negative effects of screen media use.

Several studies have shown co-viewing and active mediation to be advantageous to preschool children's language development. Bittman et al. (2011) employed a large sample of children participating in the Longitudinal Study of Australian Children (*n* = 2,335) to investigate relationships between parental mediation practices and children's language outcomes (amongst other research aims). They found that co-viewing with children aged 3–5 years was associated with higher vocabulary scores at both time points. Strouse et al. (2013) showed that 3-year-old children whose parents used dialogic questioning when co-viewing video stories had better story comprehension and learning of story vocabulary at the end of a 4-week intervention period compared to children whose parents only directed their child's attention to the video, children who watched a video where an on-screen actress used dialogic questioning, and a control group where the video played as normal. Similar results were found by Reiser et al.'s (1988) study involving 3- to 4-year-old children, where children were exposed to videotapes of Sesame Street containing instructional segments aimed at teaching recognition of letters and numerals. After a 5-day period of co-viewing the tapes daily with an adult, children who had been asked questions by the adult about the numerals and letters presented in the video, or asked questions and received feedback about their responses, performed better on identifying the letters post-test than children who had viewed with an adult who did not discuss the target letters or numerals with them.

In line with Jackson et al.'s (2018) finding for children at age two, Ostrov et al.'s (2006) study involving children aged 4–5 years found that higher levels of parental monitoring of children's screen viewing were associated with lower levels of concurrent physical aggression for children at age four. In addition, for girls, parental monitoring at 4 years predicted lower rates of physical and verbal aggression 4 months later; and lower relational, physical and verbal aggression 12 months later. These findings suggest that parental monitoring of their preschool children's screen media viewing may be a protective factor against difficulties interacting with peers (Ostrov et al., 2006).

### *1.6.2 Parent Restrictions on Preschool Children's Screen Use*

Parents of preschool children may limit their children's screen media use by restricting the amount of time they can spend using screens, the content they engage with, and the time at which they can use screens (Zaman et al., 2016). Parents are more likely to set restrictions on their preschool children's screen time if they perceive there to be risks associated with screen use, while parents who are more focused on the opportunities offered by screen media are more likely to use active mediation with their children (Nikken & Schols, 2015). To the extent that parents enforce restrictions on content, amount of time and timing of screen use, one would expect the risk of negative outcomes associated with each of these specific aspects of screen use to be reduced or eliminated.

Parents are more likely to restrict the screen media content their children can access than the amount of time they can use screens for (Vandewater et al., 2005b). Both time restrictions and content restrictions can be effective in reducing screen time (Lampard et al., 2012) and limiting screen viewing to certain categories (St. Peters et al., 1991). Restrictions on *when* children can use screens may also be important. For example, allowing children to use screens while eating meals is associated with greater consumption of unhealthy foods such as potato chips and fizzy drinks (Trofholz et al., 2019). Further, Garrison et al.'s (2011) study involving 3- to 5-year-old children found that permitting screen time at bedtime may lead to greater disruption of preschool children's sleep patterns, compared to allowing higher levels of screen time in general.

Taken together, the research to date suggests that parental mediation of preschool children's screen use has an important role to play in promoting positive outcomes and mitigating potentially negative effects on developmental outcomes.

## 1.7 The Predictors of Screen Time

The predictors of screen time are variables that are significantly associated with the amount of screen time that preschool children are allowed to have. Some predictors of screen time are modifiable, which suggests that manipulating these variables may lead to a change in children's screen time. A number of studies have investigated the predictors of screen time for children in early childhood (0–3 years) and in the preschool years (4–5 years). These are reviewed in depth in Chapters 2 and 3. Here I will discuss the importance of identifying the predictors of screen time for preschool children and introduce the models I have selected to examine the predictors of screen time.

### *1.7.1 Why Investigate the Predictors of Screen Time?*

Uncertainty about the potential effects of screen media in today's media environment (Troseth et al. 2016), coupled with children's increasing levels of screen use (Paus-Hasebrink et al., 2019), has given rise to concerns amongst parents, medical workers, educators, psychologists, and policy makers that screen time may impact negatively on preschool children's development (Harley et al., 2018; Hiniker et al., 2019). Although, admittedly, there is demurral amongst some researchers towards a focus on screen time instead of content and contextual factors (Hiniker et al., 2019), the studies previously outlined in Section 1.5.2 point to a growing body of recent research that has identified significant relationships between higher levels of screen time and poorer developmental outcomes. Each of these studies employed comprehensive measures of screen time that are relevant to the media landscape experienced by most preschool children in today's society.

The primary reason for identifying the predictors of preschool children's screen time is to avoid or ameliorate negative outcomes that may be associated with high levels of screen time. This can be achieved by identifying variables parents could modify that are likely to reduce the time children spend using screens (Gorely et al., 2004). This information could be of use to parents wishing to reduce their children's screen time, and for doctors, nurses, community workers and other health professionals who may provide guidance to parents on how to manage their children's screen time. Reductions in screen time could potentially benefit the individual child's health and development; but on a wider scale, an understanding of how to reduce screen time may help to reduce social disparities that might arise if some children become significantly more disadvantaged by their screen use than others (Certain & Khan, 2002). In particular, children from low SES backgrounds tend to have significantly higher levels of screen use than children from higher SES backgrounds (Linder et al., 2020; Rodrigues et al., 2020); therefore, they may be at greater risk of experiencing adverse developmental outcomes that might affect their future prospects (although, as outlined above, parental mediation is a factor that might improve outcomes). Past research has shown that high levels of screen time during the preschool years are associated with poorer language skills (Dynia et al., 2021; Supanitayanon et al., 2020) and poorer EFs (Cliff et al., 2018; Leppänen et al., 2020). Poorer language skills may place children at a disadvantage when they enter school (Prior et al., 2008), while Moffitt et al.'s (2011) ground-breaking research showed there is increased risk in adulthood of substance abuse, lower income, and health problems for children who display poorer EFs during the preschool years.

Although a number of studies have investigated the predictors of screen time with regard to TV, their findings may not be readily applicable to children's screen use in a modern media environment (S. Lee et al., 2009; Paus-Hasebrink et al 2019). Some studies have investigated the predictors of a comprehensive measure of screen time that incorporates different forms of screen technologies, but these are relatively few (refer to Chapters 2 and 3). More research into the predictors of comprehensive measures of screen time is called for to better understand the factors that may lead parents to allow their preschool children to engage with screens in a modern media context (Beyens & Eggermont, 2017).

Past research addressing the predictors of young children's screen time has tended to focus on quite wide age ranges, for instance, "0 to 8 years or 2 to 12 years" (Elias & Sulkin, 2019, p. 2803). This is problematic as infants and toddlers are at different developmental stages than older preschool children, and consequently have different capabilities and require different parenting input (Elias & Sulkin, 2019). Conducting studies that focus on narrower age brackets may uncover modifiable predictors relevant to distinct age groups and stages of development, and increase the likelihood that adjusting these variables will result in a reduction of screen time.

Arming parents with strategies they could use to limit their preschool children's screen time, if needed, could offer ongoing benefits to children's health and development, as patterns of screen use established in early childhood tend to persist beyond the preschool years (S. Lee et al., 2009).

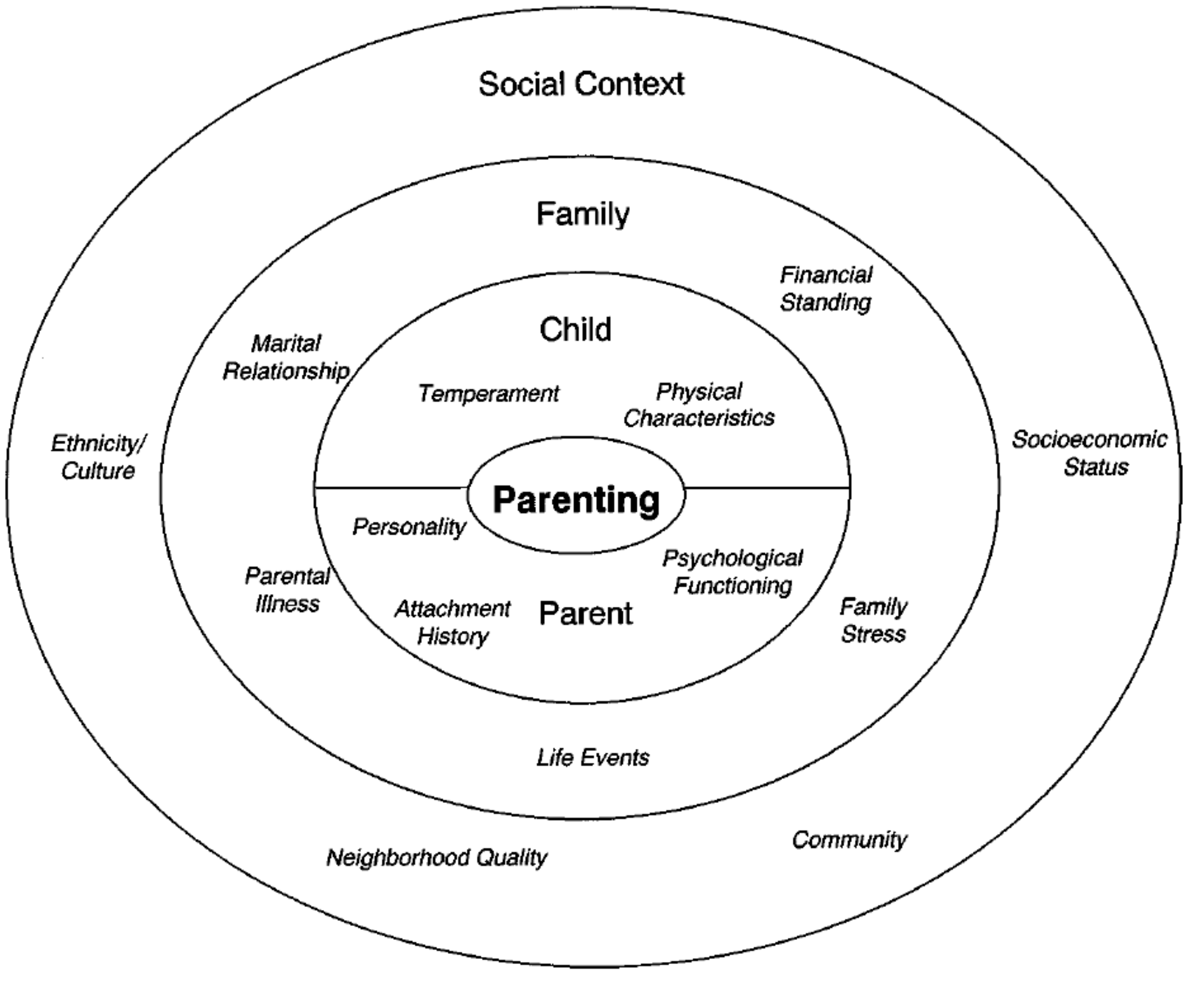
### *1.7.2 Modelling the Predictors of Preschool Children's Screen Time*

Kotchick and Forehand's (2002) and Beyens and Eggermont's (2017) models offer two alternative frameworks for conceptualising the relationships between predictors of preschool children's screen time and children's screen time as a parenting behaviour. I selected Kotchick & Forehand's (2002) model (refer to Figure 1.1) to investigate the predictors of preschool children's screen time at 2 years and Beyens and Eggermont's (2017) model (refer to Figure 1.2) to investigate the predictors at 4.5 years. Below I outline each model and explain why they were selected.

**1.7.2.1 Kotchick and Forehand's (2002) Ecological Model of Parenting.** Inspired by the seminal work of Luster and Okagaki (1993), Kotchick and Forehand's (2002) Ecological Model of Parenting captures elements of both Bronfenbrenner's (1979) Ecological Systems Theory and Belsky's (1984) Process Model of the Determinants of Parenting. With parenting as the focal variable of interest, Kotchick and Forehand's model is depicted as a series of extending levels representing, firstly, the proximal factors that impact on parenting, i.e., characteristics of the child and parent, and secondly, more distal factors that may also influence parenting, i.e., the family and social contexts (refer to Figure 1.1). This model is interpreted here to mean that characteristics of the child and parent will directly impact on children's screen time (defined here as a parenting behaviour) and on each other; family factors will impact directly on both parent and child and therefore, indirectly influence screen time, and societal factors, such as ethnicity, SES and neighbourhood, will also play a role in influencing screen time.

**Figure 1.1**

*Kotchick and Forehand's Ecological Model of Parenting*




*Note*. Reprinted with permission from "Putting Parenting in Perspective: A Discussion of the Contextual Factors that Shape Parenting Practices" by B. A. Kotchick and R. Forehand, 2002, *Journal of Child and Family Studies, 11*(3), Springer, p. 258. Copyright 2002 by Human Sciences Press, Inc.

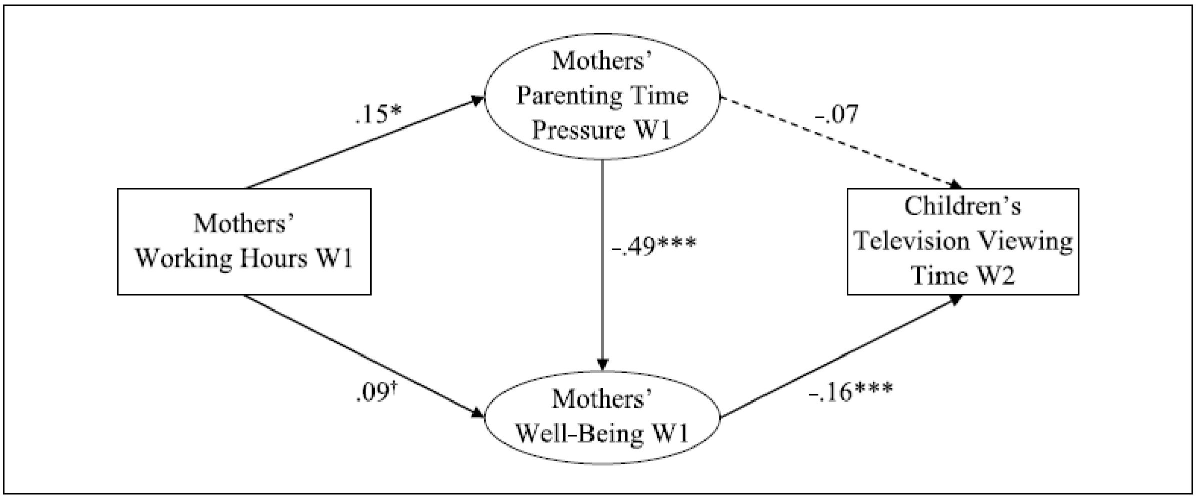
The assumption that parenting factors play the central role in determining children's screen time is in line with Lauricella et al.'s (2015) assertion that parents' media practices within the microsystem are instrumental in determining children's media experiences. An ecological model provides a useful framework for examining preschool children's screen time, as it accommodates a "simultaneous focus on the characteristics of the individual child, the critical setting of the home, and the ubiquitous cultural environment" (Jordan, 2004, p. 196). In addition, in Kotchick and Forehand's (2002) Ecological Model of Parenting, the characteristics of the parent and their screen media parenting practices can take a central role, and the bi-directionality of parent-child effects (Bell, 1968; Luster & Okagaki, 1993) is acknowledged.

An ecological model is beneficial for investigating the predictors of preschool children's screen time for several reasons: 1) it has scope to accommodate multiple potential predictors within different levels or contexts of the model; 2) it can be applied to help understand the processes underlying relationships between significant predictors and screen time; and 3) it can provide insight into the variables most likely to influence screen time.

**1.7.2.2 Beyens and Eggermont's (2017) Observed Life Logistics Model.** Beyens and Eggermont (2017) developed and tested a sociological family systems model linking mothers' life logistics to the amount of screen time (TV viewing) they allowed their preschool children to view. Named the Observed Life Logistics Model, this model focused on mothers specifically as mothers still tend to shoulder more responsibility for child-rearing than fathers (Argyrous & Rahman, 2017). Within the family system, mothers' life logistics are at play as mothers expend time and energy into the domains of home and the workplace (Beyens & Eggermont, 2017). Although other researchers had speculated a relationship between mothers' workhours and children's screen time (e.g., Vaala & Hornik, 2014; Warren, 2005), Beyens and Eggermont were the first researchers to empirically test the mechanisms by which this might occur. Their literature review led them to believe that mothers' wellbeing and perception of time pressure might mediate the relationship between mothers' workhours and children's TV viewing time. They developed a model representing these relationships (refer to Figure 1.2) and tested the model using structural equation modelling (SEM) in a sample of 404 one- to four-year-olds and their mothers, who were predominantly of White Belgian ethnicity. They found that mothers' workhours were a marginally significant predictor of mothers' wellbeing, and poorer maternal wellbeing was associated with higher levels of TV viewing in children. They also found that mothers' workhours were associated with an increase in mothers' time pressure, and, as time pressure was inversely related to mothers' wellbeing, this led indirectly to an increase in screen time. Therefore, in terms of the relationship between mothers' workhours and preschool children's TV time, the model suggests that increased TV time is likely to occur only when there is conflict between mothers' family demands and work demands (Beyens & Eggermont, 2017).

**Figure 1.2**

*Results of Structural Equation Modelling of the "Observed Life Logistics Model" of the Determinants of Screen Time in Preschool Children*




*Note*. Reprinted with permission from "Understanding Children's Television Exposure From a Life Logistics Perspective: A Longitudinal Study of the Association Between Mothers' Working Hours and Young Children's Television Time," by I. Beyens and S. Eggermont, 2017, *Communication Research, 62*(1), SAGE Publications, Inc., p. 703. Copyright 2015 by the Authors.

I saw several benefits in selecting this model for my own investigations into the predictors of screen time. In contrast to ecological models where "everything counts" (O'Neill, 2015, p. 48), family system models can focus attention on the family and social contexts that directly impact on parents and may exert the greatest influence on their parenting (Beyens & Eggermont, 2017). Further, the Observed Life Logistics Model offers a concise and readily testable explanation for children's screen time. Its focus on the interplay between mothers' worklife and parenting is validated by Belky's (1984) influential Process Model of the Determinants of Parenting, which recognised work as one of three significant contexts that can be either a source of support or stress for parents (the others being the marital relationship and social networks), and thus play a key role in determining parenting. Thus, Beyens and Eggermont's model provided me with a framework for examining psychological processes that determine parenting, in this case, mothers' decision to let their children engage with screens. This model also offered an opportunity to investigate the relationship between mothers' life logistics and preschool children's screen media use in a modern media environment, which in turn offers an opportunity to advance the understanding of parental influence on preschool children's screen time.

## 1.8 Technoference

"Technoference" describes the distraction from interpersonal activities that can occur due to use of mobile screen devices. Potential sources of technoference include becoming absorbed in using a phone, taking phone calls, checking the phone, and receiving notifications (Kushlev et al., 2016; McDaniel, 2015; Nakamura, 2015; Reed et al., 2017; Vanden Abeele, 2020). To date, there is not much research into how parental technoference might affect preschool children's development. Parents' use of screen media in their children's presence is essentially a form of background media for the child, and to some extent the effects of technoference on children's development may have some cross-over with the effects of background TV (Barr, 2019). However, technoference due to mobile phones may have greater implications for children's development, due to the pivotal role of mobile technologies in the way people now organise and manage their everyday lives (Morris & Cravens Pickens, 2017); the portability of mobile devices, which increases the opportunity for intrusion on parent-child interactions; and the "attachment" people often feel towards their phones, which increases the likelihood that it will attract their attention (McDaniel & Coyne, 2016; Pempek & Lauricella, 2017). Indeed, technoference occurs frequently amongst parents of preschoolers, with 95% of mothers and 90% of fathers of children aged 0–5 years experiencing at least once instance of technoference per day (McDaniel & Radesky, 2018).

### *1.8.1 The Role of Parental Technoference in Parent–Child Interactions*

Optimal development during the preschool years depends on children having caregivers who are emotionally available, able to pay attention to them; scaffold their learning; and respond contingently, appropriately and with sensitivity to their bids for attention (e.g., Biringen, 2020; Kara & Acikel, 2020; Tamis-Lemonda et al., 2006; Tamis-Lemonda et al., 2014). Each of these aspects of high-quality parent–child interactions could be compromised if parents' use of mobile technologies diverts some or all of their attention away from their interactions with their child. This suggests that technoference has the potential to undermine preschool children's development, although this is likely to be influenced by how often parents experience technoference, and the context, e.g., a quick check of their phone as opposed to sustained use (Vanden Abeele et al., 2020). Hence technoference may have implications for children's development as it may divert some or all of the parent's attentional resources away from their child and towards their mobile device, reducing the quality and quantity of their interactions with their child. Several studies to date have found evidence of associations between technoference and poorer quality of parent-child interactions, including lack of responsiveness and sensitivity (e.g., Golen & Ventura, 2015; Hiniker et al., 2015; Radesky et al., 2014a; Radesky et al., 2016), and increased levels of directiveness (Radesky et al., 2014a). Two other markers of quality parent-child interactions, scaffolding and CJA, are also likely to be impaired when technoference is at play, as both of these require the parent to focus their attention on the child and the child's activities (Bakeman & Adamson, 1984; Biringen et al., 2000). Technoference may also decrease the quantity of parent-child interactions (Radesky et al., 2015a), as face-to-face interactions are often perfunctory or put "on hold" during phone use (Aagaard, 2016; Radesky et al., 2014a).

### *1.8.2 Effects of Parental Technoference in Preschool Children's Development: The Research to Date*

My literature review uncovered only a few studies that have investigated relationships between parental technoference due to mobile technology and preschool children's developmental outcomes. There is some evidence to suggest that higher levels of parental technoference may be associated with poorer language development during the preschool years, perhaps attributable to technoference decreasing the opportunities for parent-child verbal interactions, which are crucial for the development of children's language (Kara & Acikel, 2020). Kara and Acikel's (2020) study of 40 children < 6 years (20 with speech delay and 20 with typically developing speech) and their parents found that parents of children with delayed speech were experiencing higher technoference, as measured on the Problematic Mobile Phone Usage Scale (PMPUS), than parents of typically developing children. Reed and colleagues' (2017) study involving 38 two-year-olds and their mothers provides further evidence that technoference may be disadvantageous to preschool children's language development. Using a within-subjects design in a laboratory setting, Reed et al. found that when mothers were interrupted by a mobile phone call whilst teaching their child two new words (the interrupted condition), children were less successful in learning the words compared to when the teaching proceeded without a phone call (the uninterrupted condition). (Relationships between different forms of parental technoference and infants' vocabulary development, as well as the mechanisms through which this may occur, will be explored further in Chapter 5).

A study conducted by Linder et al. (2021) suggests that technoference may also impact negatively on attachment between parent and child. Linder et al. employed a sample of 248 parents and their 11- to 26-month-old children, and required parents to report their level of media absorption. Parent-child attachment was assessed via the Attachment Q-Sort (AQS). A significant relationship was found between insecure attachment and higher levels of parental media absorption. Although there is only one study supporting this association thus far, this finding is important because establishing secure parent-child attachment in early childhood supports the development of emotional regulation, self-reliance and social competence (Sroufe, 2005).

Technoference may result in behavioural problems for young children, which may be due in part to children exhibiting attention-seeking behaviours in a bid to capture their parent's attention (Kildare & Middlemiss, 2017). In Sundqvist et al.'s (2020) study, parents of 3- to 5-year-olds were required to estimate the frequency with which parent-child interactions were interrupted by either the parent's or child's use of technology per day (not only mobile technology). Sundqvist et al. then examined the potential associations between parents' and children's technoference levels and children's behavioural difficulties as measured by the SDQ. More technology interruptions caused by parents' use of technology, but not children's, was associated with children obtaining poorer Total Difficulties scores on the SDQ. McDaniel and Radesky's (2018) study suggests there may be a bi-directional relationship whereby parents' technoference may adversely impact on children's behaviour and, conversely, parenting stress may mediate relationships between children's externalising and internalising behaviours and technoference.

## 1.9 The Present Research

### *1.9.1 Sources of Data for the Present Research*

Data for the current research were obtained from two sources. Studies 1–3 used data from the Growing Up in New Zealand Longitudinal Study (GUiNZ). GUiNZ is New Zealand's contemporary longitudinal cohort study. Six-thousand, eight hundred and twenty-two expectant mothers with due dates between April 2009 and March 2010 (Morton et al., 2013) were recruited antenatally. The number of children in the original cohort was 6,846, providing for high statistical power. An important feature of this study is that partners ($N$ = 4,401) were included in this study from inception (Morton et al., 2013). Although the term "partner" could include any partner the mother was in a 'significant social relationship with", 99.3% of partners at the time of recruitment were the child's biological father (Pryor et al., 2014, p. 7). The GUiNZ cohort is representative of children in the NZ population, in terms of SES and ethnicity (Morton et al., 2015).

Data collected during several GUiNZ data collection waves (DCW) have been employed in the current study, i.e., the antenatal, 9-month, 2-year, 45-month and 54-month DCWs. Data related to the study children's use of screen media and the family media environment they experienced in the home was collected at three time points during the preschool years: the 2-year, 45-month and 54-month DCWs. Therefore it was possible to examine preschool children's screen use during specific age-bands, i.e., at 2 years, 45 months and 54 months.

Study 4 used data from the broader, Digitally Mediated Early Communication Study (DIME), that was conducted in the Early Learning Lab (ELLA) at the University of Auckland. The study utilised data from observations of main caregivers and their 20-month-old children during a semi-naturalistic dyadic interaction, and parent-report on a sub-set of relevant questionnaires (i.e., technology questionnaire, MCDI). The technology questionnaire was specially designed for the current research, which provided an opportunity to explore a range of novel questions about parents' and children's media use.

### *1.9.2 Rationale for the Thesis*

The over-arching goal of this thesis was to investigate the role of screen media in early childhood development and parental influences on children's screen exposure and use. This research is underpinned by two key premises. Firstly, due to their immaturity, preschool children's activities are managed by their parents; hence, the screen exposure of preschool children can be described as a parenting behaviour (Ansari & Crosnoe, 2016). Secondly, screen media has become a fixture in the environments preschool children experience every day, and, as such, can be expected to impact on their development and parent-child interactions. The key research questions (RQs) addressed in this research are: 1) What are the predictors of screen time for children during the preschool years? (Chapters 2 and 3); 2) What is the role of media exposure in the development of EFs and symptoms of inattention/hyperactivity? (Chapter 4); and 3) Is parental technoference associated with preschool children's vocabulary and is this relationship mediated by key markers of optimal parent-child interactions? (Chapter 5). These questions offer the opportunity to explore different ways in which parents of preschool children influence key aspects of their children's screen media experience, including the amount of screen time children consume, as well as developmental outcomes associated with screen exposure and use.

This thesis contains four studies: Studies 1 and 2 address RQ 1, Study 3 addresses RQ 2, and Study 4 addresses RQ 3. Each of these studies makes its own significant contribution to the literature, which will be fully explored in the General Discussion; however, as a corpus, they advance the literature by researching different facets of parent-child media use and parenting practices with a comprehensive measure of screen time relevant to today's media environment. These studies were undertaken with a view to providing parents with information they can use when making decisions about their preschool children's screen media use, their own screen media use and media parenting practices. Studies 1–3 used data from the GUiNZ study and Study 4 used data from the DIME study. Below I provide an overview of each study.

## 1.10 Overview of Studies

### *Study 1 (Chapter 2): The Predictors of Screen Time at Two Years in a Large Nationally Diverse Cohort*

The primary aim of this study was to investigate the predictors of screen time on a weekday for children at approximately 2 years of age. The secondary aim was to identify the prevalence of screen time and features of the screen media environment that 2-year-old NZ children experience in the home. The hypothesis was that screen media parenting variables would be the strongest predictors overall as preschool children's screen time can be controlled by their parents (Duch et al., 2013). The potential predictors of screen time investigated in this study extended to all contextual levels of Kotchick and Forehand's (2002) Ecological Model of Parenting, and were informed by previous research into the predictors of screen time for children aged up to 3 years, and the wider screen media and parenting research for this age group.

### *Study 2 (Chapter 3): Examining the Association Between Mothers' Life Logistics and Screen Time of Children Aged 4–5 Years Old*

The aim of this study was to enhance understanding of the predictors of screen time during the latter preschool years by building on and extending the work of Beyens and Eggermont (2017). The model was extended by including screen media variables found to be predictive of screen time in Study 1 and other variables suggested by the wider literature examining the predictors of screen time for preschool children aged 4–5 years of age. To my knowledge, this was the first study to employ an ethnically diverse sample and a comprehensive measure of screen time to test whether a model contingent on mothers' life logistics predicts preschool children's screen time in a modern media environment.

### *Study 3 (Chapter 4): Preschool Screen Media Exposure, Executive Functions and Symptoms of Inattention/hyperactivity*

The aim of this study was to determine the associations between preschool children's screen media exposure at 2 years and 45 months with hot and cool EFs and symptoms of inattention/hyperactivity at 54 months. The hypothesis was that the content of preschool media exposure at age two (adult-directed vs child-directed) and the involvement of parents in their children's media exposure would be stronger predictors of EFs and attention than the amount of screen time. My literature review revealed that no study to date had investigated associations between EFs or attention and a comprehensive range of screen time measures, incorporating the amount of screen time (using a longitudinal, comprehensive measure of screen time), content, context, and parental mediation measures in the same study. I chose EFs and attention as the focal developmental outcomes for this study because there is strong evidence that EFs provide a buffer against academic difficulties and multiple adverse outcomes in adolescence and adulthood (Moffitt et al., 2011). Further, the development of self-control is highlighted as an important developmental goal for preschool children in NZ (Ministry of Education, 2017). Attention was selected as a second outcome to focus on as it is thought to promote cognitive development (Rothbart et al., 2011) and supports academic success and social competence (American Psychiatric Association, 2013), which again, is likely to proffer benefits through the life course.

### *Study 4 (Chapter 5): Associations Between Technoference, Quality of Parent–Infant Interactions, and Infants' Vocabulary Development*

The aims of Study 4 were two-fold: 1) to explore the relationship between potential sources of technoference, parent-child interactions and early language development; and 2) test whether any sources of technoference are associated with vocabulary and, if so, mediated by key parent-child interaction variables. The hypothesis was that higher levels of technoference via mobile screen technology would be associated with lower levels of parent responsiveness, scaffolding, CJA and higher levels of directiveness even when parents are not actively using their phones. To my knowledge, there are no studies that have focused specifically on whether technoference may influence parent-infant interactions when parents are not using their mobile phones.

The following research article is the author's copy of a manuscript published by Springer in *Journal of Child and Family Studies*.

Please see:

Corkin, M. T., Peterson, E. R., Henderson, A. M. E., Bird, A. L., Waldie, K. E., Reese, E., & Morton, S. M. B. (2021). The predictors of screen time at two years in a large nationally diverse cohort. *Journal of Child and Family Studies, 30*(8), 2076–2096. https://doi.org/10.1007/s10826-021-01985-5

## Chapter 2. The Predictors of Screen Time at Two Years in a Large Nationally Diverse Cohort (Study 1)

"Screen time" no longer consists of simply watching television (TV), but includes time engaging with an array of screen-based devices, including laptops, gaming consoles, tablets and smart phones (Canadian Paediatric Society, 2017). Devices such as tablets and smart phones are relatively small and feature touch screen capability and interactivity, which facilitates their use by children under 5 years (Neumann, 2015). As the use of devices such as tablets and smartphones has become increasingly commonplace, a corresponding increase in the use of digital screen-based technologies other than TV has been observed in children under the age of three (Kabali et al., 2015) and concerns about the possible effects of exposure to newer screen technologies have added to existing concerns about the impact of TV viewing on child health and development (Haughton et al., 2015).

Survey results in the United States indicate that increased uptake of newer screen technologies amongst preschool children aged 2 years old does not simply replace time spent engaging with traditional technologies such as TV but leads to an increase in children's total screen time, with total screen time for 2- to 4-year-olds increasing from 1 hr 58 min in 2013 to 2 hr 39 min per day in 2017 (Rideout, 2013, 2017). Higher screen time levels for children in this age group may be of particular concern because the early childhood years are considered to be a critical period in childhood development (Irwin et al., 2007) and duration of screen media exposure for children in this age group has been associated with a range of adverse outcomes. These include difficulties with aggression (Chonchaiya et al., 2015); hyperactivity/inattention (Cheng et al., 2010); cognitive ability, language and motor skills (Lin et al., 2015); later school achievement (Pagani et al., 2010); self-regulation (Radesky et al., 2014b); and overweight (Lumeng et al., 2006). However, scientific research has struggled to keep pace with each new technological advance (LeBlanc et al., 2017), which has resulted in young children engaging with “newer” mobile devices and engaging in higher levels of screen time before the potential effects of early childhood exposure are fully understood (Radesky et al., 2015a).

Duch et al.’s (2013) systematic review of 29 peer-reviewed research papers encompasses much of the research that has been conducted into the determinants of screen time for children aged up to 3 years. Based on their analysis, Duch et al. (2013) reported that screen time for this age group was positively associated with BMI, ethnicity (non-Caucasian), age of child, maternal depression and mothers’ TV viewing, and negatively associated with cognitive stimulation in the home environment (refer to Table 2.1). They also reported “no association” for eight variables, meaning that these variables have been investigated by three or more studies, with 60% or more of those studies finding no significant association between that variable and screen time of children aged up to 36 months. They also classified 16 associations found in the previous research as being “inconclusive” due to fewer than three studies having been conducted. Finally, Duch et al. reported “unclear” relationships between maternal age, maternal education and household income and screen time for children aged up to 36 months, due to some studies finding a negative association and other studies finding no association, and the proportion of studies showing a negative association failing to reach a threshold of 60% (refer to Table 2.1). Although Duch et al.’s (2013) review encompasses research conducted in relatively recent times (up to and including 2013), some of their findings may be limited in their generalisability to the determinants of screen time in today’s media context, as 12 of the 29 studies focused solely on children’s TV viewing, and only five studies included children’s use of electronic media other than TV, DVDs and videos (Duch et al., 2013).

**Table 2.1**

*Summary of the Findings of Duch et al.'s (2013) Comprehensive Systematic Review of the Correlates of Screen Time for Children Aged Up to 36 Months of Age https://ijbnpa.biomedcentral.com/articles/10.1186/1479-5868-10-102, Licensed Under CC-BY, Adapted from Original.*

| Positive association | Negative association | Inconclusive association | No association | Unclear association (negative) |
|---|---|---|---|---|
| Age of child | Cognitive stimulation of home environment | Child's daily crying duration[a] | Childcare | Maternal age |
| Child's BMI | | Child's daily sleep duration | Child gender | Maternal education |
| Ethnicity (non-Caucasian) | | Child living in heavy TV household | Maternal employment | Household income |
| Maternal depression/distress | | Having time/content restrictions | Non-English speaking[a] | |
| TV viewing time of mother[a] | | Living in urban area | Number of children in household | |
| | | Maternal BMI (obese)[a] | Parity (first born) | |
| | | Mother non-US born[a] | Paternal education | |
| | | Onset age of watching TV[a] | Two parent household[a] | |
| | | Parent believes their child enjoys TV[a] | | |
| | | Parent believes that TV is educational[a] | | |
| | | Parental education (data not disaggregated) | | |
| | | Paternal employment | | |
| | | Season (Winter) | | |
| | | Shorter breastfeeding of child | | |
| | | TV in child's bedroom[a] | | |
| | | TV viewing time of father[a] | | |

*Note.* Adapted from "Screen Time Use in Children under 3 years old: A Systematic Review of Correlates," by H. Duch, E.M. Fisher, I. Ensari and A. Harrington, 2013, *International Journal of Behavioral Nutrition and Physical Activity, 10*(102), pp. 1-10. Copyright 2013 by The International Society of Behavioral Nutrition and Physical Activity (ISBNPA).
[a] Same or similar variable is not available for analysis in the current study.

In addition to the studies included in Duch et al.'s (2013) review, our literature review found 10 other studies that have investigated the predictors of screen time for children up to 3 years of age (refer to Table 2.2). Some of the significant findings reported by these studies are in agreement with the significant findings reported by Duch et al., including positive associations between screen time and child age (Carson & Janssen, 2012; Carson & Kuzik, 2017; Hesketh et al., 2015; Pempek & McDaniel, 2016), parental screen time (Bernard et al., 2017; Birken et al., 2011; Pempek & McDaniel, 2016) and being of non-Caucasian ethnicity (Carson & Kuzik, 2017). However, there are some key differences, whereby Duch et al. found no association while some of the other studies reported significant associations, that is, negative associations between screen time and childcare attendance (Carson & Kuzik, 2017; Elias & Sulkin, 2019); and positive associations between screen time and non-parental childcare (Lin et al., 2015); birth order (first born) (Bernard et al., 2017); maternal employment (weekday) (Birken et al., 2011); and child gender (female) (Carson & Kuzik, 2017). Several of these studies found significant associations with variables that had not been investigated by any of the studies included in Duch et al.'s systematic review, finding positive associations between screen time and eating meals in front of TV (Birken et al., 2011); mother's perception that her neighbourhood is unsafe (Burdette & Whitaker, 2005); frequency of mother's use of tablets (Pempek & McDaniel, 2016); video games in child's bedroom; parent's descriptive norms of the maximum amount of screen time their child should have; perception of barriers to reducing their child's screen time (Carson & Janssen, 2012); child being of Malay and Indian ethnicity compared to Chinese (Bernard et al., 2017); and child co-viewing adult programming with a caregiver (weekend days) (Elias & Sulkin, 2019). Negative associations were found between screen time and the cognitive, motor and language skills of the child (Lin et al., 2015) and self-regulation of the child (Radesky et al., 2014b) (refer to Tables 2.1–2.2).

**Table 2.2**

*Significant Associations with Screen Time as Reported by Ten Studies Additional to Duch et al.'s (2013) Systematic Review Investigating the Predictors of Screen Time for Children Aged Up to 36 Months*

| Study | Positive association | Negative association |
|---|---|---|
| Bernard et al. (2017)[a] | Parental TV time[b] | Parental age |
| | Malay and Indian ethnicity compared to Chinese[bc] | Maternal education |
| | Birth order (first born) | Household income |
| Birken et al. (2011)[a] | Eating meals in front of TV[bc] | Family rules (weekend) |
| | Maternal employment (weekday) | |
| | Parental screen time[b] (weekend) | |
| Burdette & Whitaker (2005) | Mother's perception that her neighbourhood is unsafe[c] | |
| Carson & Janssen (2012)[a] | Child age | Education |
| | Parental attitudes towards child's screen time[b] (positive) | Household income |
| | Barriers to reduction of screen time[bc] | |
| | Descriptive norms (view of max. time child should spend on screens)[bc] | |
| | Video games in bedroom[b] | |
| Carson & Kuzik (2017)[a] | Child age | Attends childcare centre |
| | Child gender (female) | Household income |
| | Ethnicity (non-Caucasian) | |
| Elias & Sulkin (2019)[a] | In home childcare (weekday and weekend days) | Bedroom TV access[b] (weekend) |
| | Co-viewing of adult programmes[c] (weekend) | Parental screen uses: bedtime facilitation[bc] (weekend) |
| | Parental screen uses[bc]: enrichment, schedule regulation (weekdays); calming child, rewarding child, as a babysitter (weekend days); background for child's activities (weekday and weekend days) | |
| Hesketh et al. (2015) | Child age | Mother university educated (child age 20 months) |
| Lin et al. (2015) | Non-parental care-givers (nannies or grandparents) | Cognitive, motor and language skills of child[c] |
| | | Maternal education |

| Study | Positive association | Negative association |
|---|---|---|
| Pempek & McDaniel (2016) | Child age | Mothers' relational well-being[c] |
| | Mothers' use of tablets[bc] | |
| Radesky et al. (2014b) | | Self-regulation of the child[c] |

*Note.* Only variables that were clearly significant predictors of screen time are shown.
[a] Employed a comprehensive measure of screen time. [b] Same or similar variables not available for analysis in the current study. [c] Variables not investigated in the research included in Duch et al.'s (2013) review.

In addition, Elias and Sulkin (2019) found that several parental screen uses had positive associations with toddlers' screen time: use for schedule regulation and enrichment on weekdays, use as a babysitter and as a reward on weekend days, to calm the child on weekend days, and as a background to child's activities on both weekdays and weekend days. A negative association was found between screen time and parents using screens to facilitate children's bedtime on weekend days (Elias & Sulkin, 2019) (see Table 2.2). Together these studies expanded the search for predictors of screen time to include wider ecological factors that may promote or hinder children's engagement with screens. However, five of the ten studies focused exclusively on TV viewing (Hesketh et al., 2015; Lin et al., 2015), TV and video viewing (Burdette & Whitaker, 2005; Radesky et al., 2014b) or tablet use (Pempek & McDaniel, 2016).

## 2.1 The New Zealand Context

In 2017 the Ministry of Health (MoH) released guidelines for New Zealand (NZ) parents on activities for children aged up to 5 years of age. The guidelines recommend that children aged 2 years and under should be discouraged from screen time, children aged 2 to 5 years should have less than one hour of screen time per day, and parents should "avoid having the TV playing in the background" (Ministry of Health, 2017, p. 9). Notably the MoH guidelines for 2-year-olds align with those released by the World Health Organization in 2019, which advised that children at age two should not exceed an hour of sedentary screen time per day (World Health Organization, 2019).

## 2.2 The Current Study

The aims of the present study were twofold. The first aim was to identify the prevalence of screen time and the features of the screen media environments that 2-year-old NZ children experience at home. The second aim was to investigate the predictors of the children's total screen time on a weekday. Our data comes from the Growing Up in New

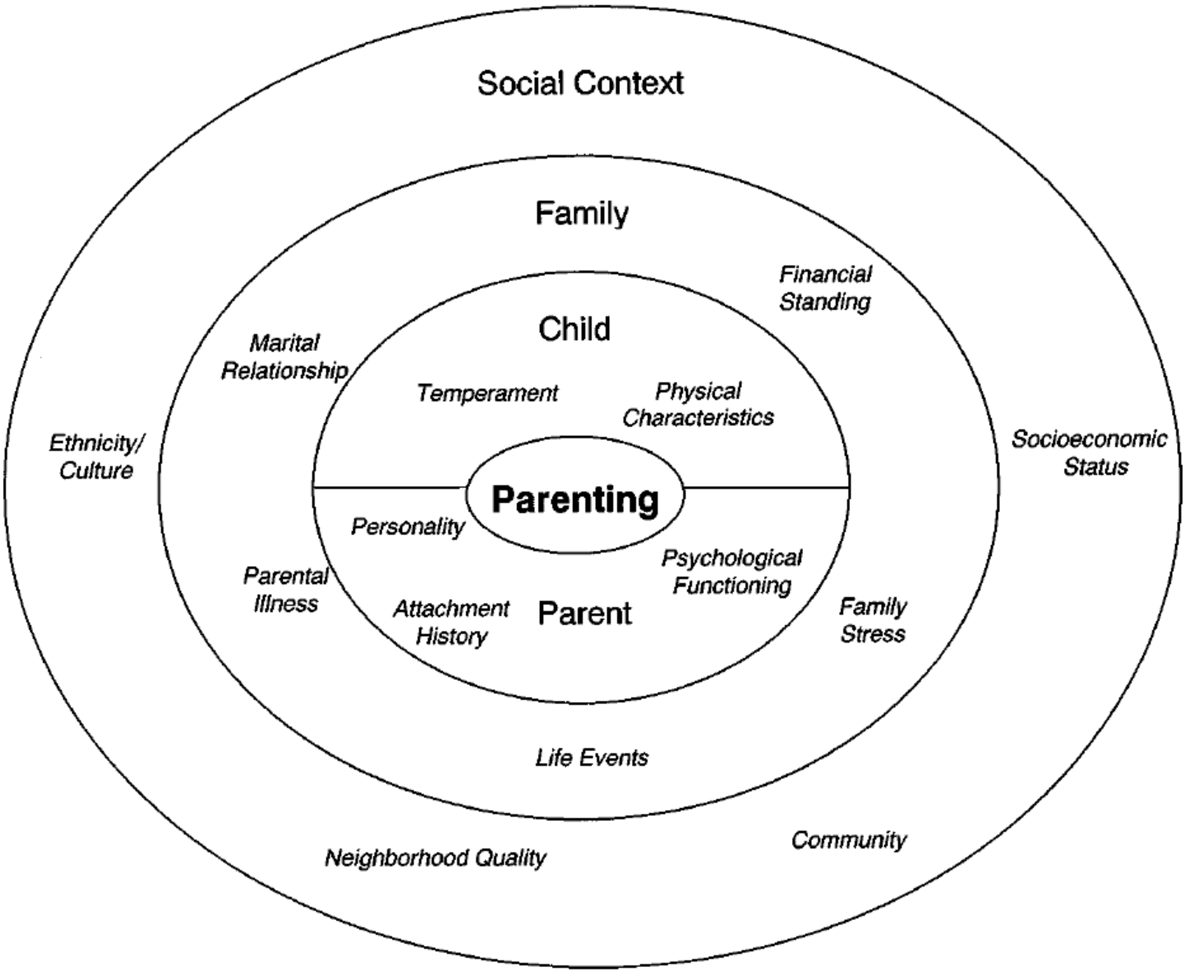
Zealand (GUINZ) longitudinal study, which features a large ethnically diverse cohort that is broadly representative of pre-school children and their families in the NZ population in terms of socioeconomic status (SES) and ethnic diversity (Morton et al., 2013). Importantly, this dataset contains responses from both mothers and their partners, which provided a valuable opportunity to explore the role of paternal factors in children's screen time use.

Our study employed a more comprehensive measure of screen time compared to past research that has focused mainly on TV use, or on TV, DVD and video viewing. This approach enabled us to investigate whether the determinants of screen time identified by previous research hold when a more comprehensive measure of screen time is used. We investigated all variables reported by Duch et al. (2013) and the variables found to be significant in the ten other studies included in our literature review, if available in the GUiNZ datasets (refer to Tables 2.1–2.2). In addition, we investigated six potential predictors of screen time that have not yet been addressed specifically for this age group: the child's time spent outdoors, total behavioural difficulties, child temperament, concerns about the child's physical health, parents' self-rated parenting efficacy, and reading to the child on a daily basis.

Our study employed Kotchick and Forehand's (2002) Ecological Model of Parenting, which draws on the previous work by Luster and Okagaki (1993), as a framework for examining the influence of these factors on the amount of screen time to which 2-year-old children are exposed. With parenting as the focal variable of interest, Kotchick and Forehand's model is an adaptation of the ecological framework by Bronfenbrenner (1979) and shows that the characteristics of the child and the parent represent the proximal factors, whilst the family and the societal contexts represent the more distal factors, all of which exert an influence on parenting. Thus in the present study, we interpret the model to mean that characteristics of the child and parent will directly influence children's screen time (defined here as a parenting behaviour); family factors will impact directly on both parent and child and therefore, indirectly influence screen time; and societal factors, such as ethnicity, SES and neighbourhood, will also play a role in influencing screen time (refer to Figure 2.1). We believe that screen time of 2-year-old children is under parental control because very young children are reliant on their parents to allow them access to media (Duch et al., 2013; Knowles et al., 2015). Parenting behaviours specifically related to the child's digital media consumption in the home are likely to reflect parental beliefs about the benefits and risks of their children engaging with screen media (Hinkley et al., 2017), and influence the media environment the child experiences in the home (Elias & Sulkin, 2019). Therefore, we hypothesised that screen media-related parenting behaviours would be the most important predictors of total screen time for 2-year-old children.

**Figure 2.1**

*Kotchick and Forehand's Ecological Model of Parenting*




*Note*. Reprinted with permission from "Putting Parenting in Perspective: A Discussion of the Contextual Factors that Shape Parenting Practices" by B. A. Kotchick and R. Forehand, 2002, *Journal of Child and Family Studies, 11*(3), Springer, p. 258. Copyright 2002 by Human Sciences Press, Inc.

## 2.3 Method

### *2.3.1 Study Design and Participants*

The current study design is correlational and cross-sectional using secondary data derived from the GUiNZ study, a longitudinal birth cohort study that antenatally recruited 6,822 mothers whose babies were due between April 2009 and March 2010 (Morton et al., 2015). GUiNZ has been designed and conducted by a team led by the University of Auckland. Ethics approval was obtained from the MoH Northern Y Regional Ethics

Committee in NZ (Morton et al., 2015). Informed consent was obtained for all individual participants in the study. The 2-year DCW was conducted between April 2011 and November 2012, when the children were aged approximately 2 years old (*M* = 2.07 years, *SD* = 0.17), and included 6,327 children, 6,242 mothers and 3,804 fathers. There were 3,771 children whose mothers reported on their children's use of screen media on the last weekday in the 2-year DCW and whose fathers also participated in the 2-year DCW. Only one child from each family was included in our analyses to avoid dependent observations, resulting in a sample size of 3,720 children. Subsequently, missing data on predictor variables resulted in an analysis sample size of *n* = 3,081 (82.8%). In nearly all cases, the mother's partner at the time of recruitment self-reported to be the child's biological father (> 99%) (Morton et al., 2013). Therefore, for clarity and simplicity, we use the title of "father" in place of "partner" in our description of the findings. Table 2.3 provides demographic characteristics of the current study sample.

**Table 2.3**

*Demographics of Children, Fathers and Mothers (N = 3,720) in the Current Study*

| | *n* (%) | *M* (*SD*) |
|---|---|---|
| Child's age (years) | | 2.05 (.14) |
| Child gender | | |
| Boy | 1,946 (52.3%) | |
| Girl | 1,772 (47.7%) | |
| Child ethnicity[a] | | |
| European | 2,137 (60.1%) | |
| Māori | 321 (9.0%) | |
| Pacific Peoples | 264 (7.4%) | |
| Asian | 393 (11.1%) | |
| MELAA[b] /NZ | 439 (12.4%) | |
| Child birth order | | |
| Firstborn | 1,660 (44.7%) | |
| Subsequent child | 2,056 (55.3%) | |
| Household NZ Deprivation Index[c] | | |
| Low decile (1–3) | 1,178 (32.4%) | |
| Medium decile (4–7) | 1,448 (39.8%) | |
| High decile (8–10) | 1,010 (27.8%) | |
| Maternal age | | 33.48 (5.26) |
| Paternal age | | 35.72 (6.13) |
| Maternal education | | |
| No secondary school education | 121 (3.3%) | |
| Secondary school/ NCEA[d] Level 1–4 | 728 (19.6%) | |
| Diploma/Trade cert/NCEA 5–6 | 1,010 (27.2%) | |
| Bachelor's degree | 1,061 (28.6%) | |
| Higher degree | 793 (21.4%) | |
| Paternal education | | |
| No secondary school education | 210 (5.7%) | |
| Secondary school/ NCEA Level 1–4 | 706 (19.1%) | |
| Diploma/Trade cert/NCEA 5–6 | 1,337 (36.2%) | |
| Bachelor's degree | 751 (20.3%) | |
| Higher degree | 692 (18.7%) | |

*Note.* Where frequencies do not total 3,720, this is due to missing data. [a] Child prioritised ethnicity reported by mothers in the 54-month DCW. [b] "MELAA" includes mothers of Middle Eastern, Latin American or African ethnicity. [c] The New Zealand Deprivation Index is based on nine different socioeconomic variables in the 2006 New Zealand census, which are combined to describe the deprivation level of a small geographical area. Decile 10 describes the areas of greatest deprivation and Decile 1 describes areas of least deprivation. [d] "National Certificates of Educational Achievement" offered in New Zealand's education system.

## 2.4 Measures

### *2.4.1 Outcome Measure*

When the GUiNZ cohort children were aged approximately 2 years old, a computer-assisted personal interview (CAPI) of 90 min duration was administered to mothers and a 60-min CAPI was administered to fathers. Mothers were asked three questions about their children's screen media use on the last weekday. Specifically: "Thinking about the last weekday, i.e. [YESTERDAY/LAST FRIDAY], how many hours did [NAME] spend at home watching all types of TV, DVDs, and videos?"; "Again just thinking about the last weekday, i.e. [YESTERDAY/LAST FRIDAY], how much time did [NAME] spend using a computer or laptop, including children's computer systems such as Leapfrog" and "And on that last weekday, how much time did [NAME] spend playing with an electronic gaming system?". Mothers had the option of reporting "none" or reporting the amounts of time spent in each of these activities, in hours, while the proportions of an hour were converted to decimal numbers. The number of hours reported by mothers across these three media questions were added together, producing our outcome variable of total screen time for the child on the most recent weekday. This combination of time spent watching TV programmes, DVDs and videos, using a computer and playing video games to obtain a measure of total screen time has been employed by previous researchers (e.g., Cliff et al., 2018; Wiecha et al., 2001; Xu et al., 2016).

Our screen time outcome measure is comprised of count data (number of hours spent on screen-based media) and our data were positively skewed. The variance of the data was somewhat greater than the mean ($M$ = 1.20, variance = 1.71), which raised the possibility that the data might not fit a Poisson distribution and Negative Binomial regression might be more suitable than Poisson regression (Coxe et al., 2009). However, as a safeguard to ensure the correct type of analysis was employed, we decided to conduct the analyses using both

Poisson and Negative binomial regression, and select the final model with the best fit to the data with reference to the Akaike information Criterion (AIC) (Burnham & Anderson, 2002). Consequently, cases in which mothers included fractions of hours in their report of their child's screen time were rounded so that our outcome variable consisted of positive integers only, which is required for both Poisson and Negative binomial regression. Decimal numbers 0.5 and above were rounded to the closest integer above that value, while decimal numbers below .5 were rounded to the closest integer below that value. Scores ranged from 0 up to 10 hr total screen time.

### *2.4.2 Independent Variables*

Our independent variables comprised the variables reported in Duch et al.'s (2013) review and variables found to be significant in more recent studies, if available in the GUiNZ datasets. We also included additional variables that the wider literature on parenting and children's media exposure suggests might also influence the parenting behaviour of exposing children aged up to 3 years old to screens. Table 2.4 contains information on each of the predictor variables employed in our study. The majority of variables employed in our study were drawn from the 2-year DCW. However, some variables were drawn from other DCWs: Parental education was obtained in the antenatal CAPI; child gender was reported at the 6-week computer-assisted telephone interview (CATI); breastfeeding or not at 9 months; symptoms of maternal and paternal post-natal depression and child temperament were reported in the 9-month CAPI; siblings living at home was obtained from the 16-month CATI and parent-reported child ethnicity was identified in the 54-month CAPI and used retrospectively. We do not believe that the relevancy of these particular variables is diminished through being collected non-concurrently with the outcome measure, although we acknowledge that it is possible that there may have been changes in the number of siblings living at home with the child between the 16-month and the 2-year DCWs.

However, note that number of siblings was not ultimately included in the full model as it was not significant in the bivariate analyses employed for model selection.

**Table 2.4**

*Full Table of Measures Prepared for Use in Hierarchical Analysis for Investigating Predictors of Screen Time for Two-Year-Old Children*

| Construct | Brief description and administration period | Scale, preparation and reliability |
|---|---|---|
| Parenting Behaviour | | |
| Breastfeeding or not at 9 months | Single item: Did you ever breastfeed this baby? Administered to mothers in the 9-month DCW. | Response scale of 1 (still breastfeeding); 2 (breastfed but stopped); 3 (never breastfed); Responses 2 and 3 were combined and labelled 'not breastfeeding at 9 months' (1); Response 1 was labelled 'still breastfeeding at 9 months'. |
| Co-viewing | Single item: When your [child is/children are] watching TV, DVDs or videos, how often is an adult watching with [him/her/them]? Administered to mothers in the 2-year DCW. | Response scale of 1 (all of the time), 2 (most of the time), 3 (about half the time), 4 (less than half the time) and 5 (Never), 6 (not applicable). Responses 4 and 5 were combined and labelled 'Co-views less than half the time, or never' (1). Scale was reversed to represent increasing levels of co-viewing. |
| TV environment | Single item: And again just thinking about that last weekday (i.e. [YESTERDAY/LAST FRIDAY]), how much time was the TV on in the same room as [NAME], whether or not [HE/SHE] was watching it? Administered to mothers in the 2-year DCW. | Mothers reported time as 1 (not at all) or 2 (total hours). Responses of 'Not at all' were assigned scores of 0 hr, in combination with the total hour scores of children exposed to TV playing in the same room. 0–1 hr was coded "low TV environment" (1), 1.01–5.99 hr was coded "moderate to high TV environment", and scores ≥ 6 hr was coded "heavy TV environment". |
| Exposure of child to adult-directed content | Two items: 1) Thinking about the last weekday, how many hours did child spend at home watching TV, DVDs, or videos? 2) And how much of this time was spent watching 'grown-up' DVDS or television programmes on free-to-air and pay TV? Question 2 was only asked if mothers indicated that their child had watched TV, DVD or videos in question 1. Administered to mothers in the 2-year DCW. | Mothers reported time as 1 (none) or 2 (total hours) for both questions. Responses of 2 (total hours) for question 2 (i.e. time spent viewing grown-up content) were coded as 'Child viewed adult-directed content'. Scores of 1 (none) to either question 1 or question 2 were coded as 'Child did not view adult-directed content' (1). |
| Exposure of child to child-directed content | Three items: 1) Thinking about the last weekday, how many hours did child spend at home watching TV, DVDs, or videos? 2) Of this time, how much was spent watching just children's television programming, including free-to-air and pay TV, and children's TV programmes on DVD, but not children's movies on DVD? 3) And how much of this time was spent watching children's movies on DVD or video, e.g. Toy Story? Questions | Mothers reported time as 1 (none) or 2 (total hours) for all 3 questions. Total hours viewing child-directed content was computed by summing total hours reported for questions 2 and 3. If no viewing time was reported to either question 2 or 3, this was coded as 'Child did not view child-directed content'. This variable used in descriptive analysis only. |

| Construct | Brief description and administration period | Scale, preparation and reliability |
| --- | --- | --- |
| | 2 and 3 were only asked if mothers indicated that their child had watched TV, DVD or videos in question 1. Administered to mothers in the 2-year DCW. | |
| Outdoors | Single item: Thinking about the LAST FOUR WEEKS, approximately how many hours has [NAME] spent outdoors on an average weekday? Administered to mothers in the 2-year DCW. | Mothers reported time 1 (1–24 hr); 2 (responses < 1 hr); 3 (No exposure at all). Response 1 was labelled "An hour or more outdoors on a weekday" (1); Responses 2 and 3 were combined and labelled 'less than an hour outdoors on a weekday'. |
| Reading stories to child daily | Single item: How often do you read books with your [child/children]? Administered to mothers and fathers separately in the 2-year DCW. | Response scale of 1 (seldom or never), 2 (once a week), 3 (several times a week), 4 (once a day) and 5 (several times a day). Responses 1–3 were combined and labelled 'Less than daily' and responses 4–5 were combined and labelled 'At least daily' (1). |
| Time rules | Single item: Are there rules about…How many hours of TV, videos, and DVDs your [CHILD/CHILDREN] can watch? Administered to mothers in the 2-year DCW. | Mothers responded Yes (1), No, or Not Applicable. Interviewers were instructed to code Not Applicable if the participant indicated that the questions were not applicable because there was not TV. |
| Parental Characteristics | | |
| Average parental age | Derived variable. Mean of mother's age and father's age on the date of the 2-year child-proxy CAPI. | Mothers' and fathers' ages were calculated separately by calculating the difference between their birth dates (administered in the antenatal CAPI) and the date of the 2-year child-proxy CAPI, then the mean of mothers' and fathers' ages was calculated. |
| Mother's personality | Factor scores on the personality traits of Agreeableness (9 items, $\alpha = 0.69$), Openness (10 items, Cronbach's $\alpha = 0.76$); Conscientiousness (9 items, $\alpha = 0.78$); Neuroticism (9 items, $\alpha = 0.77$) and Extraversion (8 items, $\alpha = 0.81$). Administered to mothers in the 2-year DCW. | The Big Five Trait Taxonomy (John & Srivastava, 1999). All items used the scale 1 (disagree strongly), 2 (disagree a little), 3 (neither agree nor disagree), 4 (agree a little) and 5 (agree strongly). Mean scores were calculated for each subscale. |
| Parental education | Separate variables indicating the highest level of education reached by the mother and the father. Administered separately to mothers and fathers in the antenatal DCW. | Education qualifications in ascending order: 'No secondary school qualification' and 'Secondary school/NCEA L1-4' were combined to make 'School qualifications or less' (1), 'Diploma/trade cert NCEA L5-6', 'Bachelor's Degree', and 'Higher degree'. |
| Paternal and maternal self-rated efficacy | Single question: We would like to know how you feel about being a parent. Overall, do you feel that as a parent you are: Administered to mothers and fathers separately in the 2-year DCW. | Response options ranged from 1 (not very good at being a parent), 2 (a person who has some trouble being a parent), 3 (an average parent), 4 (a better than average parent) and 5 (a very good parent). Responses 1–3 were combined and labelled Low to average efficacy and responses 4 and 5 were combined and labelled High efficacy (1). |
| Symptoms of maternal postnatal depression | A 10-item screening tool for identifying post-natal depression (Cronbach's $\alpha = 0.85$). Sample item: In the last 7 days the | Edinburgh Post Natal Depression Scale (Cox et al., 1987). Sample response scale 0 (never), 1 (hardly ever), 2 (sometimes), 3 (yes, quite |

| Construct | Brief description and administration period | Scale, preparation and reliability |
|---|---|---|
| | thought of harming myself has occurred to me. Administered to mothers in the 9-month DCW. | often). Items were totalled and scores ≥13 were coded 1 (depressed) and scores <13 were coded 0 (not depressed) (1). |
| Symptoms of paternal postnatal depression | A 9-item screening tool for identifying depression (Cronbach's $\alpha = 0.76$). Sample item: Over the last two weeks, how often have you been bothered by the following problems? Feeling down, depressed, or hopeless. Administered to fathers in the 9-month DCW. | Patient Health Questionnaire (PHQ) (Spitzer et al., 1999). All items used the scale 0 (not at all), 1 (several days), 2 (more than half the days), 3 (nearly every day). Items were totalled and scores ≥10 were coded 1 (depressed) and scores <10 were coded 1 (not depressed) (1) (National Collaborating Centre for Mental Health (UK), 2010). |
| Child Characteristics | | |
| BMI for age z-score | BMI calculated based on child observations administered in the 2-year DCW and converted to z-scores adjusted for age and gender. | Standardised BMI measurements were obtained using the WHO Anthro programme, version 3.1.0 (World Health Organization, 2010). |
| Child age | Derived variable. Child's age on day of mother's 2-year CAPI. | The difference between child's birth date (administered in the 6-week CATI) and the date of the 2-year CAPI. |
| Child gender | Single item: Did you have a boy or a girl? Administered in the 6-week CATI. | Mothers responded Girl or Boy (1). |
| Child temperament | Five factor model of the Infant Behavior Questionnaire Revised-Very Short Form (E. R. Peterson et al., 2017; Putnam et al., 2014), adapted from the IBQ-R-VSF. Sample item: "When tired, how often did your baby show distress?" Administered in the 9-month DCW to mothers. | Response scale ranges from 1 (never) – 6 (always). Total score on each temperament factor was calculated: Negative affect (9 items, Cronbach's $\alpha = .80$); Positive affect and surgency (PAS) (14 items, Cronbach's $\alpha = .72$); Fear (3 items, Cronbach's $\alpha = .89$); Orienting Capacity (OC) (5 items, Cronbach's $\alpha = .63$; Affiliation (6 items, Cronbach's $\alpha = .70$). |
| Health concern | Single item: During the past 4 weeks, how much emotional worry or concern did child's physical health cause you? Administered to mothers in the 2-year DCW. | Response options ranged from 1 (none at all) (1), 2 (a little bit), 3 (some), 4 (quite a bit), 5 (a lot). Responses 4 and 5 were combined and labelled 'Quite a bit or a lot of health worry'. |
| Language development | MacArthur CDI-II short form A (100 items) (Fenson et al., 2000), adapted for New Zealand English (as per Reese et al., 2018). Sample item: Child can say aeroplane in 'English' language. | Mothers responded Yes (scored as 1) or No (scored as 0) as to whether the child could say each word. A total score was computed. Administered in the 2-year DCW. |
| Parity | Administered to mothers in the 6-week DCW. | Indicates whether the child is a firstborn (1) or subsequent child. |
| Sleep | Two items: On average, how much time does [NAME] spend asleep at night in total? On average, how much time does [NAME] spend asleep during the day? Administered to mothers in the 2-year DCW. | Mothers responded with the number of hours and minutes that the child spends asleep each day at night and during the day. First, the hours and minutes of both day and night sleep were combined to obtain separate totals of sleep (night) and sleep (day). These totals were then added together to obtain the total amount of sleep in 24 hr. Scores were not included for children of mothers who reported "Don't know" for either day sleep or night sleep. Extreme scores 3x the interquartile range above and below the median were winsorised, resulting in a range of 7- |

| Construct | Brief description and administration period | Scale, preparation and reliability |
|---|---|---|
| | | 18 hr. This range corresponds to 2 hr above and below the upper and lower bounds of appropriate sleep guidelines for toddlers (Ministry of Health, 2019), thus incorporating scores representative of sleep difficulties. |
| Total difficulties | Strength and Difficulties Questionnaire (SDQ) (Goodman, 1997). Measure of child's behavioural strengths and difficulties based on parental report of their behaviour over the last six months. Sample item: "Many fears, scares easily." Administered to mothers in the 2-year DCW. | The SDQ contains 4 difficulties subscales: emotional symptoms, peer problems, hyperactivity-inattention and conduct problems (5 items each). Based on their child's behaviour over the last six months, mothers reported whether the behaviours in each subscale was 0 (not true), 1 (somewhat true) or 2 (certainly true) of their child. A 'Total difficulties' score (Cronbach's α = .76) was calculated by summing the scores on each subscale. |
| Family Context | | |
| Childcare | Single item: "Over the past 1 month [HAS YOUR CHILD/HAVE YOUR CHILDREN] been looked after at regular times during the week by anyone other than you or your partner? DO include regular care by neighbours and/or grandparents. DO NOT include casual or occasional babysitting. DO NOT include care by a non-resident parent." Administered to mothers in the 2-year DCW. | Mothers responded Yes (1) or No. |
| Family stress | An 8-item scale developed for the *Growing up in New Zealand* (GUiNZ) study, with reference to Abidin (1995), to assess current levels of family stress. Sample question: "Thinking about the time since your [CHILD WAS/CHILDREN WERE] nine months old, to what extent are the following sources of stress for you and your family. If any of these things are not present in your life, please choose 'not applicable'." Administered to mothers in the 2-year DCW. | Sample item: Worry about a disabled or ill family member (adult or child). Response scale ranged from 1 (not at all stressful) to 4 (highly stressful), or 'Not applicable'. The mean score was calculated. Cronbach's α = .76. |
| Paternal and maternal employment | Single item: Do you have a paid job at the current time? Administered to both mothers and fathers in the 2-year DCW. | Mothers and fathers responded Yes (1) or No. |
| Relationship environment | Warmth and Hostility Scale from the Iowa Family Interaction Rating Scale (Melby et al., 1998). A 9-item scale measuring positivity of relationship environment for those mothers who have a current partner. Administered to mothers in the 2-year DCW. | Sample item: During the PAST FOUR WEEKS how often did you let each other know you really care about each other? Response scale ranged from 1 (never) to 7 (all the time). The mean score was calculated. Cronbach's α = .85. |

| Construct | Brief description and administration period | Scale, preparation and reliability |
|---|---|---|
| Siblings living at home | Variable derived from two separate items: Mothers were first asked: "Could you please tell me how many brothers and/or sisters [NAME] has?" then for each sibling, they were also asked: "Lives in same house (Y/N)". Administered in the 16-month CATI. | Mothers responded to first question with number of siblings, then responded Yes or No to identify whether siblings lived at home. The total number of siblings living at home was calculated. |
| TVs in home | Single item: How many TVs do you have in regular use in your home? Administered to mothers in the 2-year DCW. | Response options included 0 (none), 1 (one), 2 (two), 3 (three), 4 (four), 5 (five or more). Responses of 0 or 1 TV set were combined and labelled '0 or 1 TV set) (1), Responses of 2 TV sets were labelled '2 TV sets', responses of 3 or more TV sets were combined and labelled '3 or more TVs'. |
| Social Context | | |
| Deprivation group | Variable derived through using Census data using geocoding data of residential areas. The New Zealand Deprivation Index is based on nine different socioeconomic variables in the 2006 New Zealand census, which are combined to describe the deprivation level of a small geographical area. Decile 1 describes the area of least deprivation and Decile 10 indicates the greatest deprivation. | NZ Deprivation Index (Salmond et al., 2007). Deprivation is divided into 3 groups: Low (Deciles 1–3) (1), Medium (Deciles 4–7) and High (Deciles 8–10). |
| Ethnicity | Derived variable. Single item: "Which is the MAIN ethnic group that [NAME] identifies with?" Administered to mothers in the 54-month DCW. | Response options included 32 different ethnicities and 'Other Ethnicity (Please specify)', which were then upcoded by the GUiNZ study team to the following categories: 0 (European) (1), 1 (Māori), 2 (Pacific Peoples), 3 (Asian), 4 (MELAA) and 5 (New Zealander). Due to low frequencies in the NZ category, we combined categories 4 and 5 to create MELAA/NZ. |
| Neighbourhood safety | Single item: "To what extent do you agree or disagree with these statements about your neighbourhood?: This is a safe neighbourhood." Administered to mothers in the 2-year DCW. | Response options included 1 (strongly disagree), 2 (disagree), 3 (agree) and 4 (strongly agree). Responses 1-2 were combined and labelled unsafe; options 3 and 4 were combined and labelled safe (1). |
| Rurality | Variable derived through using Census data using geocoding data of residential areas. Based on demographic information, participants' residential areas were classified into levels of rural or urban. Created by the GUiNZ study team for the 2-year dataset. | Categories included: 1 (main urban area), 2 (satellite urban area), 3 (independent urban area), 4 (rural area with high urban influence), 5 (rural area with low urban influence), 6 (rural area with moderate urban influence), 7 (highly rural/remote area), 8 (area outside urban/rural profile). Categories 1-3 were combined and labelled 'Urban' (1) and categories 4-8 were combined and labelled 'Rural'. |
| Seasonality | Derived from interview date at 2-year child proxy interview. | Categories are Summer months (1), Spring, Autumn and Winter. |

## 2.5 Data Analyses

### *2.5.1 Preliminary Analyses*

**2.5.1.1 Descriptive Analyses.** Descriptive analyses were conducted on the outcome variable (screen time), as well as the predictor variables related to the screen media environment in the homes of the children included in our sample. Descriptive analyses were conducted prior to rounding the screen time outcome measure, to provide a more accurate indication of levels of screen engagement on a weekday for this group of children. Where the total number of children in the sample of 3,720 is not equal to the stated frequencies, this is due to missing data on predictor variables.

**2.5.1.2 Analysis of Correlations Between Predictor Variables.** To screen for multicollinearity, Pearson correlations were conducted. Maternal and paternal age were found to be strongly correlated, $r_p = .69$, $p < .01$. Therefore we computed an average parental age variable for use in a regression model including data from both mothers and fathers, to avoid using maternal age and paternal age together in the same analysis. Parity and number of siblings were found to be moderately correlated at $r_p = .66$, $p < .01$; however, only parity was significant in bivariate analyses and subsequently included in the final multivariable regression. All other associations between predictor variables used in our regression analyses were $r_p < .60$.

**2.5.1.3 Analysis of Patterns of Missing Data.** We analysed missing data across the predictor variables included in the multivariable analysis conducted on our sample of 3,720 mothers, fathers and children. The variables had low rates of missingness, with 4.5% on child ethnicity, and missingness of all other variables ≤ 3.5%. Missingness in our dataset is likely attributable to reduction of sample size due to drawing on data from different data points, as participants do not always take part in every DCW. Including only one child per family in our regression analyses, our analysis sample size of 3,081 represents 82.8% of those children whose mothers reported on their children's screen time in the 2-year DCW child proxy questionnaire and whose fathers also participated in the 2-year DCW ($n$ = 3,720).

### 2.5.2 Bivariate Analyses

A large number of potential predictors of screen time were identified ($n$ = 45), therefore bivariate analyses were conducted to identify which of our potential predictors were related to our outcome of screen time and would be included in the full model. As it was not yet established whether Poisson or Negative Binomial analyses would provide the best fit for our final model, we conducted generalised linear model (GLM) Poisson and Negative binomial bivariate regression analyses with a critical $p$-value of .05. We decided beforehand that if a potential predictor was statistically significant ($p < .05$) in one type of analysis but not the other, it would be included in the full model. Two variables met these criteria: Neighbourhood safety had a significant Poisson regression ($b$ = -0.13, Wald $\chi^2(1)$ = 5.95, $p$ = .01) but not a Negative binomial regression ($b$ = -0.13, Wald $\chi^2(1)$ = 2.44, $p$ = .12), and similarly, Paternal postnatal depression had a Poisson regression ($b$ = -0.16, Wald $\chi^2(1)$ = 4.30, $p$ = .04) and a Negative binomial regression ($b$ = -0.16, Wald $\chi^2(1)$= 1.74, $p$ = .19), and thus both were included in the final model. All other variables had statistically significant results in both Poisson and Negative binomial analyses. Thirty-eight variables met statistical criteria for inclusion ($p < .05$) (see Table 2.5).

### 2.5.3 Multivariable Analyses

Variables that were significant at a $p$-value of .05 in the bivariate analyses were included in multivariable GLM Negative binomial and Poisson regression models. As recommended for count data, we employed the robust estimator (Hilbe, 2017). All analyses were conducted using SPSS IBM version 24. Once the final model had been identified, we calculated McFadden's pseudo-$R^2$ separately to assess model fit (Hemmert et al., 2018).

**Table 2.5**

*Results of Poisson Bivariate Regression Analysis Testing the Association Between Screen Time of Children at Age of Two Years and Each Potential Predictor, Ordered by Size of Wald Chi-Square Statistic for Each Category of Predictor*[a]

| Variable | Wald $\chi^2$ | *df* | *p*-value |
|---|---|---|---|
| Parenting Behaviours | | | |
| TV environment | **1,117.71** | **(2, *N* = 3,655)** | **<.001** |
| Exposure to adult-directed content | **386.68** | **(1, *N* = 3,590)** | **<.001** |
| Time rules | **353.56** | **(1, *N* = 3,717)** | **<.001** |
| Reading stories to child daily (mother) | **209.11** | **(1, *N* = 3,720)** | **<.001** |
| Co-viewing | **162.66** | **(4, *N* = 3,719)** | **<.001** |
| Reading stories to child daily (father) | **107.71** | **(1, *N* = 3,692)** | **<.001** |
| Outdoors | **73.81** | **(1, *N* = 3,678)** | **<.001** |
| Breastfeeding or not at 9 months | **26.68** | **(1, *N* =3,654)** | **<.001** |
| Parenting Characteristics | | | |
| Maternal education | **162.00** | **(3, *N* = 3,713)** | **<.001** |
| Average parental age | **138.42** | **(1, *N* = 3,696)** | **<.001** |
| Mother conscientiousness | **81.51** | **(1, *N* = 3,718)** | **<.001** |
| Paternal education | **73.80** | **(3, *N* = 3,696)** | **<.001** |
| Symptoms of maternal postnatal depression | **60.57** | **(1, *N* = 3,666)** | **<.001** |
| Mother agreeableness | **50.59** | **(1, *N* = 3,718)** | **<.001** |
| Mother neuroticism | **46.98** | **(1, *N* = 3,718)** | **<.001** |
| Mother extraversion | **35.03** | **(1, *N* = 3,719)** | **<.001** |
| Mother openness to experience | **26.44** | **(1, *N* = 3,718)** | **<.001** |
| Symptoms of paternal post-natal depression | **4.30** | **(1, *N* = 3,605)** | **.038** |
| Parental efficacy (mother) | 2.37 | (1, *N* = 3,718) | .124 |
| Parental efficacy (father) | 1.03 | (1, *N* = 3,692) | .309 |
| Child Characteristics | | | |
| Total difficulties | **258.39** | **(1, *N* = 3,713)** | **<.001** |
| Language development | **167.00** | **(1, *N* = 3,719)** | **<.001** |
| Sleep | **92.97** | **(1, *N* = 3,707)** | **<.001** |
| Child age | **78.44** | **(1, *N* = 3,717)** | **<.001** |
| Temperament: Negative affect | **69.65** | **(1, *N* = 3,665)** | **<.001** |
| Temperament: Fear | **68.74** | **(1, *N* = 3,626)** | **<.001** |
| Health concern | **33.62** | **(3, *N* = 3,720)** | **<.001** |
| Temperament: PAS | **16.53** | **(1, *N* = 3,665)** | **<.001** |
| Parity | **7.17** | **(1, *N* = 3,716)** | **.007** |
| Temperament: Orienting control | 1.71 | (1, *N* = 3,665) | .191 |
| Temperament: Affiliation/Regulation | .98 | (1, *N* = 3,665) | .322 |
| BMI z score | .42 | (1, *N* = 3,089) | .517 |

| Variable | Wald $\chi^2$ | *df* | *p*-value |
|---|---|---|---|
| Child gender | .001 | (1, *N* = 3,718) | .981 |
| Family Context | | | |
| Childcare | **126.80** | **(1, *N* = 3,718)** | **<.001** |
| TVs in home | **102.80** | **(2, *N* = 3,720)** | **<.001** |
| Parental employment (mother) | **62.58** | **(1, *N* = 3,719)** | **<.001** |
| Parental employment (father) | **45.52** | **(1, *N* = 3,692)** | **<.001** |
| Family stress | **22.86** | **(1, *N* = 3,708)** | **<.001** |
| Relationship environment | **21.83** | **(1, *N* = 3,701)** | **<.001** |
| Siblings living at home | .030 | (1, *N* = 3,720) | .861 |
| Social Context | | | |
| Ethnicity | **362.50** | **(4, *N* = 3,554)** | **<.001** |
| NZDep2006[b] | **193.51** | **(2, *N* = 3,636)** | **<.001** |
| Seasonality | **23.60** | **(3, *N* = 3,720)** | **<.001** |
| Rurality | **16.27** | **(1, *N* = 3,639)** | **<.001** |
| Neighbourhood safety | **5.95** | **(1, *N* = 3,714)** | **.015** |

*Note.* The statistically significant predictors at the .05 alpha level are printed in bold. BMI = Body Mass Index; *df* = degrees of freedom; PAS = Positive Affect and Surgency.
[a] Categories of predictors correspond to the levels of Kotchick and Forehand's (2002) Ecological Model of Parenting. [b] Based on the NZ Deprivation Index (Salmond, Crampton, & Atkinson, 2007).

## 2.6 Results

### *2.6.1 Descriptive Analyses*

Our descriptive analyses focused on the screen time outcome variable and predictor variables related to the media environment in the homes of the children included in our sample of 3,720. The median of the children's total screen time was 1 hr and the mean was 1.20 hr (*SD* = 1.31). The minimum screen time was 0 hr and the maximum was 10 hr. Forty-five point six percent (*n* = 1,698) had 0–1 hr of screen time, 28.5% had 1–2 hr (*n* = 1,059), 13.9% had 2–3 hr (*n* = 517) and 12.0% had 3 hr or more (*n*=446).

A large proportion (81.2%, *n* = 3,019) of children were reported as having TV on in the same room as them on the last weekday, whether or not they were watching it. Close to one-half of the children (44.9%, *n* = 1,670) had a low TV environment (≤ 1 hr of exposure to TV), 45.5% of children (*n* = 1,694) had a moderate to high TV environment (between 1 and 6 hr), and 7.8% (*n* = 291) experienced a heavy TV environment (≥ 6 hr), which means that their total exposure to TV most likely exceeded half of the time that 2-year-old children are typically awake per day (Ministry of Health, 2019). Seventy-four point seven percent (*n* = 2,778) of children viewed child-directed TV, DVDs or videos and 13.8% (*n* = 513) watched “grownup”, or adult-directed, television programming or DVDs. Those who viewed child-directed content did so on average for 1.34 hr (*SD* = 1.08), and those who viewed adult-directed content viewed for 0.65 hr (*SD* = 0.93) on average. Sixty-one percent of households (*n* = 2,271) had rules restricting the amount of time that children could spend watching TV, DVDs or videos. The majority of parents (78.5%, *n* = 2,919) co-viewed TV, DVDs or videos with their children at least half the time. However, relatively few parents co-viewed with their children all of the time (16.2%, *n* = 602). Finally, we found that very few children lived in households where there was no TV set in regular use (2.6%, *n* = 96).

### *2.6.2 Multivariable Regression Analyses*

Multivariable Poisson and Negative binomial regression analyses using GLM in SPSS were carried out to investigate the associations between maternal, paternal, child, family, and socio-contextual predictor variables found to be significant in bivariate analyses and screen time of 2-year-old children. We applied a Bonferroni correction to our alpha of .05, resulting in a critical *p*-value of .001. The Negative binomial model was statistically significant (Likelihood Ratio $\chi^2$ (56) = 682.87, $p < .001$) and had an AIC score of 8,887.82. The Poisson model was also statistically significant (Likelihood Ratio $\chi^2$ (56) = 1,505.69, $p < .001$) and had an AIC score of 7,841.85, which was lower than the AIC of the Negative binomial model, signifying a better model fit (Burnham & Anderson, 2002). Hence, the Poisson model was retained as the final model. The McFadden’s pseudo-$R^2$ was .16, where .15 - .32 for samples > 200 indicates good model fit (Hemmert et al., 2018). Five variables were found to be positively associated with the screen time of 2-year-old children: TV environment; having no rules about how much time the child can view TV, DVDs, or video; child watching adult-directed programming; child ethnicity (child being of Asian compared to European ethnicity) and child not attending childcare regularly. Always co-viewing with the child and co-viewing being not applicable (e.g., no TV) were found to be associated with lower levels of screen time compared to co-viewing less than half the time or never. We also found positive associations between screen time and child age, child being of Pacific ethnicity, and child health concerns over the last month, but at marginal levels of statistical significance (not quite meeting the Bonferroni correction cut-off of $p = .001$). The final model is presented in Table 2.6.

The strongest significant predictors of screen time, as demonstrated by the Incidence Rate Ratios (IRRs), were the TV environment that the child experienced in the home on the last weekday, and exposure to adult-directed content. On average, children who had a moderate to high (1.01–5.99 hr) or heavy (≥ 6 hr) TV environment had 95% (IRR = 1.95) and 184% (IRR = 2.84) higher screen time than children who had a low TV environment (≤ 1 hr), and children who viewed adult-directed content had 45% more screen time than those who did not (IRR = 1.45). Ethnicity was the third strongest predictor of screen time: children of Asian ethnicity had on average 30% more screen time than European children (IRR = 1.30). Further, a marginally significant result for the Pacific Peoples ethnic group suggests that children of this ethnicity may have 19% more screen time than European children (IRR = 1.19). Children whose parents co-viewed with them all the time had on average 17% less screen time than children whose parents co-viewed with them less than half the time or never (IRR = 0.83). Children who had no rules restricting the time they could spend watching TV, DVDs or videos had 12% higher screen time than children who had rules (IRR = 1.12). Not attending childcare regularly increased screen time by 17% (IRR = 1.17). The IRR of child age was 1.43, which suggests the possibility that it might have a greater effect on screen time compared to most other variables. However, as it was only a marginally significant predictor, there is not enough evidence to draw that conclusion. (Refer to Table 2.6 for the IRRs and confidence intervals for all variables.)

**Table 2.6**

*Results of Poisson Regression Investigating the Factors that are Associated with Screen Time for Children Aged Two Years of Age (N = 3,081), Using a Bonferroni Adjusted Alpha Level of .001*

| Variable | Tests of model effects | | | Parameter estimates | | |
|---|---|---|---|---|---|---|
| | Wald $\chi^2$ | *df* | *p*-value | B (*SE*) | Exp(B) (95% CI) | *p*-value |
| Intercept | .003 | 1 | .954 | -.69(.43) | .50(.21-1.17) | .111 |
| **TV environment** | **388.00** | **2** | **<.001** | | | |
| Low (≤ 1 hr) | | | | REF | | |
| Moderate to high (1.01–5.99 hr) | | | | .67(.04) | 1.95(1.81-2.09) | **<.001** |
| Heavy (≥ 6 hr) | | | | 1.04(.06) | 2.84(2.52-3.20) | **<.001** |
| Exposure to adult-directed content | **99.00** | **1** | **<.001** | .37(.04) | 1.45(1.35-1.56) | **<.001** |
| **Co-viewing** | **45.70** | **4** | **<.001** | | | |
| < half the time or never | | | | REF | | |
| About half the time | | | | -.004(.05) | 1.00(.91-1.09) | .937 |
| > half the time | | | | -.06(.04) | .94(.87-1.03) | .179 |
| All of the time | | | | -.19(.06) | .83(.74-.92) | **.001** |
| Co-viewing not applicable | | | | -1.39(.24) | .25(.16-.40) | **<.001** |
| **Rules on viewing time** | **16.44** | **2** | **<.001** | | | |
| Rules | | | | REF | | |
| No rules | | | | .12(.03) | 1.12(1.05-1.20) | **<.001** |
| Rules not applicable | | | | -.17(.10) | .84(.69-1.03) | .092 |
| **Child's ethnicity** | **25.73** | **4** | **<.001** | | | |
| European | | | | REF | | |
| Māori | | | | .06(.06) | 1.06(.95-1.18) | .305 |
| Pacific Peoples | | | | .18(.06) | 1.19(1.06-1.35) | .005 |
| Asian | | | | .26(.05) | 1.30(1.17-1.45) | **<.001** |
| MELAA/NZ | | | | .04(.05) | 1.04(.94-1.15) | .492 |
| Does not attend childcare | **18.79** | **1** | **<.001** | .15(.04) | 1.17(1.09-1.25) | **<.001** |
| **Child health concerns** | **17.47** | **3** | **.001** | | | |
| No health worry | | | | REF | | |
| A little bit of health worry | | | | .10(.04) | 1.11(1.03-1.19) | .004 |
| Some health worry | | | | .14(.05) | 1.15(1.05-1.27) | .002 |
| Quite a bit/ a lot of health worry | | | | .16(.05) | 1.18(1.06-1.30) | .002 |
| Child age | 7.71 | 1 | .005 | .36(.13) | 1.43(1.11-1.83) | .005 |
| **Mother's highest education** | 7.64 | 3 | .054 | | | |

| Variable | Tests of model effects | | | Parameter estimates | | |
|---|---|---|---|---|---|---|
| | Wald $\chi^2$ | *df* | *p*-value | B (*SE*) | Exp(B) (95% CI) | *p*-value |
| School qualifications or less | | | | REF | | |
| Dip./trade cert NCEA L5–6 | | | | -.03(.04) | .97(.89-1.06) | .487 |
| Bachelor's degree | | | | -.07(.05) | .94(.86-1.02) | .145 |
| Higher degree | | | | -.14(.05) | .87(.79-.96) | .007 |
| Parity: subsequent child | 5.17 | 1 | .023 | -.07(.03) | .93(.87-.99) | .023 |
| Hours of sleep per day | 4.81 | 1 | .028 | -.03(.01) | .97(.95-1.00) | .028 |
| **Deprivation group** | 4.62 | 2 | .099 | | | |
| Deciles 1–3 | | | | REF | | |
| Deciles 4–7 | | | | .04(.04) | 1.04(.96-1.11) | .340 |
| Deciles 8–10 | | | | .10(.04) | 1.10(1.01-1.20) | .032 |
| Mother post-natal depression | 4.27 | 1 | .039 | .12(.06) | 1.12 (1.01-1.26) | .039 |
| **Seasonality** | 3.40 | 3 | .334 | | | |
| Summer | | | | REF | | |
| Spring | | | | -.04(.04) | .96(.89-1.04) | .307 |
| Autumn | | | | -.03(.05) | .97(.88-1.07) | .536 |
| Winter | | | | .03(.04) | 1.03(.95-1.12) | .428 |
| Rurality | 2.99 | 1 | .084 | -.09(.05) | .92(.83-1.01) | .084 |
| Mother reads to child daily | 2.91 | 1 | .088 | .06(.04) | 1.07(.99-1.15) | .088 |
| Mother agreeableness | 2.87 | 1 | .090 | -.06(.04) | .94(.88-1.01) | .090 |
| < 1 hr outdoors per day | 2.84 | 1 | .092 | .11(.06) | 1.11(.98-1.26) | .092 |
| Still breastfeeding at 9 months | 2.18 | 1 | .139 | -.05(.03) | .95(.90-1.02) | .139 |
| Mother neuroticism | 2.27 | 1 | .132 | -.04(.03) | .96(.92-1.01) | .132 |
| **Father's highest education** | 2.41 | 3 | .492 | | | |
| School qualifications or less | | | | REF | | |
| Dip./trade cert NCEA L5–6 | | | | .04(.04) | 1.04(.96-1.12) | .322 |
| Bachelor's degree | | | | .07(.05) | 1.08(.98-1.18) | .130 |
| Higher degree | | | | .05(.05) | 1.05(.95-1.16) | .344 |
| Mother conscientiousness | 1.94 | 1 | .164 | -.04 (.03) | .96(.91-1.02) | .164 |
| Unsafe neighbourhood | 1.89 | 1 | .169 | -.08(.06) | .93(.83-1.03) | .169 |
| Total difficulties score SDQ | 1.59 | 1 | .208 | .005(.004) | 1.01(1.00-1.01) | .208 |
| Mother extraversion | 1.53 | 1 | .216 | .03(.02) | 1.03(.98-1.08) | .216 |
| Mother openness | 1.30 | 1 | .254 | .03 (.03) | 1.04(.98-1.10) | .254 |
| **TVs in home** | 0.38 | 2 | .829 | | | |
| 0–1 TVs | | | | REF | | |
| 2 TVs | | | | .01(.03) | 1.01(.94-1.08) | .861 |
| 3 or more TVs | | | | .03(.05) | 1.03(.93-1.15) | .540 |

| Variable | Tests of model effects | | | Parameter estimates | | |
|---|---|---|---|---|---|---|
| | Wald $\chi^2$ | *df* | *p*-value | B (*SE*) | Exp(B) (95% CI) | *p*-value |
| Child temperament: Fear | 1.02 | 1 | .313 | .01(.01) | 1.01(.99-1.03) | .313 |
| Father post-natal depression | .77 | 1 | .382 | -.07(.08) | .93(.80-1.09) | .382 |
| Father reads to child daily | .70 | 1 | .402 | .03(.03) | 1.03(.96-1.10) | .402 |
| Father not in paid work | .37 | 1 | .543 | .04(.07) | 1.04(.92-1.18) | .543 |
| Relationship environment | .24 | 1 | .625 | -.01(.02) | .99(.95-1.03) | .625 |
| Child temperament: PAS | .29 | 1 | .590 | .01(.02) | 1.01(.97-1.06) | .590 |
| Family stress | .22 | 1 | .640 | .01(.03) | 1.01(.96-1.08) | .640 |
| Mother not in paid work | .08 | 1 | .783 | -.01(.03) | .99(.93-1.06) | .783 |
| Temperament: Negative affect | .06 | 1 | .815 | -.004(.02) | 1.00(.97-1.03) | .815 |
| Child's language score | .01 | 1 | .917 | -.0001(.001) | 1.00(.999-1.001) | .917 |
| Average parental age | .002 | 1 | .962 | .0001(.003) | 1.00(.99-1.01) | .962 |

*Note*. The statistically significant predictors are printed in bold. MELAA = Middle Eastern, Latin American or African; OC = Orienting Control; PAS = Positive affect/surgency; NCEA = National Certificate of Educational Achievement; SDQ = Strengths and Difficulties Questionnaire; Coeff = Coefficient; SE= Standard Error; CI= Confidence Interval; REF= Reference category.

## 2.7 Discussion

Our findings enabled us to: 1) describe the prevalence of screen time and the features of the home media environment experienced by 2-year-olds in the NZ population; 2) identify the variables that are significantly associated with 2-year-old children's total screen time on a weekday; and 3) test our hypothesis that screen media-related parenting variables are the most important predictors of screen time for 2-year-old children.

Bearing in mind that MoH (2017) guidelines on exposure to screens and avoidance of background TV for children under five had not been issued at the time the data were collected for this study, the majority of children (*n* = 2,466, 66.3%) nevertheless had only one hour or less of screen time inclusive and thus met or were very close to meeting the NZ guidelines on screen time. There are, however, a small proportion of children who had between 3 and 10 hr of screen time on the last weekday (*n* = 446, 12.0%). Given that 2-year-old children are typically awake for 10–13 hr per day (Ministry of Health, 2019), screen times of this magnitude suggest that some children are being exposed to screens for between a quarter and potentially all of their wake time each day. Our results also indicate that some children ($n$ = 291, 7.8%) experienced a heavy TV environment on the last weekday, whereby they were in a room with the TV going for 6 hr or more, whether or not they were watching it. This suggests that some children with the highest screen time levels may be living in what Vandewater et al. (2005a) term "heavy television households" (p. 564) where TV is playing more or less constantly in the home.

Most children were supervised at least half of the time when viewing media such as TV, DVDs or video, and had time restrictions placed on their exposure to these media. However, our results suggest that most children in our sample were viewing TV, DVD or video without adult involvement at least some of the time. Children aged up to 3 years are still developing the ability to comprehend screen media (Anderson & Pempek, 2005; Moser et al., 2015), and parents play an important role in mediating the viewing experience for their children and supporting their learning (Anderson & Pempek, 2005; Barr et al., 2008). While acknowledging that parents of young children often find time management a challenge (Corkin et al., 2018), our findings suggest there is a need to raise awareness of the benefits of being present when their young children are engaging with screens, and to encourage parents to find ways and time to increase their presence when their child watches or engages in any screen time.

Variables from three contextual levels of Kotchick and Forehand's (2002) model were found to be significantly associated with screen time, including four media parenting behaviour variables (providing a moderate to heavy TV environment, having time rules, co-viewing with the child, and allowing the child to view adult-directed content), one family context variable (child attending childcare regularly), and one socio-contextual variable (ethnicity). In addition, two child variables (concerns about child health over the last month and child age) had marginally significant relationships with screen time.

Only one of the significant associations reported in Duch et al.'s (2013) review was significant in our model, specifically, the positive relationship between screen time and being of non-European ethnicity (see Table 2.1). Of the ten studies we reviewed that were not included in Duch et al.'s review, we had significant findings in common with three studies. These included a positive association between screen time and ethnicity (non-European) (Carson & Kuzik, 2017) and negative associations between screen time and non-parental childcare (Carson & Kuzik, 2017; Elias & Sulkin, 2019) and having rules restricting screen time (Birken et al., 2011). In addition, our finding that viewing adult-directed content was positively associated with screen time has similarities with Elias and Sulkin's (2019) finding that parent and child co-viewing adult-directed programming was associated with higher screen time on weekends (see Table 2.2). Some of the differences in our significant results on matched variables compared to those of the previous research may be due to our use of a more comprehensive measure of screen time compared to those employed by many of the previous studies in this field.

We looked at variables that have not been addressed by previous research into the predictors of screen time for 2-year-old children: child's time spent outdoors; total difficulties score on the Strengths and Difficulties Questionnaire (Goodman, 1997); child temperament; concerns about the child's physical health over the last month; self-rated parenting efficacy; reading to the child on a daily basis, and maternal personality. Of these, concerns about the child's physical health over the past month proved to be a marginally significant positive predictor of screen time.

We found partial support for our hypothesis that screen media-related parenting behaviours would be the most important predictors of weekday screen time for 2-year-old children, as exposing the child to a moderate to high or heavy TV environment compared to a low TV environment, and allowing the child to view adult-directed TV and DVDs, were the strongest predictors of screen time. Ethnicity was the next strongest predictor of screen time, followed by having rules about the amount of time children can spend viewing TV, DVDs or video, co-viewing with the child and child attending childcare regularly.

Parenting is central to Kotchick and Forehand's (2002) model. Parenting can be conceptualised as a conglomeration of different parenting behaviours which tend to form consistent patterns (Baumrind, 1971), which led us to expect there would be commonalities between different screen media practices. In line with this expectation, Gentile and Walsh's (2002) research into the screen media habits of families with children aged 2–17 years showed there was consistency across family media practices. Screen media parenting practices may be particularly important for 2-year-old children who typically have less autonomy than older children (Huston et al., 1999) and whose parents can readily control their access to screens (Duch et al., 2013; Knowles et al., 2015). Accordingly, we hypothesised that screen media parenting variables would be the most important predictors of screen time. We found partial support for this hypothesis as all four media-related parenting behaviours were significantly associated with screen time, and the TV environment provided to the child on the last weekday and exposure to adult-directed content were the strongest predictors of children's screen time overall.

We found that children who experienced a moderate to high (between 1 and 6 hr), or heavy (≥ 6 hr) TV environment on the last weekday had more screen time than children who had a low TV environment (≤ 1 hr). This finding includes any time that children spent in the same room with a TV that was turned on, whether or not they were watching it. Our finding confirms the previous finding of Vandewater et al. (2005a) that living in a heavy TV household is associated with higher levels of child screen time. Some children of age two may not yet be capable of turning on screen devices for themselves and making the devices "work" (Vandewater et al., 2007) but having TV available and playing in the same room makes it comparatively easy for children to access TV and thereby accrue more screen time (Vandewater et al., 2005a). Further, Vandewater et al. found that children who lived in heavy TV households not only have increased levels of TV viewing, but their use of other forms of electronic media may also be increased. Hence the heightened availability and accessibility of TV provided by moderate to high and heavy TV households, and the association with higher use of other electronic media, may explain the relationship between moderate to heavy TV environment and increased levels of screen time at 2 years identified in our study.

A relatively small proportion (18.0%, *n* = 513) of children who watched TV, DVD or video on the last weekday (*n* = 2,857) were reported as watching adult-directed content. We found that these children had significantly higher levels of screen time compared to children who viewed no adult-directed content. As 86.7% (*n* = 445) of children who viewed adult-directed content also viewed child-directed content, one reason for this finding may be that viewing of adult-directed content occurs in addition to viewing of child-directed content, rather than simply displacing it. As noted, there tends to be consistency within family media practices (Gentile & Walsh, 2002); therefore, it is also possible that parents who allow their child to view adult-directed content place fewer restrictions on their child's media exposure overall, resulting in higher screen time levels. We suspect, however, that adult-directed programming is most often not selected for the viewing of the 2-year-old child specifically. It seems more likely that the child is included when older family members are viewing their chosen programmes, allowing parents to provide supervision to their young child while at the same time having the opportunity to view the TV or video content they prefer (Anderson & Hanson, 2010). The child may begin to watch adult-directed TV programming or video that happens to be playing in the same room as them (background TV) and sustain their attention to it if the content is comprehensible to them (Anderson & Hanson, 2010). This explanation is plausible as TV content begins to become comprehensible to children from approximately age two (Anderson & Hanson, 2010), with viewing of both adult- and child-directed content facilitated by the formal features of the programming, e.g., inclusion of child characters, movement and cuts (Schmitt et al., 1999), as well as experience with the medium (Linebarger & Walker, 2005). Few studies have considered the potential effects of media content on children's development (Kostyrka-Allchorne et al., 2017a). However, we found three studies that have identified negative associations between infant and toddlers' exposure to adult-directed programming and developmental outcomes, including behavioural outcomes (Chonchaiya et al., 2015), cognitive outcomes (Barr et al., 2010) and social skills (Jackson, 2018). In light of these findings, parents may wish to limit their child's viewing of TV and video to child-directed content.

We found that having rules restricting screen time was associated with a decrease in screen time at 2 years. This finding is in line with those of Birken et al. (2011) and Xu et al. (2016). At 2 years of age, most children are developing the ability to regulate their own behaviour and comply with rules (Gralinski & Kopp, 1993). Consequently, screen time "rules" for young children can often be somewhat informal, e.g., "no TV in the morning or during meals" (De Decker et al., 2012, p. 80), as parents gradually introduce and enforce their expectations (Gralinski & Kopp, 1993). The formation of time rules, however, reflects a desire on the part of the parents to prevent their child having too much screen time (Hiniker et al., 2016b) and as parents of 2-year-olds are still effectively in control of their children's access to screens (Duch et al., 2013; Knowles et al., 2015), they have the capability to enforce their expectations about screen usage and limit their child's exposure relatively easily, which explains the negative association we found between time rules and 2-year-old children's screen time.

We found that children whose mothers reported that there was always an adult co-viewing TV, DVD or videos with their child had less screen time compared to children who co-viewed less than half the time or never. In families where children can only view TV content with an adult present, the availability of an adult places a constraint on children's screen time that does not exist if children are allowed to view without an adult present. Many mothers of young children (and by extension, fathers) experience time pressures, as they try to juggle many tasks at home and at work (Corkin et al., 2018), which may constrain the amount of time available to commit to co-viewing with their child. Also, as suggested by Barr and colleagues (2010), parents who co-view with their 2-year-olds most likely do so because they believe it is in the best interests of their child and may not particularly enjoy viewing programmes designed for 2-year-olds. Hence there may be a limit to how much child-directed TV content co-viewing adults are willing to watch, which again may place a constraint on TV viewing time for children whose parents always co-view with them.

Alongside parenting media practices, ethnicity was an important predictor of screen time. The child being of Asian ethnicity compared to European ethnicity was found to be associated with increased screen time at 2 years. We also found a marginally significant relationship between child being of Pacific ethnicity and screen time. Although ethnicity and culture do not mean exactly the same thing, past research suggests that there are shared cultural understandings within the main ethnic groups in NZ (Podsiadlowski & Fox, 2011). Kotchick and Forehand's (2002) model depicts the family as embedded within "social structures" (Trommsdorff & Kornadt, 2003), which include ethnic and cultural groups. Culture can be thought of as a set of "customs, beliefs and practices" (Super et al., 2008, p. 139) that are transmitted within cultural groups and help shape group members' understandings of what appropriate parenting entails (Bornstein, 2012; Kotchick & Forehand, 2002; Trommsdorff & Kornadt, 2003). Hence, culture can be a particularly strong predictor of parenting practices (Bornstein, 2012). Cultural considerations can influence the goals and motivations of parents in selecting activities for their children (Trommsdorff & Kornadt, 2003), including use of screen technologies (Lim & Soon, 2010). Hence, we speculate that cultural differences with respect to parenting and parenting goals may in part underlie the ethnic differences in children's screen time found in our sample.

As depicted in Kotchick and Forehand's (2002) model, parent and child characteristics can also influence parenting. This depiction is in line with our significant finding that the child's screen time was higher if they did not regularly attend childcare, and with our marginally significant findings that screen time was higher if children were older or unwell.

We found that not attending childcare regularly was positively associated with screen time at 2 years of age. This family context variable (Kotchick & Forehand, 2002) is likely to impact on family routines and the amount of time available for children to use screens in the home context (Elias & Sulkin, 2019). Parents of young children report that their children enjoy, are entertained by or can relax or calm down when using screen technology (Bentley et al., 2016; Nabi & Krcmar, 2016); additionally, screens can keep children occupied when parents are busy doing other things (Bentley et al., 2016) and many parents perceive screen time to be educational or enriching for their children (Carson et al., 2013; Elias & Sulkin, 2019). Since mothers are typically the primary caregiver (Argyrous & Rahman, 2017), mothers of children who do not attend childcare regularly are likely to spend more time in the presence of their child and consequently have more opportunity to allow their children to engage with screens, irrespective of their rationale for permitting screen use. This may explain the increase in mother-reported screen time for the group of children who do not attend childcare regularly. However, it is important to note that most early childcare providers in NZ allow children access to screens whilst attending their services (Gerritsen et al., 2016), so we cannot necessarily conclude that children who participate in non-parental childcare accrue less daily screen time than children who do not, only that they appear to accrue less screen time in the family setting.

We found that child age had a marginally positive association with children's screen time at 2 years. In Kotchick and Forehand's (2002) model, child characteristics such as age may directly impact on parenting. The impact of child characteristics on parenting decisions may be pertinent here, as at the time our data were collected, the NZ MoH had not yet issued its guidelines on preschool children's screen time, but there was likely some awareness of the American guidelines on screen time for this age group, which advised no screen time for children under 2 years (Council on Communications and Media, 2011). On this basis, some parents of children under 2 years in our sample may have considered them too young to have screen time and therefore provided them with little or no screen time compared to children aged 2 years or more.

Concern about the child's physical health over the previous month also had a marginally positive association with children's screen time at 2 years. Firstly, screen time is an activity that children can engage in fairly easily even when physically ill and confined to bed or home. Hence, screen time may replace some of the activities children might normally participate in when they are well, e.g., physical play. Secondly, being physically unwell can be a distressing experience for a young child, and parents may offer extra screen time because young children often find screen time enjoyable and calming (Bentley et al., 2016; Nabi & Krcmar, 2016). Secondly, parents typically experience increased levels of stress when faced with the illness of a child (Pinquart, 2018; Woolf et al., 2016), and as noted by Lampard et al. (2012), when parents are facing stressful situations that place extra demands on their psychological resources, "restricting screen time may be a low priority" (p. 529). An adjustment in media parenting practices when a child is unwell and parents are experiencing increased levels of stress is in line with Kotchick and Forehand's (2002) model, which identifies physical characteristics of the child and parents' psychological resources as factors likely to impact on parenting. Our study is the first study to examine the association between children's health concerns and screen time for 2-year-old children and we believe it provides an illustration of how families might adjust their expectations of how much screen time is appropriate according to the needs of their child.

### *2.7.1 Strengths and Limitations*

Our comprehensive measure of screen time captured both passive and active use of screens (Sweetser et al., 2012) and encompassed the range of screen media available at the time of the 2-year DCW. This is a strength because research that is tied to specific types of screen media can quickly become obsolete as new platforms emerge (Troseth et al., 2016).

Our research re-examined a large number of the variables addressed by previous research into the predictors of screen time at 2 years, and the wider parenting research. Four of our significant findings were in accord with the findings of previous studies: screen time rules (Birken et al., 2011) and non-parental childcare (Carson & Kuzik, 2017; Elias & Sulkin, 2019) were negatively associated with screen time, and ethnicity (non-European) (Carson & Kuzik, 2017; Duch et al., 2013) and child viewing adult-directed content (Elias & Sulkin, 2019) were positively associated. We also found a marginally significant association with one variable whose association with screen time had not been investigated by the previous research, specifically, child health concerns over the last month. Therefore, our study has built on and extended previous research by identifying eight factors that are associated with the total amount of screen time that 2-year-old children have on a weekday, inclusive of different screen technologies, as well as identifying one association not previously investigated.

Our results are based on a large sample of 2-year-old children (> 3,000) obtained from a large, ethnically diverse birth cohort in NZ (GUiNZ), whose mothers reported on their screen use on the last weekday, and whose mothers and fathers both participated in the 2-year DCW. Hence our findings are based on a NZ population and may not generalise to societies with a different ethnic make-up.

We consider the inclusion of data from both mother and father of the child to be a strength of our study as this meets a need for a greater focus on the role fathers play in parenting (Bornstein, 2016). Mothers and fathers in different families apportion child-rearing responsibilities in different ways, and each parent makes a distinct contribution to the development of their child (Bornstein, 2016; Ryan et al., 2006).

A limitation of our study is that our sample is biased towards families with two caregivers, as only 0.4% ($n$ = 15) of mothers in our sample of 3,720 did not have a partner at the time of the 2-year DCW compared to 9.9% ($n$ = 615) of all mothers ($N$ = 6,242) who participated in the 2-year DCW. We note that 2-year-old children whose mothers were sole parents appeared to accrue more screen time on the last weekday ($M$ = 1.67 hr, $SD$ = 1.69) compared to the children included in our sample ($M$ = 1.20 hr, $SD$ = 1.31). Hence there may be factors at play that lead sole parents of 2-year-olds to provide more screen time to their children, compared to parents who have the support of a partner. Therefore our findings may not be generalisable to families where mothers are parenting alone. A further limitation is that fathers did not report on children's screen media use. Failing to incorporate data from fathers may introduce error into estimates of children's screen time, particularly in cases where the father is the primary caregiver or responsible for managing children's screen time.

The cross-sectional, correlational design of the present study means that it is not possible to identify causality. We also acknowledge that our questions about screen time asked about usage and viewing on the last weekday, not on a typical day; therefore the total screen time of some children may have been atypical. A further limitation is that the predictors of screen time identified in our study may relate only to screen time accrued in the family context and may not be predictive of children's screen time in other contexts, such as childcare settings.

As with any study that gathers information primarily by self-report, there is the danger that respondents may provide socially desirable responses (Nederhof, 1985), and it is possible that this may have affected mothers' report of how much time their child spent engaging with screens. However, participants in GUiNZ have committed to participating for up to 21 years, and as such are likely to appreciate the valuable contribution that a longitudinal study can make to research. This commitment may motivate participants to make sure that the information they provide is accurate.

### *2.7.2 Implications for Practice*

Four of the six variables found to be significantly associated with screen time in the current study are readily modifiable, as parents have control over the TV environment the child experiences in the home, how frequently they co-view with their child, and whether or not they set time restrictions on their child's viewing of TV, DVD and videos or allow them to view adult-directed content. All of these parenting practices could be targeted either individually or collectively in the interests of reducing total screen time for children at age two. This information is likely to be helpful for parents, doctors, nurses, other health professionals and policy makers as it may raise awareness of the changes parents or caregivers could make to reduce their 2-year-old children's total screen time.

### *2.7.3 Recommendations for Future Research*

The current study has investigated and identified correlates of a comprehensive screen time measure for children during early childhood. An appropriate next research step would be to conduct a study investigating the correlates of total screen time for children during the later preschool years, for children aged between 3 and 5 years. A further avenue could be to investigate associations between child, parent, family and societal factors manifesting during early childhood and total screen time levels in the later preschool years.

## 2.8 Conclusions

Our results show that on average, 2-year-old NZ children spend 1.20 hr using screens on a weekday. Twelve percent of children in our sample accrued particularly high levels of screen time, between 3 and 10 hr on a weekday. Despite their young age, the majority of the children also engaged in screen time unsupervised at least some of the time. Using Poisson regression, we identified the predictors of screen time for 2-year-old children using a comprehensive measure of screen time. Several specific, modifiable parenting practices were found to be significantly associated with children’s higher use of screen time. As low levels of screen use are recommended for very young children, this information may be useful to parents seeking guidance on how to reduce their 2-year-old children’s screen time.

The following research article is the author's copy of a manuscript submitted for review in *Social Science Research*.

Corkin, M. T., Peterson, E. R., Henderson, A. M. E., Waldie, K. E., Reese, E., & Morton, S. M. B. (under review). Examining the association between mothers' life logistics and screen time of children aged 4–5 years old.

# Chapter 3. Examining the Association between Mothers' Life Logistics and Screen Time of Children Aged 4–5 Years Old (Study 2)

The recent and rapid proliferation of newer screen technologies such as tablets and smartphones has dramatically changed the screen media landscape to which young children are exposed (Troseth et al., 2016), and presents an opportunity to re-appraise the predictors of screen time for preschool children. We identified 18 studies that investigated the predictors of screen time for 4- and 5-year-old children since 2010, which is the year that the iPad was introduced (Papadakis et al., 2019) (refer to Table 3.1). Variables related to parenting practices, beliefs or attitudes emerged as important predictors of screen time for children aged four to five, with approximately half of the significant findings (53%) falling into these categories. This is not surprising because, for children this age, parents are in control of how much screen time their children are exposed to (Barr et al., 2019), and screen time can therefore be viewed as a parenting behaviour (Ansari & Crosnoe, 2016; Nathanson & Manohar, 2012).

**Table 3.1**

*Significant Associations with Screen Time for Children Aged 4–5 Years, as Reported by 18 Studies Subsequent to the Introduction of the iPad in 2010, with Significant Findings Classified into Parent Behaviours, Child Characteristics, Socio-Contextual and Demographic Variables*

| Category of correlate | Study | Significant associations with screen time | |
|---|---|---|---|
| | | Positive | Negative |
| Parenting Behaviour | Carson & Janssen (2012)<br>Downing et al. (2017) (boys)<br>Goncalves et al. (2018)<br>Hinkley et al. (2013)<br>Jago et al. (2013)<br>E. Y. Lee et al. (2021)<br>Xu et al. (2016) (mother's antenatal screen time) | Parental (own screen viewing) habits (higher use) | |
| | Carson & Janssen (2012)<br>E. Y. Lee et al. (2021) | Allowing child TV/screen media in their bedroom | |
| | Downing et al. (2017) | | Having screen time rules |
| | Hinkley et al. (2013) | Mother encouraging child to be active (boys) | |
| | Hinkley et al. (2013) | Provision of more quiet play | |
| | K. S. Khan et al. (2017) | | Parent reading to child |

| Category of correlate | Study | Significant associations with screen time | |
|---|---|---|---|
| | | Positive | Negative |
| | Xu et al. (2016) | Child' screen time at 1 year | |
| Parental beliefs or attitudes | Campbell et al. (2010)<br>Carson & Janssen (2012)<br>Downing et al. (2017)<br>Goncalves et al. (2018)<br>Hinkley et al. (2013) (boys)<br>Jago et al. (2013)<br>E. Y. Lee et al. (2021)<br>Smith et al. (2010) | | Parental self-efficacy to limit screen use and/or promote physical activity |
| | Carson & Janssen (2012) | Parental descriptive norms/ attitudes/beliefs about digital media (positive) | |
| | Carson & Janssen (2012)<br>Smith et al. (2010) | Parental perception of greater number of barriers to child's physical activity | |
| | Downing et al. (2017)<br>Hinkley et al. (2013) | Parental concerns about screen use and physical activity (girls) | |
| | Downing et al. (2017) | | Parents reporting they get bored watching their children play (boys) |
| | Hinkley et al. (2013) | | Parental belief that their child's level of screen use won't affect their health (girls) |

| Category of correlate | Study | Significant associations with screen time | |
|---|---|---|---|
| | | Positive | Negative |
| | Hinkley et al. (2013) | Parents preferring child to do the same activities as their older children (girls) | |
| | E. Y. Lee et al. (2021) | Expects negative outcomes in limiting screen time | |
| Parent characteristics | Ansari & Crosnoe (2016) | More depressive symptoms | |
| Child characteristics | Ansari & Crosnoe (2016) | Hyperactive behaviours moderated by less optimal parental mental health, lower SES and child being female | |
| | Ebenegger et al. (2012)<br>C. J. Miller et al. (2007) | Hyperactivity/inattention | |
| | Berglind & Tynelius (2018) | Gender (boys) | |
| | Downing et al. (2017)<br>Hinkley et al. (2013) | | Child's sleep duration (boys) |
| | Downing et al. (2017)<br>Hinkley et al. (2013) | Child prefers screens to active play | |
| | Smith et al. (2010) | Child age | |
| | Suglia et al. (2013) | Obesity (boys) | |
| Family factors | Jago et al. (2013) | Number of pieces of media equipment available in the home | |
| | Hinkley et al. (2013) (boys) | | Child's attendance at childcare |

| Category of correlate | Study | Significant associations with screen time | |
|---|---|---|---|
| | | Positive | Negative |
| | Gottfried & Le (2017) | | |
| | Tandon et al. (2011) | | |
| Demographic variables | Ansari & Crosnoe (2016) | Low SES | |
| | Carson & Janssen (2012) | | Higher family income |
| | Smith et al. (2010) | | |
| | Carson & Janssen (2012) | | Higher parental education |
| | Smith et al. (2010) | | |
| | Downing et al. (2017) | Higher paternal education (Year 12/trade/diploma compared to Year 10 or equivalent) | |
| Socio-contextual variables | Berglind & Tynelius (2018) | Weekends compared to weekdays | |
| | Carson et al. (2010) | Low SES neighbourhood compared to high (girls) | |
| | Downing et al. (2017) | Mother born overseas (not Australia) (girls) | |
| | Hinkley et al. (2013) | | |
| | E. Y. Lee et al. (2021) | Ethnicity (Canadian compared to Korean) | |
| | Hinkley et al. (2013) | Living on a cul de sac (boys) | |
| | E. Y. Lee et al. (2021) | | Neighbourhood safety |

Recognising that mothers are typically the main caregiver for preschool children (Argyrous & Rahman, 2017), Beyens and Eggermont (2017) were the first researchers to take a family systems approach to investigate the role of mothers' "life logistics" in determining preschool children's screen time. This analysis involved extending beyond maternal behaviour and characteristics situated in the context of the home to consider how mothers' life circumstances, specifically, their work hours, might impact on the decision to allow their children to watch TV. Although previous evidence linking mothers' work hours to children's screen time has been unclear (Cillero & Jago, 2010), like Vaala and Hornik (2014), Beyens and Eggermont speculated that this may have resulted from a lack of theory underpinning this relationship. Their review of the literature suggested that the path from mothers' working hours to children's screen time might be mediated by mothers' perceived parenting time pressure and mothers' wellbeing.

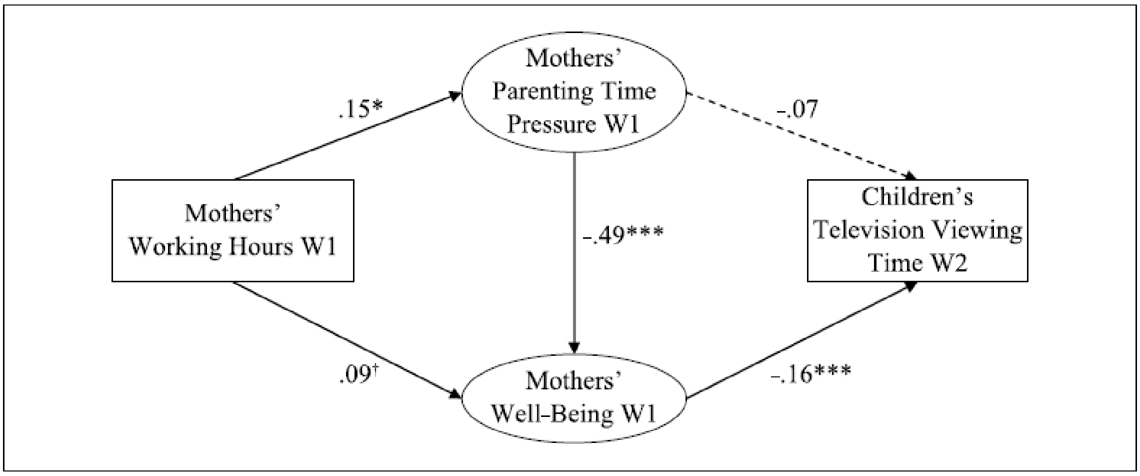
According to Beyens and Eggermont (2017), support for this theory was provided by two distinct groups of studies. The first group suggested that higher work hours would be positively associated with parenting time pressure, which in turn would be negatively associated with wellbeing (e.g., Eby et al., 2005; Greenhaus & Beutell, 1985; Roxburgh, 2006; 2012; van der Lippe, 2007). Thus, as children of mothers with lower wellbeing tend to watch more TV (D. A. Thompson & Christakis, 2007), higher work hours would indirectly be associated with increased screen time. However, Beyens and Eggermont also reviewed evidence linking mothers' hours of work to *increased* levels of wellbeing (e.g., Moen et al., 1995), and identified a second set of studies suggesting that hours of work would be associated with a decrease in children's screen time, due to the negative relationship between maternal wellbeing and children's screen time (e.g., Bank et al., 2012; D. A. Thompson & Christakis, 2007).

To conduct their study, Beyens and Eggermont (2017) employed a sample of 404 one- to four-year-old children ($M$ = 2.15 years, $SD$ = 0.78) and their mothers who were recruited from randomly selected kindergartens and daycare centres throughout Belgium. Data were collected at two time points, 6 months apart. Structural equation modelling (SEM) was used to test the Observed Life Logistics Model, testing the relationship between children's TV viewing time and mothers' working hours (mediated by mothers' wellbeing and mothers' parenting time pressure) (see Figure 3.1). Two extensions of the life logistics model were also tested, comprised of the same variables as the life logistics model but including: 1) mothers' own TV viewing times; and 2) mothers' attitudes towards TV (i.e., viewing TV as educational for children).

The results of Beyens and Eggermont's (2017) Observed Life Logistics Model supported an indirect longitudinal relationship between mothers' hours of work and children's hours of TV viewing, with maternal wellbeing and time pressure mediating this relationship (refer to Figure 3.1). This life logistics model explained 52% of the variance in children's TV viewing. Their findings also suggested that the mechanism underlying the relationship between mothers' work hours and children's TV time may be determined by two different processes. Firstly, hours of employment had a marginally positive effect on maternal wellbeing, which was negatively associated with children's time watching TV. Secondly, although there was no direct statistically significant relationship between mothers' parenting time pressure and children's TV viewing time, mothers' working hours were positively associated with mothers' parenting time pressure, which was negatively associated with maternal wellbeing. Therefore, in terms of the relationship between mothers' work hours and children's TV time, the model suggests that increased TV time is likely to occur only when there is conflict between mothers' family demands and work demands (Beyens & Eggermont, 2017).

**Figure 3.1**

*Results of Structural Equation Modelling of the "Observed Life Logistics Model" of the Determinants of Screen Time in Preschool Children*

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There is evidence that the screen time of preschool children aged 4–5 years is predicted by parents' own screen time (Carson & Janssen, 2012; Downing et al., 2017; Hinkley et al., 2010; Jago et al., 2013; Xu et al., 2016), and parenting attitudes, such as the perception of children's screen use as positive, e.g., "good for his/her brain" (Carson & Janssen, 2012, p. 3) or not harmful to their health (Hinkley et al., 2013). In Beyens and Eggermont's (2017) study, parenting attitudes were measured by a 3-item scale ascertaining the extent to which parents believed TV benefits children's learning, e.g., "Do you think that watching television is beneficial for children's education?" (p. 700). However, when parents' screen time and attitudes were included separately Beyens and Eggermont's life logistics model, neither were found to be statistically significant, and their inclusion did not explain any further variance in the model. These results suggest that mothers' life logistics have likely confounded previous significant findings linking children's screen time with mothers' attitudes and screen time (Beyens & Eggermont, 2017) and that Beyens and Eggermont may have identified the mechanism linking three important predictors of children's screen time (maternal work hours, parenting time pressure and wellbeing) across two different ecological contexts, i.e., the home and mother's workplace. Beyens and Eggermont's model may represent an important step forward in clarifying which factors lead parents to provide screen time to their children and the mechanism by which this occurs.

However, the variables identified in Beyens and Eggermont's study are not necessarily exhaustive of all predictors of children's screen time: there are likely to be other child and parenting characteristics, family and socio-contextual variables that are also associated with the parenting practice of allowing 4- to 5-year-old children to engage with screens. We have conducted an earlier study investigating the predictors of screen time for children aged 2 years, which used a sample from the Growing Up in New Zealand (GUiNZ) study. This study yielded six significant predictors and two marginally significant predictors of children's screen time at age two (Corkin et al., 2021). These include four media parenting behaviour variables, two of which had a negative association with screen time (co-viewing with the child, and having rules restricting child's use of TV, DVD or video), and two that had positive associations (allowing child to view adult-directed content, and providing children with a moderate to high (1.01–5.99 hr) or heavy (≥ 6 hr) TV environment compared to a low TV environment (≤ 1 hr)). We found that one family context variable (child not attending regular childcare) and one socio-contextual variable (being of Asian ethnicity) had significant positive associations with screen time at 2 years, and two child variables (concern about the child's physical health over the previous month and child age) had marginally significant associations with screen time.

Although mothers' attitudes to TV and their own TV viewing time were not found to be significant in Beyens and Eggermont's (2017) life logistics model, media parenting behaviours such as those investigated in our previous study may be predictive of screen time for preschool children because these behaviours relate directly to the management of children's screen time and create a home media environment that either supports or hinders children's access to screens. There is evidence that other media parenting behaviours may also be associated with preschool children's screen time at 54 months, i.e., reading to the child on a daily basis is negatively associated (K. S. Khan et al., 2017) and allowing children to eat meals in front of TV is positively associated (Birken et al., 2011; Jago et al., 2008; Saelens et al., 2002) with screen time. Children who eat meals in front of TV are likely to have more opportunities to accrue TV screen time compared to children who are not allowed to have the TV on while they eat, while the reduction in screen time for children who are read to daily may be due to the process of "displacement", whereby an increase in one activity reduces the time available for another activity (Christakis, 2009). However, these connections arguably have wider implications, in terms of contributing to the media environment the child experiences in the home, the screen-related behaviours that the child sees modelled, and the routines related to media-usage that are established even from an early age (Birken et al., 2011; Jago et al., 2008).

As noted, in addition to parenting media practices, we found that children attending childcare regularly was negatively associated with screen time at 2 years of age in our previous research. This relationship appears to hold for older preschool children, as three of the studies we reviewed for the current study (i.e., Gottfried & Le, 2017; Hinkley et al., 2013; Tandon et al., 2011) identified a negative relationship between childcare attendance and screen time for children aged 4 to 5 years. Childcare attendance may be relevant to the Observed Life Logistics Model as it may play a role in helping working mothers to balance the demands of work and home life.

We also found that parental concerns about their child's health over the last month had marginally positive associations with screen time at 2 years, which we believe is a novel finding with regard to the correlates of screen time. Parental concerns about their child's health are likely to be positively related to screen time throughout the preschool years, not just for 2-year-old children. Children who are unwell often cannot participate in their normal activities, which may lead their parents to allow them to use screens more than usual to keep them occupied and calm (Elias & Sulkin, 2019). In addition, there is support in the literature for an association between preschool children's attention problems and screen time (e.g., Ansari & Crosnoe, 2016; Ebenegger et al., 2012).

The aim of the present study was to enhance our understanding of the predictors of screen time during the preschool years by building on and extending the work of Beyens and Eggermont (2017). Our measure of screen time included time spent watching television programming on any device as well as time spent completing any other activity on a screen-based device, including newer technologies such as iPads, tablets and smartphones. These measures were combined to produce a measure of Total screen time. Use of this outcome variable allowed us to test whether Beyens and Eggermont's (2017) Observed Life Logistics Model, which has predicted TV viewing for children aged 1 to 4 years, also applies to a comprehensive measure of screen time for preschool children aged 4 to 5 years. Included in the model were significant predictors of screen time identified in our previous study for children at age two (Corkin et al., 2021), provided they are available in the GUiNZ datasets for the cohort at age 54 months, and three other variables suggested by past research, i.e., allowing meals in front of TV, reading to the child on a daily basis, and inattention/hyperactivity of the child. In addition, we assessed whether there is a direct relationship between mothers' work hours and children's hours of screen time.

## 3.1 Method

### *3.1.1 Participants*

GUiNZ is a longitudinal birth cohort study that antenatally recruited 6,822 mothers whose babies were due between April 2009 and March 2010 (Morton et al., 2013). Our sample included children who participated in the 54-month data collection wave (DCW) (*N*

= 6,156), whose mothers responded to questions about how many hours their child spends engaging with screens on a usual weekday, i.e., by watching television programming including free-to-air, online, and pay TV or DVDs (either on TV or other media), and using electronic media e.g., computer or laptop (including children's computer systems such as Leapfrog, iPads, tablets, smartphones and any electronic gaming devices). In the case of twins and triplets, one child from each family was randomly selected and included in our analyses to avoid dependent observations, reducing the sample to 6,074. Due to missing data, our final sample size was 5,362, comprising 88% of our sample.

The GUiNZ cohort is broadly representative of preschool children in the New Zealand (NZ) population, in terms of ethnicity and SES (Morton et al., 2015). Our measure of SES is the NZDep2013 index, which is based on measures of deprivation obtained from the NZ national census conducted in 2013 that are linked to residential areas (Atkinson et al., 2014). The index is divided into deciles, with decile 1 representing residential areas with the lowest levels of deprivation and decile 10 representing areas with the greatest level of deprivation. In the current sample, 31% of families lived in areas of low deprivation (deciles 1–3); 36% lived in areas of medium deprivation (deciles 4–7) and 33% lived in areas of high deprivation (deciles 8–10). The NZDep2013 occurs contemporaneously with mothers' life logistics in the current study, thus reflecting the level of deprivation that mothers were experiencing at the time they reported their work hours and children's screen time. The mean age of children in our sample was 4.54 years (*SD* = 0.13) and 50% of children were identified as being of NZ European ethnicity, 13% Māori, 13% Pacific Peoples, 12% Asian, 10% New Zealander, and 1% MELAA (Middle Eastern, Latin American or African) or other ethnicity. Fifty-two percent of the children were male and 48% of the children were female. The average age of mothers in our sample was 34.98 years (*SD* = 5.82). Ninety percent of mothers had a partner at the time of the 54-month DCW and 10% did not. In terms of education, 6% of mothers had not achieved a school qualification, 23% had achieved a school qualification (NCEA[2] levels 1–4); 30% had a diploma or trade certificate (NCEA levels 5–6), 24% had a bachelor's degree and 17% had a higher degree.

### *3.1.2 Procedure*

The majority of data for the current study were obtained during a 90-min face-to-face computer assisted personal interview (CAPI) administered by trained interviewers to mothers when their children were aged approximately 54 months old. A small amount of data were collected from mothers at other time points. Information on maternal education was collected during the antenatal CAPI and one variable related to children's screen media exposure (allowing meals in front of TV) was collected during the 45-month computer assisted telephone interview (see Table 3.2).

[2] NCEA = National Certificate of Educational Achievement, earned as part of the national education system in New Zealand.

**Table 3.2**

*Full Table of Measures Prepared for Use in SEM for Investigating the Role of Mothers' Life Logistics in Children's Screen Time and the Determinants of Screen Time for Children Aged Four to Five Years*

| Construct | Brief description and administration period | Scale and preparation |
|---|---|---|
| Parenting Behaviour | | |
| Allows meals in front of TV | Single item: How often is the TV on in the same room when your child is eating a meal? Administered in the 45-month DCW. | Mothers rated frequency as 1 (always), 2 (almost always), 3 (sometimes) and 4 (Almost never), or 5 (never). Responses 1–3 were combined and labelled 'Allows meals in front of TV'; responses 4 and 5 were combined and labelled 'Never/almost never allows meals in front of TV' (1). |
| Mother reading stories to child daily | Single item: How often do you read books with {NAME}? Administered to mothers in the 54-month DCW. | Response scale of 1 (seldom or never), 2 (once a week), 3 (several times a week), 4 (once a day) and 5 (several times a day). Responses 1–3 were combined and labelled 'Less than daily' (1) and responses 4–5 were combined and labelled 'At least daily'. |
| Time rules | In your household are there rules for your {CHILD/CHILDREN} about the amount of computer, TV, or DVD time they are allowed? Administered in the 54-month DCW. | Mothers responded Yes or No (1). |
| TV environment of the child | Single item: Thinking about a usual weekday, approximately how many hours does {NAME} spend at home with the TV on in same room as {NAME}, whether or not {HE/SHE} was watching it? Administered in the 54-month DCW. | Mothers reported time as 0 (None) or 2 (total hours and minutes). Responses of "None" were assigned scores of 0 hr, in combination with the total hour scores of children exposed to TV (both foreground and background). Scores >12 were identified as outliers and winsorised down to 12. |
| Maternal characteristics | | |
| Poor maternal wellbeing | Patient Health Questionnaire-9 (Spitzer et al., 1999), a 9-item tool for identifying measuring the severity of symptoms of depression (Cronbach's $\alpha = .811$). Sample item: "Over the LAST TWO WEEKS, how often have you been bothered by the following problems?: Feeling tired or having little energy." Administered in the 54-month DCW. | Mothers responded 1 (Not at all); 2 (Several days); 3 (More than half the days); 4 (Nearly every day). Total score of items in the scale was calculated for GLM Poisson regression and used as a latent variable in Mplus SEM. For the purpose of reporting on prevalence of poorer maternal wellbeing in Table 3.3, scores 10 and above were coded 1 (depressed) and scores below 10 were coded 1 (not depressed) |

| Construct | Brief description and administration period | Scale and preparation |
|---|---|---|
| | | (National Collaborating Centre for Mental Health (UK), 2010). Used as a latent variable in Mplus SEM. |
| Maternal education | Single item indicating the highest level of education reached by the mother of the study child: "Looking at the showcard, what is your highest completed secondary school qualification?" Administered to mothers in the antenatal DCW. | Education qualifications in ascending order: 'No secondary school qualification', 'Secondary school/NCEA L1–4', 'Diploma/trade cert NCEA L5–6', 'Bachelor's Degree', and 'Higher degree'. Due to low cell count, 'No secondary school qualification' was combined with 'Secondary school/NCEA L1–4' to make 'School qualifications or less'. This variable was dummy coded to produce 'Diploma/trade cert NCEA L5–6', 'Bachelor's Degree', and 'Higher degree' with 'School qualifications or less' as the reference group. |
| Child Characteristics | | |
| Child age | Derived variable. Child's age on day of mother's 54-month CAPI. | The difference between child's birth date (administered in the 6-week CATI) and the date of the mother's interview in the 54-month DCW. |
| Child health | Single item: "In general how would you say {NAME}'s current health is?" Administered to mothers in the 54-month DCW. | Response options ranged from 1 (Excellent); 2 (Very good); 3 (Good); 4 (Fair); 5 (Poor). Responses 1–3 were combined and labelled 'Healthy'. Responses 4–5 were combined and labelled 'Fair or poor health' (1). |
| Hyperactivity/inattention | A 5-item sub-scale (Cronbach's $\alpha$ = .718) of the Strength and Difficulties Questionnaire (Goodman, 1997), measuring children's behavioural difficulties related to hyperactivity/inattention over the last six months. Based on parental report. Sample item: "Constantly fidgeting or squirming." Administered to mothers in the 54-month DCW. | Responses ranged from 0 (not true), 1 (somewhat true) or 2 (certainly true). A 'Hyperactivity/inattention' score was obtained by calculating the mean of the five items in the subscale for use in GLM Poisson regression and used as a latent variable in Mplus SEM. For the purpose of reporting frequencies in Table 3.3, we used the established cut points of $\leq 5$ for within the normal range, 6 for borderline and 7–10 for scores in the abnormal range, i.e., indicative of problematic levels of inattention/hyperactivity (Goodman et al., 1998). Mean score of items in the scale was calculated for GLM Poisson regression; used as a latent variable in Mplus SEM. |
| Family Context | | |
| Regular childcare | Single item: "Over the past year {has your CHILD/have your CHILDREN} been looked after at regular times during the week by anyone other than you?" Parents were advised: "DO include regular care by neighbours and/or grandparents. DO NOT include casual or occasional babysitting. DO NOT include care by a non-resident parent or the {CHILD/CHILDREN}'s other parent. DO | Mothers responded No (1) or Yes. |

| Construct | Brief description and administration period | Scale and preparation |
|---|---|---|
| | include early childhood centres. Administered in the 54-month DCW." | |
| Mothers' work hours | Mothers were asked: "Including overtime, how many hours a week do you usually work in all your jobs?" Administered in the 54-month DCW. | Mothers who worked provided an average number of hours worked per week. Mothers who did not work were assigned a score of zero hours. |
| Work-family strain | A 3-item scale extracted from 8 items from Marshall and Barnett's (1993) Work-Family Strains and Gains scale (Cronbach's α = .708). Sample item: "Please could you tell me how much you agree or disagree with the following statements?: Because of the requirements of my job I miss out on home or family activities I would prefer to participate in" (Marshall & Barnett, 1993). Administered to mothers in the 54-month DCW. | A maximum likelihood factor analysis with direct oblimin rotation was conducted on the 8 items taken from the Work-Family Strains and Gains scales by Marshall and Barnett (1993). Note that the original scale utilised a 4-point Likert scale while our scale had a 7-point scale ranging from 1 = Strongly disagree to 7 = Strongly agree. Two factors had eigenvalues over 1 and together explained 45% of the variance. The scree plot also appeared to show two inflexions, so two factors were retained. Conceptually, Factor 1 represented Work-Family Gains and Factor 2, which was used in the current study, represented Work-Family Strains. Factor 2 explained 24% of the variance with factor loadings from .547 to .775. Used as a latent variable in Mplus SEM. |
| Social context | | |
| Deprivation group | The New Zealand Deprivation Index is based on nine different socioeconomic variables in the 2013 New Zealand census, which are combined to describe the deprivation level of a small geographical area. Decile 1 describes the area of greatest deprivation and Decile 10 indicates the least deprivation. | NZ Deprivation Index (Atkinson et al., 2014). Deprivation is represented by ten deciles, with 1 signifying an area of least deprivation and 10 signifying an area of greatest deprivation. |
| Ethnicity | Derived variable. Single item: "Which is the MAIN ethnic group that {NAME} identifies with?" Administered to mothers in the 54-month DCW. | Response options included 32 different ethnicities and 'Other Ethnicity (Please specify)', which were then upcoded by the GUiNZ study team to the following categories: 1 (European) (1), 2 (Māori), 3 (Pacific), 4 (Asian), 5 (MELAA) and 6 (Other) and 8 (New Zealander). MELAA, Other and New Zealander were combined due to low frequencies. This variable was dummy coded to produce Māori, Pacific, Asian and MELAA/NZ/Other variables, with European as the reference group. |

### *3.1.3 Measures*

**3.1.3.1 Outcome Variable.** During their 54-month CAPI, mothers were asked two questions: “Thinking about a usual week day, approximately how many hours does {NAME} spend at home…watching television programming including free-to-air, online, and pay TV or DVDs either on TV or other media?”; and 2) “using electronic media e.g., computer or laptop, including children’s computer systems such as Leapfrog, iPads, tablets, smartphones and any electronic gaming devices?” Mothers responded with “None” if their child had not used these media, or gave an amount of time in hours if their child had used these media. Children whose mothers responded “none” for either question were assigned a score of zero hours for the relevant question. The time scores of the two questions were summated to form a total screen time score, which was subsequently employed as our outcome measure. The combination of time spent viewing TV, using other electronic media and playing games on an electronic device has been employed in previous research to form a total screen time score, e.g., Birken et al. (2011); Cliff et al. (2018); Xu et al. (2016). Our screen time outcome measure was comprised of count data, i.e., number of hours of screen time, beginning at zero. Accordingly, cases in which mothers had reported fractions of hours for their child’s screen time were rounded to the nearest integer, as required for analysing count variables. Decimal numbers .5 and above were rounded up, while decimal numbers below .5 were rounded down. In line with our previous research, we identified 10 hr as an upper limit of time that preschool children are likely to spend engaging with screens in a 24-hr period. As a result, 29 values > 10 hr were identified as outliers and winsorised down to 10.

**3.1.3.2 Predictor Variables.** First, we endeavoured to match as closely as possible the three variables included in Beyens and Eggermont’s (2017) Life Logistics Model that were found to be predictive of children’s screen time. These included mothers’ hours of work, maternal wellbeing and parenting time pressure. Like Beyens and Eggermont, we had available a measure of mothers' hours of work, i.e., the number of hours employed mothers usually worked per week in all their jobs. We matched Beyens and Eggermont's variable 'parenting time pressure' with a 'work-family strain' scale extracted using factor analysis from the Work-Family Strains and Gains scales by Marshall and Barnett (1993) (refer to Table 3.2 for more information on this procedure). 'Work-family strain' measures the extent to which the demands of work impact negatively on time spent in the family environment (Alexander & Baxter, 2005), e.g., "Work leaves me with too little time [or energy] to be the kind of parent I want to be" (Marshall & Barnett, 1993, p. 278). By comparison, Beyens and Eggermont's 'parenting time pressure' scale was based on Roxburgh's (2006) 3-item scale; sample item: "You often feel rushed when you're with your children" (p. 534). We measured maternal wellbeing with the Patient Health Questionnaire-9 (PHQ-9; Spitzer et al., 1999). This scale effectively measures a reduction in or lack of wellbeing, i.e., symptoms of depression, which we have termed "poorer maternal wellbeing". Our measure of poor maternal wellbeing is comparable to the measure of wellbeing employed by Beyens and Eggermont, i.e., the Mental Health Inventory-5, which is a psychiatric screening tool for mental health disorders (MHI-5; Berwick et al., 1991), rather than a measure of wellbeing per se.

Seven other variables were included in our model. These included child factors, i.e., the child's health over the last month, inattention/hyperactivity of the child, and child attending regular childcare or not; and media parenting practices, i.e., having household rules about the amount of time children can spend using TV, DVD or computers, level of exposure of child to background and foreground TV, allowing the child to eat meals in front of the TV, and reading to the child on a daily basis. Predictor variables that occurred concurrently with children's screen time were used wherever possible, so that identification of significant findings related to modifiable predictor variables would potentially provide parents who wish to reduce their children's current screen time with a means to do so.

We controlled for maternal education, age of the child, parent-reported child ethnicity and SES. Categorical variables were dummy coded, and continuous variables except for control variables were centred. Refer to Table 3.2 for a full description of all variables employed in the present study.

### *3.1.4 Analyses*

#### 3.1.4.1 Preliminary Analyses.

***3.1.4.1.1 Analysis of Associations Between Predictor Variables.*** To rule out multicollinearity, we conducted Pearson correlations to test the strength of association among our predictor variables and found that all significant associations were $r_p \leq .40$.

***3.1.4.1.2 Missing Data Analysis.*** A missing data analysis was conducted and we found very low levels of missing data on predictor variables, at 3% or below. The exception was our measure of SES, i.e., the New Zealand Deprivation Index (NZdep2013; Atkinson et al., 2014) with 5.6% missing data. This data is not missing due to non-response by participants and in nearly all cases is due to mothers residing in a country other than NZ at the time of their 54-month interview. A small proportion of missing data on this variable may also be due to some "meshblocks" (or geographical areas) not being assigned deprivation indices for technical reasons (Atkinson et al., 2014).

***3.1.4.1.3 Descriptive Analyses.*** Descriptive analyses were conducted on the predictor variables included in our model. Refer to Table 3.3.

**Table 3.3**

*Frequencies, Means and Standard Deviations of Variables included in SEM Model Testing the Predictors of Screen Time at 54 Months*

| | *M* (*SD*) | *n* (%) |
|---|---|---|
| Total screen time (hr/day) | 2.20 (1.62) | |
| Total exposure to TV (background and foreground) hr/day | 2.14 (2.14) | |
| Mother's hours of work (hr/week) | 19.71 (18.55) | |
| Mother's work-family strain | 3.72 (1.42) | |
| Above the median | | 2,210 (37%) |
| At or below the median | | 3,701 (63%) |
| Mother's depressive symptoms on the PHQ-9 | 3.56 (3.82) | |
| Not depressed | | 5,483 (92%) |
| Elevated depressive symptoms | | 494 (8%) |
| Allowing meals in front of TV | | |
| Never/almost never allows meals in front of tv | | 2,745 (47%) |
| Allows meals in front of TV | | 3,145 (53%) |
| Having rules about amount of TV/DVD or computer time | | |
| Yes | | 4,126 (69%) |
| No | | 1,885 (31%) |
| Child attending regular childcare | | |
| Yes | | 5,812 (97%) |
| No | | 201 (3%) |
| Child health | | |
| Good health | | 5,919 (97%) |
| Fair or poor health | | 152 (3%) |
| Mother reading to child | | |
| At least once a day | | 3,592 (59%) |
| Less than once a day | | 2,473 (41%) |
| Child's inattention/hyperactivity | 3.92 (2.26%) | |
| Normal range | | 4,666 (77%) |
| Borderline | | 611 (10%) |
| Abnormal range | | 797 (13%) |

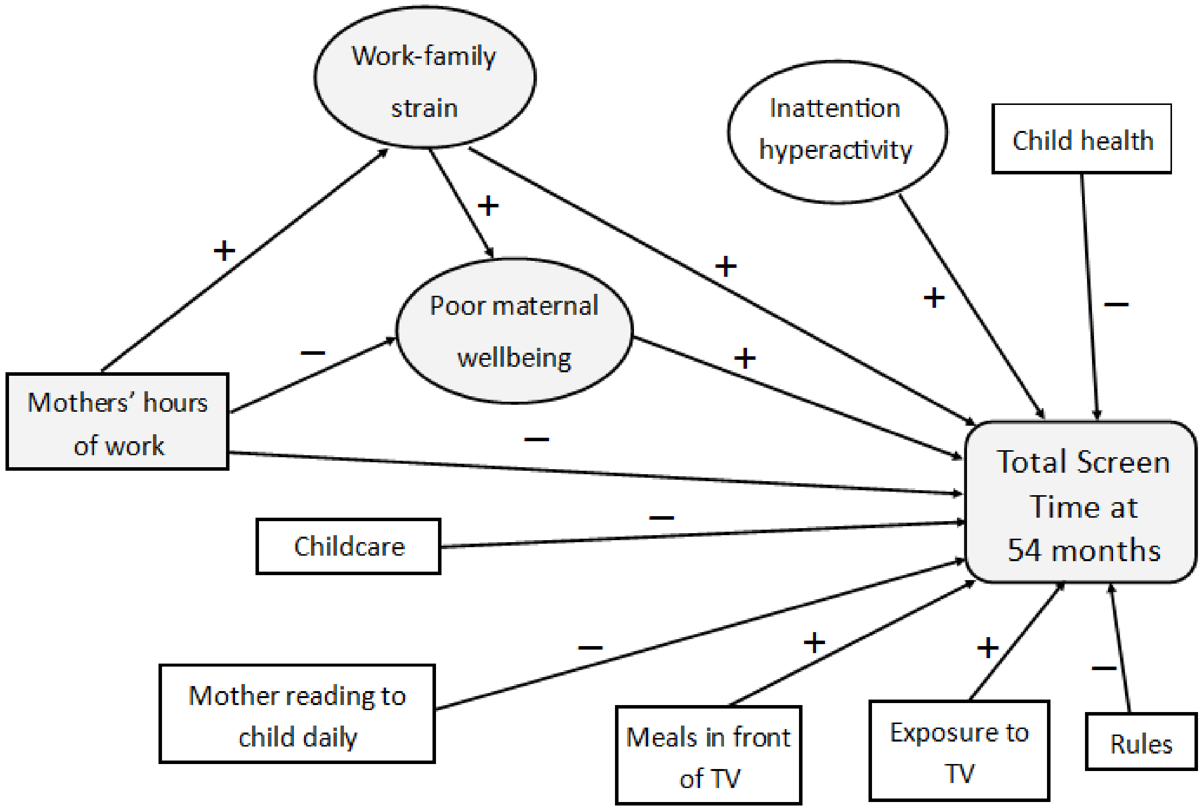
### 3.1.4.2 Main Analyses.

***3.1.4.2.1 Structural Equation Modelling in Mplus.*** As our screen time data is count data (i.e., number of hours of exposure), we used Mplus version 8.1 to conduct SEM treated with Poisson regression to test our model. Our model incorporated the Life Logistics Model created by Beyens and Eggermont (2017), variables we found to be predictive of screen time for children in this cohort at age two, and the variables inattention/hyperactivity, allowing child to eat meals in front of TV and mother reading to child on a daily basis. We also tested an additional direct path, i.e., the effect of mothers' work hours on screen time. (Refer to Figure 3.2 for the proposed model.) As the variance of our screen time outcome variable was higher than the mean (2.63 compared to 2.20), we suspected over-dispersion of the data and commenced our first analysis in Mplus using SEM treated with Negative Binomial regression; however, the results estimated the dispersion parameter at zero, which meant that using Mplus treated with Poisson regression was appropriate (Muthén & Muthén, 1998 - 2017).

We first ran the complete model as shown in Figure 3.2, identified variables that were not related to screen time, then made adjustments to the model by removing these variables sequentially in order of highest *p*-value (described below). We compared alternative models using change in AIC (Burnham & Anderson, 2002). When the model was finalised, we re-ran it in Mplus to obtain the incident rate ratios (IRRs), which are similar to odds ratios, and provide an indication of effect size.

**Figure 3.2**

*Modified "Observed Life Logistics Model" of the Determinants of Screen Time in Preschool Children*




Adapted with permission from "Understanding Children's Television Exposure from a Life Logistics Perspective: A Longitudinal Study of the Association Between Mothers' Working Hours and Young Children's Television Time," by I. Beyens and S. Eggermont, 2017, *Communication Research*, *62*(1), SAGE Publications, Inc., p. 703. Copyright 2017 by the Authors. Rectangles represent observed variables and ovals represent latent variables. + means a positive relationship is expected; – means a negative relationship is expected. Variables corresponding to those included in the "Observed Life Logistics Model" (Beyens & Eggermont, 2017) are shaded grey.

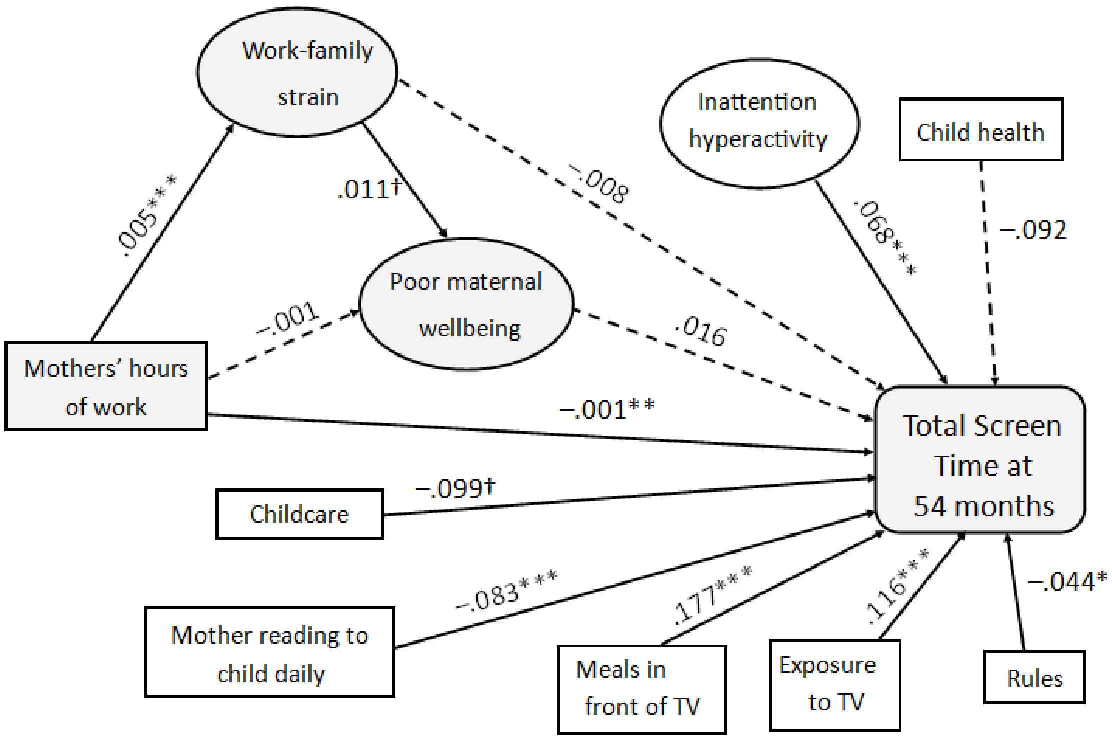
***3.1.4.2.2 GLM Poisson Regression in SPSS.*** As goodness of fit statistics are not available when conducting analyses with a count outcome in Mplus, we re-ran our final model using GLM Poisson regression in SPSS version 24, as a check that the overall model was significant and for confirmation of significant findings. As the ratios of the deviance to degrees of freedom (Value/DF) for the model in SPSS (Value/*DF* = 0.706) showed signs of under-dispersion, we used the robust estimator (Cameron & Trivedi, 2013). Note that the robust estimator was also employed in Mplus as the default estimator for count data (Muthén & Muthén, 1998 - 2017).

## 3.2 Results

Our analysis of the modified "Observed Life Logistics Model" (Beyens & Eggermont, 2017) showed that the observed life logistics component of the overall model was not significant. While mothers' hours of work were related to work-family strain and screen time at 54 months, neither poor maternal wellbeing nor work-family strain were related to children's screen time. Instead, mothers' hours of work were directly related to children's screen time and work-family strain, and work family strain had a marginally significant positive relationship with poor maternal well-being. AIC of the model was 199,317.91 (refer to Figure 3.3).

**Figure 3.3**

*Results of SEM Analysis of a Modified "Observed Life Logistics Model" of the Determinants of Screen Time in Preschool Children, Using Mplus Treated with Poisson Regression*

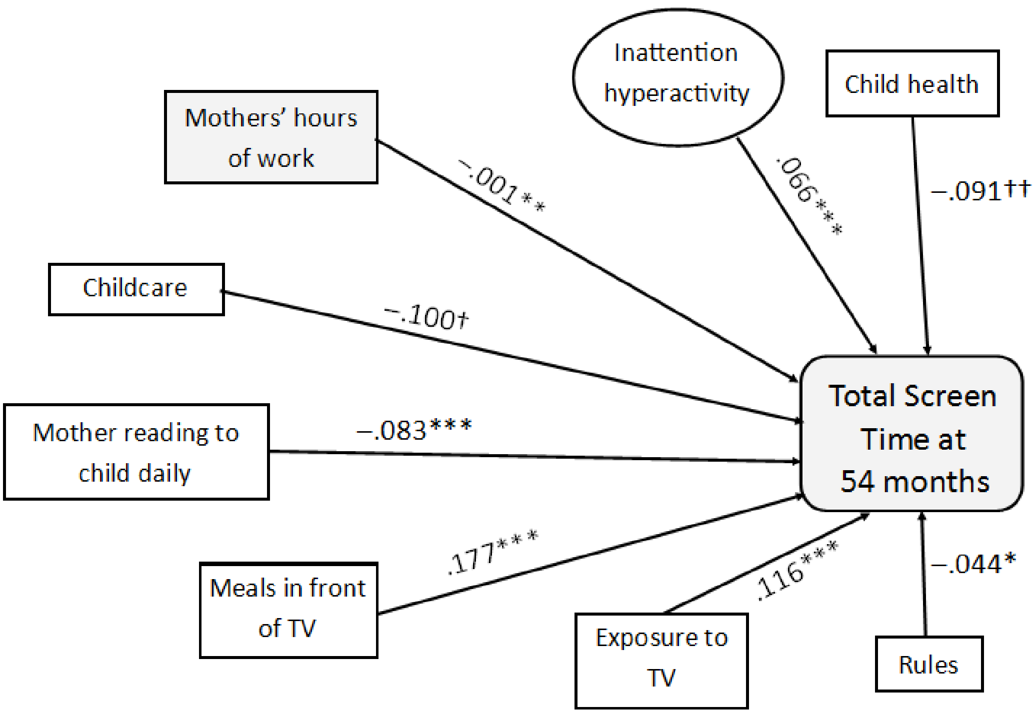



Adapted with permission from "Understanding Children's Television Exposure from a Life Logistics Perspective: A Longitudinal Study of the Association Between Mothers' Working Hours and Young Children's Television Time," by I. Beyens and S. Eggermont, 2017, *Communication Research*, *62*(1), SAGE Publications, Inc., p. 703. Solid lines represent significant pathways and broken lines represent non-significant pathways. Model adjusted for maternal education, age of the child, child ethnicity and SES. Variables corresponding to those included in the "Observed Life Logistics Model" (Beyens & Eggermont, 2017) are shaded grey. Coefficients are unstandardised. †$p < .1$, *$p < .05$, **$p < .01$, ***$p < .001$.

To improve the model, we followed a step-wise procedure of removing variables that were not significantly related to screen time, in order of size of their *p*-value. Hence the variable poor maternal wellbeing ($b$ = .190, $p$ = .508) was removed first, which reduced the AIC to 124,233.94, without affecting the significance of other variables. Next we ran the model without work-family strain, as the path from work-family strain to children's screen time remained statistically non-significant ($b$ = -.077, $p$ = .333), and now had the highest *p*-value. This reduced the AIC of the model considerably to 64,729.86 (see Figure 3.4). Finally, we re-ran the model without child health, which had remained consistently non-significant in all analyses. However, as the exclusion of child health increased the AIC to 64,744.26, the model shown in Figure 3.4 was retained as the final model.

**Figure 3.4**

*Final Results of SEM Analysis of Modified "Life Logistics Model" of the Determinants of Screen Time in Preschool Children, Using Mplus SEM Treated with Poisson Regression*




Adapted with permission from "Understanding Children's Television Exposure from a Life Logistics Perspective: A Longitudinal Study of the Association Between Mothers' Working Hours and Young Children's Television Time," by I. Beyens and S. Eggermont, 2017, *Communication Research*, *62*(1), SAGE Publications, Inc., p. 703. Model adjusted for maternal education, age of the child, child ethnicity and SES. Variables corresponding to those included in the "Observed Life Logistics Model" (Beyens & Eggermont, 2017) are shaded grey. Coefficients are unstandardised. ††$p$ < .15, †$p$ < .1, *$p$ < .05, **$p$ <.01, ***$p$ < .001.

Three variables were associated with higher levels of screen time on a weekday. Children who were allowed to eat meals in front of TV had on average 19% more screen time than children who did not eat TV meals in front of TV (IRR = 1.19, 95% CI [1.15, 1.24]). For every hour that children were exposed to TV on a weekday (background and foreground), screen time increased by 12% (IRR = 1.12, 95% CI [1.11, 1.13]). Symptoms of Inattention/hyperactivity increased screen time by 7% (IRR = 1.07, 95% CI [1.03, 1.10]).

Four variables were associated with lower screen time. Children whose mothers read to them daily had on average 8% less screen time than children whose mothers read to less frequently (IRR = 0.92, 95% CI [0.89, 0.95]). Children who had rules about the amount of time they could spend using TV, DVD or computers had 5% less screen time than children without rules (IRR = 0.95, 95% CI [0.92, 0.99]). 'Child attending regular childcare' was only marginally significant but this result suggests that children who attend childcare may have 9% less screen time than children who do not attend childcare (IRR = .91, 95% CI [0.80, 1.01]). The effect of mothers' work hours on children's screen time was significant but negligible (IRR = .999, 95% CI [.998, 1.00]). Child health was not significant.

Ethnicity, which was used as a control variable, was also associated with screen time at 54 months. Children of Māori ($b$ = .137, $p$ < .001), Asian ($b$ = .205, $p$ < .001) and Pacific ($b$ = .153, $p$ < .001) ethnicities tended to have higher screen time compared to children of European ethnicity. Ethnicity was in fact the strongest predictor of screen time, as children of Asian ethnicity had, on average, 23% more screen time than European children (IRR = 1.23, 95% CI [1.16, 1.29]). Children of Pacific (IRR = 1.16, 95% CI [1.10, 1.23]) or Māori ethnicity (IRR = 1.14, 95% CI [1.09, 1.20]) had 16% and 14% more screen time than European children respectively.

Using GLM Poisson regression in SPSS, we re-ran our final model, as depicted in Figure 3.4. This was to test whether the final model was significant, as this information is not available when conducting SEM treated with Poisson in Mplus. The model was significant (Likelihood Ratio $\chi^2$ (17) = 1,967.28, $p$ <.001) and the results were a very close match to those obtained in Mplus (see Table 3.4). There was some variation in the results for Inattention/hyperactivity, which may be attributable to the use of a latent variable in Mplus and a factor score in SPSS.

**Table 3.4**

*Results of GLM Poisson Regression Using Robust Errors Investigating the Factors that are Associated with Screen Time for Children Aged 54 months, Testing Predictors Identified in a Final Model Obtained Using Structural Equation Modelling Treated with Poisson Regression, AIC = 16,753.95*

| Variable | (Likelihood ratio $\chi^2$ (17) = 1,967.28, $p$ < .001) | | | | | |
|---|---|---|---|---|---|---|
| | Tests of model effects | | | Parameter estimates | | |
| | Wald $\chi^2$ | *df* | *p*-value | IRR (95% CI) | B (*SE*) | *p*-value |
| Intercept | 1.00 | 1 | .318 | | | |
| Mother's work hours | 8.31 | 1 | .004 | 0.999(0.998-.1.00) | -.001(.001) | .004 |
| Attending regular childcare | 3.01 | 1 | .083 | 0.90(0.81-1.01) | -.10(.06) | .083 |
| Level of TV exposure | 667.86 | 1 | <.001 | 1.12(1.11-1.13) | .12(.01) | <.001 |
| Rules about TV/DVD or computer time | 5.60 | 1 | .018 | 0.96(0.92-0.99) | -.04(.02) | .018 |
| Allows TV meals | 99.27 | 1 | <.001 | 1.19(1.15-1.24) | .18(.02) | <.001 |
| Hyperactivity/inattention | 12.46 | 1 | <.001 | 1.01(1.006-1.02) | .01(.004) | <.001 |
| Child health | 2.27 | 1 | .132 | 0.91(0.81-1.03) | -.09(.06) | .132 |
| Mother reads books to child on daily basis | 20.78 | 1 | <.001 | 0.92(0.89-0.95) | -.08(.02) | <.001 |

*Note*. Regression adjusted for Maternal Education, Age of the Child, Child Ethnicity, SES. IRR = Incident Rate Ratio; Coeff = Coefficient; SE= Standard Error.

## 3.3 Discussion

We tested a modified version of the Observed Life Logistics Model of the determinants of screen time for preschool children (Beyens & Eggermont, 2017) (refer to Figure 3.2) and found that the observed life logistics component of our model did not contribute to children's screen time at 54 months. Two screen media parenting variables that were associated with screen time in our previous study at age two (Corkin et al., 2021) were associated with screen time in the current study, i.e., level of child's daily exposure to TV (background and foreground), and having rules restricting screen time. The media parenting practices of allowing meals in front of TV and mother reading to their child on a daily basis were also associated with children's screen time, as was the child characteristic of inattention/hyperactivity. Attending childcare was only marginally significant.

Although we found a significant negative relationship between mothers' working hours and children's screen time, the effect size was negligible and may have been detected only because of our very large sample size. The effect size is so small that our finding essentially aligns with Beyens and Eggermont's (2017) finding that mothers' work hours had no direct effect on children's screen time.

Unlike Beyens and Eggermont (2017), we found that maternal wellbeing was not directly related to children's screen time, and did not mediate the relationship between work hours and screen time. Additionally, unlike Beyens and Eggermont, we did not find that maternal wellbeing mediated an indirect relationship between work-family strain (our measure of parenting time pressure) and screen time. However, in keeping with the results of Beyens and Eggermont, the results of our first model (see Figure 3.3) did indicate that mothers' work hours were positively associated with work-family strain, and there was a marginally significant positive relationship between work-family strain and poorer maternal wellbeing. These findings suggest that mothers who work longer hours are experiencing time-based work-family conflict, whereby time expended at work leads to a reduction in time available for parenting (Greenhaus & Beutell, 1985). This can create stress for mothers and impact on their wellbeing as they strive to perform the parenting role with less time to fit in everything they need to do (Greenhaus & Beutell, 1985). However, our results indicate that mothers who are experiencing greater work-family strain or poorer wellbeing are no more likely to expose their children to screen time than mothers not experiencing these difficulties. One possible explanation for this finding is that mothers experience intense societal pressure to excel in their role of mother, even when it puts a strain on them personally (Green, 2015), and this may deter them from giving their child extra screen time to get some reprieve from their parenting duties. Indeed, work-family strain arguably results from mothers' efforts to provide high quality care to their child and their family in the limited time they have available (Greenhaus & Beutell, 1985). This may explain why the number of hours that mothers worked was positively associated with work-family strain in our first model, but work-family strain did not in turn increase the time children spent occupied by screens (refer to Figure 3.3).

In line with previous research, we found that three screen media parenting practices were associated with screen time at 54 months, i.e., setting restrictive rules about screen time (Corkin et al., 2021; Vandewater et al., 2005b; Xu et al., 2016) was negatively related; while level of child's exposure to TV (background and foreground) (Corkin et al., 2021; Vandewater et al., 2005a) and allowing meals in front of TV (Birken et al., 2011; Saelens et al., 2002) were both positively associated.

We found that providing children with high levels of exposure to TV (background and foreground) and allowing meals in front of TV increases screen time. One explanation for these findings is simply that having TV playing in these contexts may add to overall screen time (Saelens et al., 2002; Vandewater et al., 2005a). However, another explanation is that these practices may arise from a more permissive home media environment that puts fewer controls on children's screen time (Saelens et al., 2002). This may afford children with more opportunities for screen use, including other screen media, thus leading to an increase in children's overall screen time. There is support for this mechanism as Vandewater et al. (2005a) found that children exposed to higher levels of background TV had increased levels of use of other types of screen media as well.

It is not surprising that having rules is associated with a reduction in the amount of screen time, as young children have little autonomy over how they spend their time (Huston et al., 1999), and screen media parenting practices such as these place structural limitations on children's access to screen technology (Knowles et al., 2015). Thus in most cases, providing they are enforced, having restrictive rules should result in children having less time to engage with screens.

In line with the previous finding of K. S. Khan et al. (2017), we found that reading to preschool-aged children on a daily basis had a negative association with screen time. Although somewhat confounded by the availability of digital story books, participation in parent-child reading activity would generally prevent children from using screens, i.e., it would displace screen time (Clarke & Kurtz-Costes, 1997). Our finding of a marginally negative association between attending childcare and screen time at age four is also supported by past research (i.e., Gottfried & Le, 2017; Hinkley et al., 2013; Tandon et al., 2011), including our own earlier study examining this relationship for children at age two. This association is most likely also due to displacement, as time spent at childcare diminishes the amount of time available to use screens in the home context.

Children had higher levels of screen time if their mothers reported them to have higher levels of inattention/hyperactivity. The majority of research in this field has also found this association (see for e.g., Acevedo-Polakovich et al., 2007; Ansari & Crosnoe, 2016; Cheng et al., 2010; Ebenegger et al., 2012; C. J. Miller et al., 2007). Although there is evidence that parents of more active children may use screen time to help calm down their child (A. L. Thompson et al., 2013), it is unlikely that a "babysitting" scenario is responsible for the increase in screen time we observed, as research shows that parents of children experiencing difficulties with inattention/hyperactivity are in fact more likely to co-view with their child than are other parents (Acevedo-Polakovich et al., 2007). Instead, as children with symptoms of inattention/hyperactivity often experience difficulties with social interactions, they may be attracted to watching TV (or having other screen time) as a pastime more so than their peers (Acevedo-Polakovich et al., 2007). Further, screen media such as video games may sustain the interest of children with inattention/hyperactivity (compared to activities such as reading books) because these media typically incorporate salient formal features, e.g., bright lights and sounds, that may help to focus attention (Arnsten, 2009; Gentile et al, 2012).

Ethnicity was employed as a control variable in the current study but, interestingly, with reference to the IRRs, was the strongest predictor of screen time overall. Ethnicity and culture are not completely synonymous; nevertheless, cultural differences within and across ethnic groups are known to have a powerful influence on parenting (Bornstein, 2012; Super et al., 2008). There are many different reasons why parents might let their children use screens (Elias & Sulkin, 2019) and of course, in today's media environment, many different ways in which children can use screens. Although in the current study we have no information about parents' motivations for allowing their children to use screens, our finding that children of Asian, Māori and Pacific ethnicity had significantly higher screen time than European children suggests that differences in cultural values and beliefs about parenting may play a part in the choices parents make around their children's screen use (Jarvenpaa & Lang, 2005; Trommsdorff & Kornadt, 2003).

As mothers' life logistics, as depicted in Beyens and Eggermont (2017), were not found to be associated with children's screen time in the current study, here we suggest some possible explanations for the divergence of our findings from this previous work.

Firstly, Beyens and Eggermont's (2017) model focused on TV viewing, which is usually passive screen time, while our screen time measure included children's use of any screen-based device and encompassed both passive (viewing content) and active screen time (i.e., doing something or creating something using a screen based device) (Sweetser et al., 2012). With regard to Beyens and Eggermont's finding that the children of mothers with poorer wellbeing viewed more TV, it is possible that mothers in this situation may be more inclined to encourage *passive* screen time, perhaps because preschool children can watch screen content independently, whereas use of screen devices for activities other than viewing TV or video can place more demands on parents to scaffold children's use (Archer, 2017).

Another methodological difference between the two studies is that we looked at the concurrent relationship between mothers' life logistics and children's screen time whereas Beyens and Eggermont (2017) took a longitudinal approach. Their longitudinal approach established temporal precedence for mothers' life logistics (Kline, 2011) and demonstrated that mothers' life logistics predict children's screen time (TV viewing) and not the other way around (Beyens & Eggermont, 2017). With Beyens and Eggermont's study having established the direction of this relationship, our study enabled us to then explore whether the positives or negatives of a mother's current work situation and its effects on maternal wellbeing and work-life balance may impact on the child's screen time contemporaneously. Essentially, we were able to explore whether mothers whose structural life circumstances are negatively related to their current well-being or work-life balance might provide their children with more screen time, for instance, as a way to cope with poorer well-being (D. A. Thompson & Christakis, 2007) or to free up more time for themselves  e.g., Bentley et al., 2016; de Decker et al., 2012). While both approaches have merit, this methodological difference may have contributed to the differences between the findings of our two studies.

Differences in the characteristics of our samples may also have contributed to the differences in our findings. Beyens and Eggermont (2017) report that 99% of mothers in their sample were White, and representative of "homogeneous White Belgian society" (p. 698). In contrast, our sample was diverse in terms of both ethnicity and SES. Beyens and Eggermont have themselves highlighted the need for their model to be tested in populations that are more diverse in terms of ethnicity and social background. It is therefore possible that this model may be applicable to a specific group of mothers, i.e., White mothers in Belgium, but not necessarily applicable to all mothers and in all cultural contexts.

### *3.3.1 Strengths and Limitations*

A strength of our study is that we used a comprehensive measure of screen time that captures preschool children's passive and active use of screen media (Sweetser et al., 2012) and encapsulates the range of screen devices that preschool children engage with in today's media environment, such as tablets and smartphones. Therefore our study extends the findings of previous work in this field, which has focused predominantly on TV viewing.

A further strength of our study is the large sample size and the diversity of our sample, in terms of ethnicity and SES, which is representative of preschool children in the NZ population (Morton et al., 2015). Therefore, our findings may be broadly applicable to the screen time of children in other Western societies.

In contrast to Beyens and Eggermont's (2017) model, we found that poorer maternal wellbeing did not mediate a relationship between work-family strain and screen time. While it is established that work-family strain can impact negatively on wellbeing (Brough & O'Driscoll, 2005), it is possible that our measure of wellbeing, i.e., symptoms of depression, did not fully capture the aspects of wellbeing that might be affected when work-family strain is high. For instance, it may be that increases in work-family strain are associated with decreases in mothers' subjective evaluations of their satisfaction in the domains of work or family life specifically (Diener et al., 2003), which then might impact on the amount of screen time that children are exposed to. However, it is worth noting that our measure of wellbeing, i.e., the PHQ-9 (Spitzer et al., 1999), is similar to that employed by Beyens and Eggermont, i.e., the MHI-5 (Berwick et al., 1991), as they are both screening tools for mental health disorders.

Beyens and Eggermont's (2017) screen time measure differs from ours by their inclusion of children's weekend screen time in mothers' report of children's total TV viewing time across the week. In contrast, as previously noted, mothers in our study reported the average amount of time in hours that children spent watching or using a range of different screen-based devices on a usual weekday. Therefore a potential limitation of our study is that our findings might be related only to children's screen time during the week but not on weekends.

Finally, in studies such as GUiNZ, a large proportion of information is obtained by participant report, which can be prone to social desirability bias (Nederhof, 1985). However, in each DCW, GUiNZ highlights the scientific importance of gaining accurate information about a diverse range of children growing up in NZ and the valuable role each participant plays in this, which may go some way towards preventing this bias from occurring.

### *3.3.2 Implications for Practice*

Our findings suggest a range of screen media parenting practices that could be modified to bring about a reduction in preschool children's screen time. This information could be communicated to parents by health professionals who support families with young children.

## 3.4 Conclusion

In summary, we did not find the model of mothers' "Observed Life Logistics" (Beyens & Eggermont, 2017) to be predictive of children's screen time at 54 months. Instead, we identified three screen media parenting practices that may impact on children's access to screens at 54 months, i.e., having rules restricting screen time, total TV exposure provided to the child on a weekday and allowing meals in front of TV. In addition, the media parenting practice of reading to the child regularly was also found to be negatively associated with children's screen time. Our findings concur with those of Vandewater et al.

(2007), who identified family media variables as particularly important predictors of media exposure for young children. Parenting practices may have a particularly strong impact on preschool children's screen time because parents are effectively the "gatekeepers" of screen technologies for their children during the preschool years (Knowles et al., 2015, p. 460).

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Please see:

Corkin, M. T., Peterson, E. R., Henderson, A. M. E., Waldie, K. E., Reese, E., & Morton, S. M. B. (2021). Preschool screen media exposure, executive functions and symptoms of inattention/hyperactivity. *Journal of Applied Developmental Psychology*, *43*, 1–16. https://doi.org/10.1016/j.appdev.2020.101237

# Chapter 4. Preschool Screen Media Exposure, Executive Functions and Symptoms of Inattention/Hyperactivity (Study 3)

Digital media now feature prominently in family life (McDaniel & Coyne, 2016), and even preschool-aged family members are availed of access to a wide range of digital technologies, including interactive and touch-screen devices (Neumann, 2015). Although the evidence is considered to be inconclusive (Conners-Burrow et al., 2011; Fietzer & Chin, 2017), childhood exposure to screen media, typically television (TV), has been linked to disadvantageous effects on executive functions (EFs), attention and symptoms of Attention Deficit Hyperactivity Disorder (ADHD; e.g., Acevedo-Polakovich et al., 2007; Huber et al., 2018; Nathanson et al., 2014; Schmiedeler et al., 2014). As newer screen technologies grow in popularity amongst preschool children, and greater quantities of child-directed media products are being produced specifically for this age group (Wartella et al., 2005; Zosh et al., 2017), concerns about potential risks of screen time are no longer limited to TV viewing but now extend to newer screen technologies (Haughton et al., 2015). However, to date, very little is known about the possible effects of newer technologies on EFs and attention (Huber et al., 2018) or rather, about the effects of the amalgam of different screen media that preschool children of today typically experience (Rideout, 2013, 2017). This highlights the need for further research in this rapidly evolving area.

The preschool years are a period of increased neural plasticity (Conway & Stifter, 2012; Kolb & Fantie, 2009; Zelazo & Carlson, 2012) during which EFs, including executive attention, develop rapidly (Best et al., 2009; Courage, 2017; Horowitz-Kraus et al., 2016; Ruff & Rothbart, 1996). As such, this crucial period of early childhood development is arguably the best place to start for investigating whether exposure to screen media affects these essential functions (Best et al., 2009; Conway & Stifter, 2012).

## 4.1 Attention

Attention, a specific component of EFs (Fisher & Kloos, 2016) is a complex construct that is difficult to fully define (Courage, 2017; Fisher & Kloos, 2016). However, it has been conceptualized as being comprised of three sub-functions: 1) alerting, or sensitivity to external stimuli, 2) orienting, which entails focusing on a target stimulus, and 3) executive attention, the ability to purposefully disengage and shift awareness to a new stimulus as the situation demands (Nigg, 2017; Posner & Rothbart, 2007; Ruff & Rothbart, 1996). The stimulus-driven orienting function is believed to underpin sustained attention during infancy, with executive attention gradually taking over from the end of the first year of life due to maturation of the prefrontal cortex (PFC). From this point, children begin to a) be able to set goals, and b) develop the ability to maintain attention towards non-novel stimuli, in line with their goals (Ruff & Rothbart, 1996).

Based on epidemiological data, around 2.4% of preschool children may be affected by ADHD (Danielson et al., 2016), which is a disorder characterised by high levels of inattention, hyperactivity and impulsiveness (American Psychiatric Association, 2013). Attention is believed to play a pivotal role in supporting cognitive development (Rothbart et al., 2011), and children with Attention Deficit Hyperactivity Disorder (ADHD) are at greater risk of significant academic and social difficulties compared to their peers (American Psychiatric Association, 2013). Our review of the literature, investigating the relationship between screen time and attention or symptoms of ADHD, found 21 studies on this topic that included results for children aged up to 6 years. Although the majority of these studies ($n$ = 16) reported positive associations between screen time (predominantly TV viewing) and attention difficulties or symptoms of ADHD, five studies found no association (i.e., Foster & Watkins, 2010; Obel et al., 2004; Parkes et al., 2013; Stevens & Mulsow, 2006; Sugawara et al., 2015). Foster and Watkins (2010) found that TV viewing was associated with attention deficits only for children exposed to very high levels of TV viewing per day, i.e., seven hours or more, which suggests children who are not exposed to excessive levels of screen time will not be at risk of developing attention deficits as a result.

Of the 21 studies we reviewed investigating the association between attention and screen media exposure, only two (Cliff et al., 2018; Tamana et al., 2019) used a comprehensive measure of screen time that reflects the range of screen devices currently available. Only three used measures of media exposure other than screen *time*. Zimmerman and Christakis (2007) included a measure of media content but not screen time; Conners-Burrow et al. (2011) included measures of both media content and screen time, and Acevedo-Polakovich et al. (2007) included measures of media content, co-viewing and screen time; the remaining 18 studies focused exclusively on screen time as their measure of screen exposure.

Zimmerman and Christakis (2007) found that there was a significant positive relationship between viewing of non-educational content (TV) before the age of three and later attentional problems (as measured by the Hyperactive subscale of the Behavior Problems Index – parent report), while Conners-Burrow et al. (2011) found that for children with a mean age of 61 months there was a positive relationship between viewing PG-13 or R-rated content and teacher reported scores on the Hyperactive Behavior Subscale of the Achenbach System of Empirically-Based Assessment. Interestingly, they also found that there was no relationship between hyperactivity and TV viewing time, which is in line with Kostyrka-Allchorne et al.'s (2017a) assertion that media content may predict developmental outcomes better than screen time. Finally, Acevedo-Polakovich et al. (2007) found that children aged 4–9 years old who had been diagnosed with ADHD spent more time watching TV and co-viewing with an adult, compared to those without an ADHD diagnosis. With regard to content, Acevedo-Polakovich et al. found that the type of programming viewed varied by age rather than by diagnosis of ADHD. Together these studies highlight the need for researchers to consider both qualitative and quantitative aspects of screen media in their analyses, in order to gain a better understanding of the mechanisms that might underpin relationships between screen exposure and attention deficits (Kostyrka-Allchorne et al., 2017a).

Age of the child is also likely to play a role in any effects of screen exposure on attentional difficulties. From birth to two years the human brain experiences a period of rapid synaptic proliferation (Kolb & Fantie, 2009), which may result in increased susceptibility to environmental influences such as exposure to screen media (Christakis, 2009). From 2–7 years, the executive attention network undergoes substantial development, facilitating goal-directed deployment of attention (Rueda et al., 2004; Rueda et al., 2005). However, exactly how any associations between screen exposure and attentional difficulties might vary across the preschool years remains unclear. Studies conducted by Christakis et al. (2004) and Zimmerman and Christakis (2007) suggest that only TV viewing that occurs before the age of 3 years is predictive of later attentional problems, whereas Mistry et al., (2007) found that if children aged between 30 and 33 months viewed more than two hours of TV per day, but then reduced their viewing to below two hours by the age of five, there was no association between TV viewing and attention deficits at age five; only sustained exposure of two hours or more at both time points was associated with an increase in attention problems. Further research is therefore needed to determine whether screen exposure at different ages during the preschool years is differentially related to preschool children's attention problems and symptoms of ADHD.

## 4.2 Executive Functions

EFs encapsulate a set of top-down cognitive processes (Nigg, 2017; Zelazo et al., 2005) that depend on cortical networks primarily located in the PFC (E. K. Miller & Cohen, 2001) and allow individuals to plan and carry out volitional goal directed behaviour (Best et al., 2009; Lezak et al., 2004). Of these, working memory, inhibition and set shifting are considered to be core EFs (Miyake et al., 2000). Research suggests that working memory and inhibition develop during infancy and improve progressively throughout the preschool years (Diamond & Taylor, 1996) and form a base for the later development of more complex EFs (Diamond, 2006).

An important distinction is the categorisation of EFs as “hot” or “cool” (Zelazo et al., 2005). Hot and cool EFs both involve top-down goal-directed responses (Meuwissen & Zelazo, 2014), but hot EFs are elicited in contexts that invoke affect and emotion, e.g., in situations where there is the possibility of receiving a punishment or reward, whereas cool EFs are affectively neutral (Zelazo et al., 2005). Hot EFs are particularly associated with the development of social competence during the preschool years (Di Norcia et al., 2015; Kim et al., 2013). Conversely, cool EFs, which are viewed as being primarily cognitive (Zelazo et al., 2005), are associated with intellectual development (Hongwanishkul et al., 2005) and academic achievement (Brock et al., 2009; Kim et al., 2013).

In preschool aged children, cool EFs are often measured by conflict tasks (e.g., when the child has to keep a rule in mind and inhibit a prepotent response) (Diamond & Taylor, 1996; E. Peterson & Welsh, 2014). An example is the pencil tapping task (C. J. Golden et al., 1979; Luriia͡, 1973; Luriia͡, 1980), which requires the child to tap once when the experimenter taps twice and vice versa, instead of copying what the experimenter does (Diamond & Taylor, 1996). Hot EFs are typically measured by tasks involving delay of gratification, e.g., inhibiting the prepotent response of obtaining an accessible and immediate reward instead of waiting for an often larger or preferred reward (Diamond & Taylor, 1996; Kim et al., 2013). An example is the Gift Wrap task, in which the experimenter tells the child they are going to receive a gift, but first they must turn around while the experimenter wraps it, and not peek. In this task, the child must inhibit the prepotent response of peeking at the gift before they are told they can look (Kochanska et al., 2000; Mischel & Ebbeson, 1970). A marked improvement in preschool children's performance on both cool EF and hot EF tasks is apparent in the latter preschool years, from approximately the age of three to five (Diamond & Taylor, 1996; Kerr & Zelazo, 2004; Zelazo & Müller, 2011).

We conducted a review of the literature investigating the associations between media exposure and EFs, identifying 14 studies in total. Twelve of these studies addressed some form of exposure to TV or video and each of the studies that focused specifically on TV or video viewing time (Munzer et al., 2018; Nathanson et al., 2014; Radesky et al., 2014b; Ribner et al., 2017) and exposure to background TV (Barr et al., 2010; Linebarger et al., 2014; Munzer et al., 2018; Nathanson et al., 2014) reported a link between higher TV exposure *time* and impaired performance on EFs.

Seven studies in our review examined the relationship between content of media exposure and EFs. EFs were reported to have a) no association with neutral or prosocial content (Friedrich-Cofer, 1979) or child-directed content (Barr et al., 2010); b) positive associations with prosocial content (Friedrich & Stein, 1973), inappropriate content (i.e., entertainment; for "low risk" children), educational programming (moderated by parent warmth and responsiveness for "high risk" children) (Linebarger et al., 2014); and Public Broadcasting Service programming (Nathanson et al., 2014), and c) negative associations with adult-directed content (Barr et al., 2010), aggressive content (Friedrich & Stein, 1973), educational cartoons (Nathanson et al., 2014) and fantastical content (Lillard et al., 2015a; Lillard & Peterson, 2011). In addition, Huber et al. (2018) found that for children aged 2–3 years of age, educational apps were positively associated with both hot EFs and cool EFs compared to cartoons. Three studies have also investigated the relationship between pacing of scene changes in TV programming and EFs. Although Lillard and Peterson (2011) found that exposure to fast-paced fantastical programming was associated with impaired EFs, a later study conducted by Lillard et al. (2015a) suggested that it was the fantastical content of fast-paced children's programming rather than the pace of programming per se that is linked to poorer EFs. This finding is in line with an earlier study conducted by Anderson et al. (1977) which also found no association between fast-paced programming and EFs. Collectively these findings shed some light on how screen media content might differentially impact on EFs compared to screen time.

## 4.3 Potential Correlates of EFs and Attention

Children's neurocognitive systems undergo a period of "heightened neuroplasticity" throughout the preschool years (Conway & Stifter, 2012, p. 1022; Kolb & Fantie, 2009), which may offer a "window of opportunity" for external factors to exert a relatively large influence on the development of EFs, including attention (Conway & Stifter, 2012, p. 1022). Environmental factors, including media exposure (Kostyrka-Allchorne et al., 2017a), parenting and child characteristics, and socio-contextual factors may each have a role to play (Denham et al., 2015; Foster & Watkins, 2010) and therefore the contribution of each should be assessed.

Past research has shown that parental characteristics, including maternal education (Denham et al., 2015), parenting style (Linebarger et al., 2014; Radesky et al., 2015b), and the quality of parent-child interactions (Hughes & Ensor, 2009; Schore, 1996) can influence the development of preschool children's EFs (Bernier et al., 2010). Likewise, the socio-contextual factors of socioeconomic status (SES; Schmiedeler et al., 2014) and culture (Harkness & Super, 1994), and family factors including parental employment (Belsky, 1984) and family stress (Greenhill et al., 2008), have been shown to influence developmental outcomes in children. Child factors have also been associated with EFs and attention, including age and gender (hot EFs positively associated with being female) (Denham et al., 2015), parity (having siblings positively associated with EFs) (McAlister & Peterson, 2013), amount of sleep (Nathanson & Fries, 2014), motor skills (Houwen et al., 2019), and temperament (effortful control positively associated and negative affect negatively associated with cool EFs, i.e., conflict resolution) (Rothbart et al., 2007). Most notably, Hughes and Ensor's (2009) study showed that the child's EFs at age two years and their language ability at age four years explains 48% of the variance in their EFs measured at age four. These findings highlight the importance of controlling for a wide range of individual and contextual factors when investigating the associations of screen exposure with EFs and attention.

### 4.4 The Current Study

The aim of the current study is to determine the associations of preschool children's screen media exposure measured at two time points during the preschool years (2 years and 45 months) with hot EFs, cool EFs, and symptoms of inattention/hyperactivity at 54 months, thereby taking account of the timing of media exposure (Mistry et al., 2007; Sugawara et al., 2015). We also examine the associations of EFs and inattention/hyperactivity at 54 months with different contexts of media exposure at 2 years, i.e., exposure to adult- or child-directed screen media (TV, DVD and video), frequency of parental co-viewing, having rules restricting media exposure (TV, DVD and video), and exposure of the child to TV on a weekday, incorporating both background and foreground TV. In addition, we consider the associations with EFs of allowing the child to eat meals in front of TV at 45 months.

Our research will contribute to the literature by building on previous research that has tended to investigate a single aspect of media exposure, typically TV viewing, as we consider context and content (adult- versus child-directed) of media exposure within the one study. We augment the prevalent focus on TV exposure by using a comprehensive measure of total amount of screen time that is more representative of the media landscape children experience today. It is possible that variables other than screen measures, EFs, and inattention/hyperactivity at age two may be related to hot and cool EFs and inattention/hyperactivity at 54 months; therefore, a range of other factors that might be related to the development of EFs in children are examined. Research in this field has predominantly focused on cognitive, or cool, aspects of EFs, with the construct of hot EFs being identified more recently (Kerr & Zelazo, 2004; Tsermentseli & Poland, 2016); therefore our study makes a valuable contribution to the literature by investigating whether different variables are associated with hot EFs compared to cool EFs.

According to Huston et al., (1999), children's activities such as screen use are "investments of time" (p. 912). However, whether time invested in screen use is associated with positive or negative developmental outcomes is likely to be determined by the content and context of media (e.g., with or without parental involvement), rather than simply the amount of screen time children experience (Barr et al., 2010; Blum-Ross & Livingstone, 2016; Radesky & Christakis, 2016). Therefore, we hypothesise that the content of preschool children's media exposure at age two (i.e., child-directed or adult-directed) and the involvement of parents in their children's media use (i.e., co-viewing) will be stronger predictors of hot EFs, cool EFs, and symptoms of inattention/hyperactivity at 54 months, compared to the *amount* of screen time to which children are exposed.

## 4.5 Method

### *4.5.1 Participants*

Our study employed a sample of children (*N* =4,061) from the Growing Up in New Zealand (GUiNZ) longitudinal birth cohort study who participated in the 54-month data collection wave (DCW) and whose mothers and fathers have both participated in the GUiNZ DCWs. In the case of multiples, only one child per family was included in our sample. Informed consent was obtained for all participants in the study. As we used multiple imputation but employed the non-imputed versions of demographic variables in subsequent regressions, note that our final sample size was 3,787.

Mothers and their partners were invited to participate in the GUiNZ study if their baby was due between April 2009 and March 2010 and if they were living in North Island regions of New Zealand (NZ) covered by the Auckland, Waikato and Counties-Manukau district health boards (DHBs) during their pregnancy. One third of all births in NZ occur within these three DHB regions (Morton et al., 2015). The GUiNZ cohort is broadly representative of children in the wider NZ population, in terms of ethnicity and SES (Morton et al., 2015). However, as with all longitudinal studies there is the possibility of selection bias in that mothers who agreed to take part in the GUiNZ study may differ to those who did not agree. Nevertheless, families in our sample were representative of all SES levels in NZ, as measured by the 2006 NZ Deprivation Index (NZDep2006; Salmond et al., 2007), with 32% of families residing in areas of low deprivation, 40% in areas of medium deprivation, and 29% in areas of high deprivation. At the time of the 2-year DCW, the mean age of mothers was 33.2 years, of fathers was 35.4 years and of children was 2.1 years. The ethnic distribution of children in our sample was 58% European, 10% Māori, 9% Pacific Peoples, 12% Asian, 1% Middle Eastern, Latin American, African (MELAA) and 11% New Zealander. Fifty percent of the children in our sample were male and 50% were female. The majority (76%) of the children's mothers had achieved post-secondary school qualifications: 28% had diplomas or trade certificates; 28% had a bachelor's degree and 20% had a higher degree. The majority (73%) of the children's fathers had also achieved post-secondary school qualifications: 36% had diplomas or trade certificates; 19% had a bachelor's degree and 18% had a higher degree. Twenty percent of mothers and fathers had achieved school qualifications only, while 4% of mothers and 7% of fathers had achieved no qualifications. Ninety-four percent of families lived in urban areas and 6% lived in rural areas.

### *4.5.2 Procedures*

**4.5.2.1 Collection of Data for Outcome Variables.** We examined three outcomes in our study: Inattention/Hyperactivity, Hot EFs and Cool EFs when the children were aged approximately 4.5 years (i.e., 54 months). Data for Inattention/Hyperactivity were obtained by mother report on the Inattention/Hyperactivity subscale of the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) in a computer-assisted personal interview (CAPI) administered by trained interviewers in the 54-month DCW. The data for our outcome variables of cool EFs, i.e., performance on the Luria Hand Clap Task (C. J. Golden et al., 1979; Luriĭa, 1973; Luriĭa, 1980) and hot EFs, i.e., performance on the Gift Wrap Task (Kochanska et al., 2000; Mischel & Ebbeson, 1970), were gathered by the same interviewers during the child observations component of the 54-month DCW, which took place directly after the mother's CAPI was completed.

**4.5.2.2 Collection of Data for the Predictor Variables.** The data for the majority of predictors were collected at the 2-year DCW by mother or father report, in CAPIs administered by trained interviewers. A small proportion of data were collected at other DCWs, primarily for demographic variables, i.e., highest education level of the parents (antenatal DCW), child's gender and parity (6-week DCW), and child's age and ethnicity (54-month DCW). Data for the variable 'Allowing meals in front of TV' was obtained in the 45-month DCW. Measures of children's screen exposure on weekdays were collected by mother-report at two time points: 2 years and 45 months. Paternal personality measures were obtained in the antenatal DCW, and our measures of maternal parenting style were obtained at the 54-month DCW.

### *4.5.3 Measures*

Below we explain the preparation of the three outcome variables used in this study. As noted, all three of these variables are based on data collected when the children were aged 54 months. We also discuss the preparation of two of the predictor variables. Refer to Table 4.1 for information on the preparation of all other predictor variables used in the current study.

**Table 4.1**

*Table of Measures Prepared for Use in Hierarchical Regression Analysis for Investigating Predictors of Hot and Cool Executive Control and Symptoms of Inattention/Hyperactivity*

| Construct | Brief description and administration period | Scale and preparation |
|---|---|---|
| Parenting Behaviours | | |
| Allows meals in front of TV | Single item: How often is the TV on in the same room when your child is eating a meal? Administered in the 45-month data collection wave (DCW). Note: This is any meal not only main meal but does not include snacks. | Mothers rated frequency as 1 (always), 2 (almost always), 3 (sometimes) and 4 (Almost never), or 5 (never). Responses 1 - 3 were combined and labelled 'Allows meals in front of TV'; responses 4 and 5 were combined and labelled 'Never/almost never allows meals in front of TV' (1). |
| Total exposure of child to TV on a weekday | Single item: And again just thinking about that last weekday (i.e., [YESTERDAY/LAST FRIDAY]), how much time was the TV on in the same room as {NAME}, whether or not [HE/SHE] was watching it? Administered to mothers in the 2-year DCW. | Mothers reported time as 1 (Not at all) or 2 (total hours). If they answered Not at all to question 1, 0 hr were entered for the total hours of exposure to TV. Otherwise their response of number of hours was used as the child's score on this item. Two scores > 12 windsorised to 12. |
| Co-viewing | Single item: When your [child is/children are] watching TV, DVDs or videos, how often is an adult watching with [him/her/them]? Administered to mothers in the 2-year DCW. | Response scale of 1 (All of the time), 2 (Most of the time), 3 (About half the time), 4 (less than half the time) and 5 (Never), 6 (Not Applicable), 7 (Refused). Responses 1 -3 and 6 were combined and labelled 'Co-views at least half the time/not applicable' (1); Responses 4 and 5 were combined and labelled 'Co-views less than half the time, or never'. |
| Exposure to adult-directed content | Single item asked only of mothers who had provided the number of hours their child had spent watching TV, DVD or video on the last weekday: And how much of this time was spent watching 'grown-up' DVDs or television programmes on free-to-air and pay TV? Administered to mothers in the 2-year DCW. | Mothers responded 'None' or they provided the number of hours their child had watched grown up or 'adult-directed' content. If mothers responded none or had previously reported that their child had watched no hours of TV, DVD or video on the last weekday, then a score of 0 hr was assigned. Otherwise the number of hours reported by the mother was used as the child's score on this item. |

| Construct | Brief description and administration period | Scale and preparation |
| --- | --- | --- |
| Exposure to child-directed content | Two sequential items asked only of mothers who had provided the number of hours their child had spent watching TV, DVD or video on the last weekday: 1) Of this time, how much was spent watching just children's television programming, including free-to-air and pay TV, and children's TV programmes on DVD, but not children's movies on DVD? 2) And how much of this time was spent watching children's movies on DVD or video, e.g., Toy Story? Administered to mothers in the 2-year DCW. | Mothers responded 'None' or they provided the number of hours their child had watched each medium. The responses were combined to produce total hours of watching child-directed content. If mothers responded none or had previously reported that their child had watched no hours of TV, DVD or video on the last weekday, then a score of zero was assigned. The child's total hours viewing child-directed content was used as the child's score on this item. |
| Restrictive rules about TV viewing | Mothers were asked 3 related questions about restrictive TV rules: Are there rules about…What TV programmes your [CHILD/CHILDREN] can watch? How many hours of TV, videos, and DVDs your [CHILD/CHILDREN] can watch? When your [CHILD WATCHES/CHILDREN WATCH] TV? TV programming viewed on computers was counted. Administered to mothers in the 2-year DCW. | Mothers responded Yes or No to each question. If the mother indicated that the questions were not applicable because there was not TV, this was coded 'not applicable'. If mothers responded yes to having any of the 3 types of household rules restricting TV exposure, this was coded 1 (restrictive media rules)(1). If mothers reported no rules, a score of zero was assigned. Not applicable was coded as 1 because not having access to TV functions as a form of restriction. |
| Parenting characteristics | | |
| Average parental age | Mean of mother's age and father/partner's age on the dates of their 2-Year CAPIs. | The difference between the mother's birthdate and the father/partner's birth date (administered in the antenatal CAPI) and the date of the 2-year CAPI was calculated, then the mean of mother's age and father/partner's age was calculated. |
| Maternal personality | Factor scores on the personality traits of Agreeableness (9 items α = .69), Openness (10 items, Cronbach's α = .76); Conscientiousness (9 items, α = .78); Neuroticism (9 items, α = .77) and Extraversion (8 items, α = .81). Administered to mothers in the 2-year DCW. | The Big Five Trait Taxonomy (John & Srivastava, 1999). All items used the scale 1 (disagree strongly), 2 (disagree a little), 3 (neither agree nor disagree), 4 (agree a little) and 5 (agree strongly). Means of each factor score were calculated. |
| Paternal personality | Factor scores on the personality traits of Agreeableness (9 items, Cronbach's α = .72), Openness (10 items, α = .75); Conscientiousness (9 items, α = .78); Neuroticism (9 items, α = .78) and Extraversion (8 items, α = .80). Administered to fathers in the antenatal CAPI. | The Big Five Trait Taxonomy (John & Srivastava, 1999). All items used the scale 1 (disagree strongly), 2 (disagree a little), 3 (neither agree nor disagree), 4 (agree a little) and 5 (agree strongly). Means of each factor score were calculated. |

| Construct | Brief description and administration period | Scale and preparation |
|---|---|---|
| Parental education | Separate variables indicating the highest level of education reached by the mother and the father/partner. Administered separately to mothers and fathers in the antenatal DCW. | Education qualifications in ascending order: 'No secondary school qualification', 'Secondary school/NCEA L1-4', 'Diploma/trade cert NCEA L5-6', 'Bachelor's Degree', and 'Higher degree'. Due to low cell count, 'No secondary school qualification' was combined with 'Secondary school/NCEA L1-4' to make 'School qualifications or less' (1). |
| Parental efficacy | Single question: "We would like to know how you feel about being a parent. Overall, do you feel that as a parent you are:" Administered to mothers and fathers separately in the 2-year DCW. | Response options ranged from 1 (not very good at being a parent), 2 (a person who has some trouble being a parent), 3 (an average parent), 4 (a better than average parent) and 5 (a very good parent). Responses 1 - 3 were combined and labelled Low to average efficacy and responses 4 and 5 were combined and labelled High efficacy (1). |
| Parent-child relationship environment | Warmth and Hostility Scale from the Iowa Family Interaction Rating Scale (Melby et al., 1998). Measure of positivity of mother-child and father-child relationship environment. Administered separately to mothers and fathers in the 2-year DCW. | Response scale ranged from 1 (never) to 7 (all the time). The mean score of 9 items was calculated. For mothers, Cronbach's α = .72; and for fathers, Cronbach's α = .75. |
| Parenting style | 21-item scale based on the Parenting Practices Questionnaire (Robinson et al., 1995). Sample item: "Thinking about your values and attitudes toward parenting in general, how much do you agree with the following statements?: I am responsive to {HIS/HER} feelings and needs." Exploratory Factor Analysis (EFA) was conducted and four parenting style factors were extracted: Verbal hostility/discipline, Warmth/Affiliation, Permissive/low parenting confidence and Physical punishment. Together these factors explained 38.3% of the variance (E. R. Peterson, Yanga., Waldie, & Morton, 2018).). Administered in the 54-month DCW. | Mothers responded 1 (Strongly disagree); 2 (Disagree); 3 (Neither agree nor disagree); 4 (Agree); 5 (Strongly agree). The mean of responses for each parenting style subscale was calculated: Cronbach's α scores were: Warmth/affiliation, .80; Verbal hostility/discipline, .71; Permissive/low parenting confidence, .70; Physical punishment, .71. |
| Parental work hours at 2 years | Sequential items: 1) Do you have a paid job at the current time? 2) Including overtime, how many hours a week do you usually work in all your jobs? Administered to both mothers and fathers in the 2-year DCW. | Mothers and fathers responded Yes or No to question 1. If Yes, they were then asked the 2nd question and responded with the number of hours (upper limit 90). If they answered No to question 1, zero hours were entered for the total hours of paid work. |

| Construct | Brief description and administration period | Scale and preparation |
|---|---|---|
| Paternal work hours at 9 months | Two sequential questions: 1) Do you have a paid job at the current time? 2) Including overtime, how many hours a week do you usually work in all your jobs? Administered to fathers in the 9-month DCW. | Fathers reported the number of hours worked per week. Zero hours was entered for those who reported no paid work at the current time. Work hours exceeding 90 hr were coded as 90. Variable used as an auxiliary variable in the imputation model. |
| Child characteristics | | |
| Child age | Derived variable. Child's age on day of mother's 54-month CAPI. | The difference between child's birth date (administered in the 6-week CATI) and the date of the mother's interview in the 54-month DCW. |
| Child attends childcare or not | Single item: "Over the past month [HAS YOUR CHILD/HAVE YOUR CHILDREN] been looked after at regular times during the week by anyone other than you or your partner? DO include regular care by neighbours and/or grandparents. DO NOT include casual or occasional babysitting. DO NOT include care by a non-resident parent." Administered to mothers in the 2-year DCW. | Mothers responded Yes (1) or No. |
| Child temperament | Five factor model of the Infant Behaviour Questionnaire Revised-Very Short Form (E. R. Peterson et al., 2017; Putnam, Helbig, Gartstein, Rothbart, & Leerkes, 2014), adapted from the IBQ-R-VSF. Sample item: "When tired, how often did your baby show distress?" Administered in the 9-month DCW to mothers. | Response scale ranges from 1 (never) – 6 (always). Total score on each temperament factor was calculated: Negative affect (NEG) (9 items, Cronbach's $\alpha$ = .80); Positive affect and surgency (PAS) (14 items, Cronbach's $\alpha$ = .72); Fear (3 items, Cronbach's $\alpha$ = .89); Orienting Capacity (OC) (5 items, Cronbach's $\alpha$ = .63; Affiliation (Affil) (6 items, Cronbach's $\alpha$ = .70). |
| Gender of child | Single item: Did you have a boy or a girl? Administered in the 6-week CATI. | Mothers responded Girl or Boy (1). |
| Hyperactivity/inattention | A 5-item subscale ($\alpha$ = .65) of the SDQ (Goodman, 1997), measuring children's behavioural difficulties. Sample item: "constantly fidgeting or squirming?" Administered to mothers in the 2-year DCW. | Based on their child's behaviour over the last 6 months, mothers reported whether each behaviour was 0 (not true), 1 (somewhat true) or 2 (certainly true) of their child. The mean score of the 5 items in the subscale was calculated. Scores ranged from 0 - 6 (normal range), 7 (borderline), 8-10 (abnormal range) (D'Souza, Waldie, Peterson, Underwood, & Morton, 2017). Dichotomised to 0 (normal/borderline)(1) and 1 (abnormal). |

| Construct | Brief description and administration period | Scale and preparation |
|---|---|---|
| Language development | MacArthur CDI-II short form A (100 items) (Fenson et al., 2000), adapted for New Zealand English (as per Reese & Read, 2000). Sample item: Child can say aeroplane in 'English' language. Administered to mothers in the 2-year DCW. | Mothers responded Yes (scored as 1) or No (scored as 0). A total score was computed. |
| Parity | Administered to mothers in the 6-week DCW. | Indicates whether the child is a firstborn (1) or subsequent child. |
| Self-regulation | A 7-item subscale of the Caregiver Inventory of Self Concept (CISC; DesRosiers, Vrsalovic, Knauf, Vargas, & Busch-Rossnagel, 1999). Sample item: "Is upset, ashamed or sorry when [he/she] shows you [he/she] has done something bad." Administered to mothers in the 2-year DCW. | Response options ranged from 1 (Not at all typical of my child) to 4 (Very typical of my child). The mean score was taken of 7 items (Cronbach's α = .67). |
| Total sleep in 24 hours | Two items: On average, how much time does {NAME} spend asleep at night in total? On average, how much time does {NAME} spend asleep during the day? Administered to mothers in the 2-year DCW. | Mothers responded with the number of hours and minutes that the child spends asleep each day at night and during the day. First, the hours and minutes of both day and night sleep were combined to obtain separate totals of sleep (night) and sleep (day). These totals were then added together to obtain the total amount of sleep in 24 hr. Scores were not included for children of mothers who reported "Don't know" for either day sleep or night sleep. Extreme scores 3x the interquartile range above and below the median were windsorised, resulting in a range of 7-18 hr. This range corresponds to 2 hr above and below the upper and lower bounds of appropriate sleep guidelines for toddlers (Ministry of Health, 2017), thus incorporating scores representative of sleep difficulties. |
| Family context | | |
| Deprivation group | The New Zealand Deprivation Index is based on nine different socioeconomic variables in the 2006 New Zealand census, which are combined to describe the deprivation level of a small geographical area. | NZ Deprivation Index (Salmond et al., 2007). Deprivation is measured on a scale from 1 – 10. Decile 1 describes the area of least deprivation and Decile 10 indicates the greatest deprivation. Deprivation was divided into 3 groups: low (Deciles 1 – 3) (1), Medium (Deciles 4 – 7) and High (Deciles 8 – 10). |

| Construct | Brief description and administration period | Scale and preparation |
|---|---|---|
| Family stress | Scale developed for the GUiNZ study, with reference to Abidin (1995), to assess current levels of family stress. Sample question: "In the time since the baby was born, to what extent are the following a source of stress to you and your family: Worry about money problems?" Administered to mothers in the 2-year DCW. | Response scale ranged from 1 (not at all stressful) to 4 (highly stressful). The mean score was calculated of 8 items. Cronbach's $\alpha$ = .76. |
| Societal context | | |
| Ethnicity | Derived variable. Single item: "Which is the MAIN ethnic group that {NAME} identifies with?" Administered to mothers in the 54-month DCW. | Response options included 32 different ethnicities and 'Other Ethnicity (Please specify)', which were then upcoded by the GUiNZ study team to the following categories: 1 (European) (1), 2 (Māori), 3 (Pacific), 4 (Asian), 5 (MELAA) and 6 (Other) and 8 (New Zealander). MELAA, Other and New Zealander were combined due to low frequencies. |

*Note.* (1) signifies the reference category.

#### 4.5.3.1 Outcome Variables.

***4.5.3.1.1 Cool Executive Control.*** The Hand Clap task began with a training session. The interviewer showed their hands to the child and clapped, saying: “Now for this game, when I clap one time, you clap two times. And when I clap two times, you clap one time, ok? Let’s try.” When the child achieved three training trials correct or the six training trials had been completed, the interviewer moved on to the test trials, which consisted of 16 trials administered in a set order. The child’s score comprised their total score out of the 16 trials, as per Bialystok et al., (2010). Scores on this task were negatively skewed, with a median of 13. Previous work conducted by some of the authors involved in the current study (Buckley et al., 2020) had already shown that log transformation was not effective in improving the distribution of scores on this task; hence the total score was dichotomised into 0 (below the median) and 1 (at or above the median).

***4.5.3.1.2 Hot Executive Control.*** To begin the Gift Wrap task, the interviewer told the child: “Now I have a surprise to show you, but I don’t want you to see it. I want to wrap it first. Please turn around so you won’t see it. Please don’t look or peek while I wrap it. I’ll tell you when I’m done.” After the child had turned around, the interviewer set a timer for one minute and then took out materials for wrapping gifts and a pre-wrapped gift. The interviewer then made noises to make it seem as though they were wrapping the gift. After one minute the interviewer told the child: “Ok, I’m all done, you can turn around now.” During the minute, the interviewer observed the child’s behaviour.

The results of the Gift Wrap task were then scored in two ways. The first was to measure latency to first peek, i.e., the number of seconds that elapsed before the child peeked at the gift for the first time. Children were expected to wait 60 s before they could turn around and see the gift; therefore, children who did not peek were assigned a score of 60. The second way that this task was scored was by assigning a category describing the peeking behaviour of those children who did peek, i.e., 1 (child peeked once), 2 (child peeked more than once), 3 (child peeked once or more and then remained peeking for the remainder of the timing), and 4 (child peeked (one or more times) and touched the gift). Most children in our sample did not peek (73%) and consequently achieved the maximum score of 60, hence the Latency to first peek variable was very negatively skewed and failed the K-S test for normality (D = .429, $p < .001$). Therefore, this variable was dichotomised to 0 (child peeked) and 1 (child never peeked).

***4.5.3.1.3 Inattention/Hyperactivity.*** The SDQ includes a subscale consisting of five questions related to difficulties with inattention or hyperactivity that children might experience (i.e., the Inattention/Hyperactivity subscale) (Cronbach's $\alpha = .72$). A sample statement from this subscale is: "Restless, overactive, cannot stay still for long". Mothers were instructed: "For each item, please tell us if you feel the statements are Not True, Somewhat True, or Certainly True about your child. It would help us if you answered all items as best you can even if you are not certain. Please give your answers on the basis of the child's behaviour over the last six months."

Responses to questions on the SDQ are scored 0–2; therefore, with 5 items in this subscale, the highest possible total is 10. The cut points on this subscale are 5 and below for within the normal range, 6 for borderline, while scores 7–10 are classified as in the abnormal range, i.e., indicative of problematic levels of inattention/hyperactivity (Goodman et al., 1998). Normal and borderline scores were combined to produce the category 0 (normal/borderline) and scores from 7–10 were coded as 1 (abnormal).

**4.5.3.2 Predictor Variables.**

***4.5.3.2.1 Patterns of Screen Time Across the Preschool Years.*** This variable measures different patterns of screen use across the preschool years and is based on the study children's home-based screen time at two time points, i.e., at 2 years and 45 months. In the

2-year CAPI, mothers were asked three questions about their children's screen media use on the last weekday: 1) "Thinking about the last weekday, i.e. [YESTERDAY/LAST FRIDAY], how many hours did {NAME] spend at home watching all types of TV, DVDs, and videos?"; 2) "Again just thinking about the last weekday, i.e. [YESTERDAY/LAST FRIDAY], how much time did {NAME} spend using a computer or laptop, including children's computer systems such as Leapfrog" and 3) "And on that last weekday, how much time did {NAME} spend playing with an electronic gaming system?". Mothers had the option of reporting "none" or reporting the amount of time spent in each of these activities, in hours. If mothers responded "None", a score of zero was assigned for that question. The totals of all three questions were combined to obtain a measure of the children's total screen time at 2 years.

In the 45-month CAPI, mothers were asked two questions (as questions 2 and 3 from the 2-year CAPI were essentially combined): 1) "Thinking about a usual weekday, approximately how many hours does {NAME} spend at home… watching television programming including free-to-air, online, and pay TV or DVDs either on TV or other media?" and 2) "using electronic media e.g., computer or laptop, including children's computer systems such as Leapfrog, iPads, tablets, smart phones and any electronic gaming devices?" Mothers reported the amount of time in hours and minutes. The totals of these two questions were obtained to produce a measure of total screen time on a weekday for the child at 45 months. Having obtained measures of total screen time for each child at each time point, we then produced a variable that showed whether screen time was ≥ 2 hr (labelled H for high), or < 2 hr (labelled L for low) at each time point. For example, if the child had had < 2 hr of screen time at both time points, their pattern was LL; if they had had ≥ 2 hr at both time points, their pattern was HH. Two hours was chosen as the cut-off point for high screen time as this amount of screen time has previously been identified as a suitable cut point indicating higher use of screen time for preschool children (e.g., Asplund et al., 2015;

Radesky et al., 2014b). Consequently, there were four possible screen use patterns dependent on the children's level of screen time at each of the two time points, i.e., HH, LH, HL and LL. LL was used as the reference category for all analyses.

***4.5.3.2.2 Children's Physical, Health and Developmental Concerns at 2 years.*** This variable is a composite measure of the number of physical, health and developmental concerns affecting the child, as reported by the mother in the 2-year DCW. First the mother was asked: "Which, if any, of the conditions on this showcard has a doctor told you {NAME} has?" Responses included: 1 (birth condition, e.g., spina bifida, congenital heart defect, intellectual disability, or any other birth condition); 2 (epilepsy); 3 (permanent hearing problems); 4 (vision problems that can't be corrected by glasses); 5 (none of these). We allocated a score of 0–4 depending on how many conditions affected the child.

Next the mother was asked about a range of illnesses that may have affected their child, including 1) asthma; 2) meningitis; 3) whooping cough or pertussis, and 4) Hepatitis B. Responses were 1 (Yes); 2 (No). As above, children were allocated a score of 0–4 depending on how many conditions affected them.

The mother was then asked the frequency with which the following infections had affected their child since they were 9 months old: 1) chest infections, bronchitis, bronchiolitis, pneumonia and croup; 2) ear infections; 3) gastroenteritis, and 4) skin infections. Responses included: 1 (never); 2 (1–3 times); 3 (4–6 times); 4 (7–9 times); 5 (10+ times). Children were allocated a score of one for each condition that had affected them four times or more since they were 9 months old, with total scores for infections ranging from 0–4.

Finally, the mother was asked: "Does {NAME} have any health, developmental or physical problems that we haven't already discussed in this interview?" Mothers could identify up to five conditions.

By combining the scores to each set of questions relating to the child's physical, health and developmental concerns at 2 years, a composite score reflecting the total number of conditions that were affecting or had affected the child was obtained, with a possible range of 0–17.

### *4.5.4 Data Analyses*

**4.5.4.1 Preliminary Data Analyses.** We assessed the correlations between predictor variables and found that maternal and paternal age were strongly correlated, $r_p = .71$, $p < .01$. Therefore, to avoid multicollinearity, we computed an average parental age variable for use in our analyses. No other predictor variables were highly correlated (Tabachnick & Fidel, 2013).

We found that nine variables in our sample of 4,061 had more than 5% missing data. Missing data is common in large longitudinal samples following young children as they often rely on multiple informants and a parent may, for example, be unavailable, or a child can be asleep or refuse to participate. In our sample there was > 5% missing data on: father-child relationship environment (10%), father's work hours (10%) and parenting efficacy (10%); mother's work hours (6%), and child viewing of adult-directed (7%) and child-directed (7%) content at 2 years. There was also missing data > 5% on two of our outcome measures, i.e., hot EFs (7%) and cool EFs (11%) at 54 months. There were 2,702 (67%) complete cases in our dataset and our data was nonmonotonic. Little's MCAR test ($\chi^2$ = 7,641.52, [$df$ = 5,161], $p < .001$) showed that overall our data were not missing completely at random (MCAR). The missingness appeared to vary systematically with variables within our dataset, indicating that our data were missing at random (MAR; Sterne et al., 2009). As such, and insofar as 33% of cases had missing data, multiple imputation (MI) was considered a suitable solution to address the issue of missing data in our dataset (Y. Dong & Peng, 2013; Graham, 2009; Sterne et al., 2009). To avoid bias, we included all predictor variables from the analysis model in the imputation model (Shafer, 1997). Note that demographic variables were included in the imputation model for the information they contributed to the model but were used in subsequent repression models in their original non-imputed forms. In line with current recommended practice, we also imputed missing data on our outcome variables (K. Lang & Little, 2018).

We imputed missing data in SPSS using the fully conditional specification (FCS) method, which is an iterative Markov chain Monte Carlo (MCMC), with 50 iterations specified. As Kolmogorov-Smirnov tests of normality showed that the distributions of the continuous variables in our dataset were non-normal, we used model type PMM (predictive mean matching) for continuous variables, which is suitable for imputing non-normal continuous data (White et al., 2011). Thirty-three percent of cases had missing data, therefore we used MI in SPSS version 24 to impute 40 datasets, in line with the recommendation of von Hippel (2009), who advised that the number of imputed datasets should approximate the percentage of cases with missing data (Bodner, 2008).

Inspection of the means and frequencies of our original datasets and imputed datasets (pooled statistics) showed good correspondence; refer to Table S1 in the supplemental material for comparison of means and frequencies of the variables with missingness > 5%.

**4.5.4.2 Main Analyses.** We conducted three step-wise multivariable binomial logistic regression analyses using the MI datasets primarily to assess the relationship between screen media exposure during the preschool years and hot and cool EFs, and symptoms of inattention/hyperactivity at 54 months. We also included a wide range of other variables that the literature suggests may also be predictive of these outcomes. Variables were entered into the models as follows: (1) Demographic variables: Child age, gender, parity, and ethnicity; average parental age and education; SES (NZDep2006); (2) Control variables related to child development at 2 years: hyperactivity/inattention, language development, total health, physical and developmental concerns; (3) All other variables including variables related to screen media exposure.

For each of our three logistic regression models, we used Box-Tidwell tests to test the linearity of continuous variables to the logit. To conduct this test, we took the natural log of each continuous variable and produced interaction terms comprised of the independent variables and their natural log values. The interaction terms were then included in the full regression models and the analyses re-run. Significant *p*-values of interaction terms indicate non-linearity of that particular independent variable to the logit (Box & Tidwell, 1962; Cohen et al., 2003; Fox, 1997). For the purpose of conducting the Box-Tidwell tests, we added a constant of one to scores in the mothers' and fathers' work hours variables, hours of total exposure to TV on a weekday, and hours of exposure to adult-directed content and child-directed content so that they included no zero values and the logs of all values could be taken (Tabachnick & Fidel, 2013).

For comparison, the three regression analyses were also carried out using the original data, thereby conducting complete case analyses.

We used Benjamini and Hochberg's (1995) method of controlling the false discovery rate due to the large number of predictor variables entered into our models. This resulted in more stringent, critical *p*-values of $p \leq .005$ for Cool EFs and $p \leq .001$ for Hot EFs, and $p < .001$ for Inattention/Hyperactivity.

## 4.6 Results

We conducted descriptive analyses on hot and cool EFs and inattention/hyperactivity at 54 months, and predictor variables related to screen media use, inattention/hyperactivity, and children's physical, health and developmental concerns at 2 years (refer to Table 4.2).

**Table 4.2**

*Frequencies of Each Outcome Variable, EFs, Inattention/Hyperactivity and Number of Health, Physical and Developmental Conditions at 2 years, and Screen Media Variables, using Data from the Original Dataset and Pooled Results in the Multiply Imputed Datasets (N=40)*

| | Original *n* (%) | Imputed *n* (%) |
|---|---|---|
| Cool EFs (Hand Clap Task) | | |
| High (at or above median) | 2,088 (58%) | 2,320 (57%) |
| Low (below median) | 1,534 (42%) | 1,741 (43%) |
| Hot EFs (Gift Wrap Task) | | |
| High (never peeked) | 2,755 (73%) | 2,961 (73%) |
| Low (peeked) | 1,009 (27%) | 1,100 (27%) |
| Inattention/hyperactivity at 54 months | | |
| Abnormal range | 467 (12%) | 468 (12%) |
| Normal or borderline | 3,589 (88%) | 3,593 (88%) |
| Inattention/hyperactivity at 2 years | | |
| Abnormal range | 291 (7%) | 303 (7%) |
| Normal or borderline | 3,658 (93%) | 3,758 (93%) |
| Health, physical or developmental conditions | | |
| No conditions | 2,631 (66%) | 2,691 (66%) |
| 1 condition | 905 (23%) | 926 (23%) |
| 2 conditions | 296 (8%) | 303 (7%) |
| 3–9 conditions | 138 (3%) | 141 (4%) |
| Patterns of screen time across the preschool years | | |
| LL | 1,892 (50%) | 1,975 (49%) |
| LH | 925 (24%) | 986 (24%) |
| HL | 322 (8%) | 346 (8%) |
| HH | 687 (18%) | 755 (19%) |
| Co-viewing | | |
| At least half the time/not applicable | 3,354 (85%) | 3,435 (85%) |
| Less than half the time, or never | 615 (15%) | 626 (15%) |
| Hours of exposure to weekday TV | | |
| 0 hr | 695 (18%) | 720 (18%) |
| >0 hr–1 hr | 1,059 (27%) | 1,103 (27%) |
| >1 hr–2 hr | 849 (22%) | 891 (22%) |
| >2 hr–3 hr | 466 (12%) | 492 (12%) |
| >3 hr–4 hr | 306 (8%) | 325 (8%) |
| > 4 hr | 490 (13%) | 530 (13%) |

| | | |
|---|---|---|
| Hours of viewing adult content on a weekday | | |
| 0 hr | 3,425 (91%) | 3,680 (91%) |
| >0 hr–1 hr | 275 (7%) | 303 (7%) |
| >1 hr–2 hr | 44 (1%) | 47 (1%) |
| >2 hr | 29 (1%) | 31 (1%) |
| Hours of viewing child content on a weekday | | |
| 0 hr | 1,007 (27%) | 1,049 (26%) |
| >0 hr–1 hr | 1,734 (46%) | 1,884 (46%) |
| >1 hr–2 hr | 660 (17%) | 718 (18%) |
| >2 hr–3 hr | 229 (6%) | 246 (6%) |
| >3 hr–4 hr | 85 (2%) | 91 (2%) |
| > 4 hr | 64 (2%) | 73 (2%) |
| Allows meals in front of TV | | |
| Allows TV meals | 2,014 (51%) | 2,061 (51%) |
| Never/almost never allows | 1,967 (49%) | 2,000 (49%) |
| Rules restricting screen exposure | | |
| Yes/not applicable | 3,438 (87%) | 3,533 (87%) |
| No | 509 (13%) | 528 (13%) |

The Box-Tidwell tests (Box & Tidwell, 1962; Cohen et al., 2003; Fox, 1997) found that the interaction of sleep with its log was significant in the cool EFs model (B = -.94, $p$ = .003); the interaction of family stress with its log (B = -.86, $p$ = .038) and the interaction of language with its log (B= .01, $p$ = .012) were significant in the hot EFs model; and the interaction of permissive/low parenting confidence with its log (B = -1.26, $p$ = .001) was significant in the inattention/hyperactivity model. As significance in the Box-Tidwell test signifies that the assumption of linearity to the logit is violated, these variables were dichotomised by their means[3] in the MI datasets and employed in the relevant logistic regression analyses to eliminate this problem.

The omnibus tests of model coefficients showed that all of the models produced in the individual MI datasets had significantly better fit than the baseline models, for hot and cool EFs and inattention/hyperactivity inclusive; however, it is not possible to obtain pooled

[3] Pooled data for the median is not available in SPSS multiply imputed datasets; hence the mean was selected as the cut-off point for dichotomising these variables.

results of these statistics[4]. All three models were also run using complete case analysis and yielded similar results to those obtained in the main analyses conducted in the MI datasets, i.e., variables found to be significant in regression analyses conducted in the MI datasets were also significant or marginally significant in complete case analyses (refer to Tables S2-S4 in the supplemental material).

The following results and subsequent discussion focus on the variables found to be predictive of hot or cool EFs, and/or inattention/hyperactivity at 54 months, using the MI datasets (refer to Tables S5–S7 in the supplemental material).

### *4.6.1 Cool EFs*

Nine variables were found to be predictive of cool EFs at 54 months. Firstly, we found a negative relationship between the screen-media variable allowing meals in front of TV at 45 months and cool EFs at 54 months. Negative relationships with cool EFs were also identified for mothers using a permissive/low parenting confidence parenting style or a physically punishing parenting style, and the child displaying symptoms of inattention/hyperactivity at 2 years. Positive relationships were found between cool EFs and child being of Asian ethnicity compared to European ethnicity, mothers using a verbally hostile parenting style to discipline their child, the child's language development, being female and being a subsequent child (i.e., not firstborn). (Refer to Table 4.3.)

[4] The log-likelihood statistics for the models run in each individual MI dataset are available from the first author upon request.

**Table 4.3**

*Pooled Results of Binomial Logistic Regression Investigating the Factors that are Associated with Cool EFs for Children Aged 54 Months (N = 3,787) Conducted in Multiply Imputed Datasets (N=40) with an Adjusted Critical P-Value* ≤ .005[a]

| | Coeff | *SE* | OR | *p*-value |
|---|---|---|---|---|
| Intercept | -2.63 | 1.83 | .07 | .151 |
| **Child's ethnicity** | | | | |
| European | REF | | | |
| Māori | .04 | .14 | 1.04 | .747 |
| Pacific Peoples | -.15 | .16 | .86 | .351 |
| Asian | **.60** | **.14** | **1.82** | **<.001** |
| MELAA/NZ | -.06 | .12 | .94 | .588 |
| Allows meals in front of TV | **-.23** | **.08** | **.79** | **.004** |
| Gender of child (female) | **.22** | **.08** | **1.25** | **.003** |
| Inattention/hyperactivity at 2 years | **-.41** | **.14** | **.67** | **.005** |
| Language development | **.02** | **.002** | **1.02** | **<.001** |
| Permissive mother | **-.25** | **.07** | **.78** | **<.001** |
| Physically punishing mother | **-.26** | **.08** | **.77** | **.001** |
| Parity of child (subsequent) | **.24** | **.08** | **1.27** | **.003** |
| Verbal hostility/discipline (mother) | **.24** | **.08** | **1.28** | **.003** |

*Note*. The statistically significant predictor(s) in each model are printed in bold. MELAA = Middle Eastern, Latin American or African; Coeff = Coefficient; SE= Standard Error; OR = odds ratio; REF = Reference category. [a]Critical *p*-value adjusted using Benjamini and Hochberg's (1995) method for controlling the false discovery rate.

### *4.6.2 Hot EFs*

The amount of time the child was exposed to TV on a weekday at 2 years (including background and foreground TV) was negatively associated with hot EFs at 54 months. In addition, child's language development at 2 years, being a subsequent child and being female were found to be positively related to Hot EFs at 54 months. (Refer to Table 4.4.)

**Table 4.4**

*Pooled Results of Binomial Logistic Regression Investigating the Factors that are Associated with Hot EFs for Children Aged 54 Months (N = 3,787) Conducted in Multiply Imputed Datasets (N=40) with an Adjusted Critical P-Value* ≤ .001[a]

| | Coeff | SE | OR | *p*-value |
|---|---|---|---|---|
| Intercept | 1.70 | 1.94 | 5.47 | .382 |
| Gender of child (female) | **.63** | **.08** | **1.88** | **<.001** |
| Parity of child (subsequent) | **.32** | **.09** | **1.38** | **<.001** |
| Language development | **.34** | **.09** | **1.41** | **<.001** |
| Total exposure to TV | **-.07** | **.02** | **.93** | **.001** |

*Note*. The statistically significant predictor(s) in each model are printed in bold. Coeff = Coefficient; SE= Standard Error, OR = odds ratio. [a]Critical *p*-value adjusted using Benjamini and Hochberg's (1995) method for controlling the false discovery rate.

### *4.6.3 Inattention/Hyperactivity*

Four variables were found to be associated with children's scores on the Inattention/hyperactivity subscale of the SDQ at 54 months but no screen time variables were found to be significant. Mothers' parenting style, i.e., verbally hostile/discipline; child displaying symptoms of inattention/hyperactivity at 2 years; and the child's temperament score for Positive Affect and Surgency (PAS), were positively associated with the child's inattention/hyperactivity at 54 months. The child being female was negatively associated with inattention/hyperactivity at 54 months. (Refer to Table 4.5.)

**Table 4.5**

*Pooled Results of Binomial Logistic Regression Investigating the Factors that are Associated with Inattention/hyperactivity for Children Aged 54 Months (N = 3,787) Conducted in Multiply Imputed Datasets (N=40) with an Adjusted Critical P-Value < .001*[a]

| | Coeff | *SE* | OR | *p*-value |
|---|---|---|---|---|
| Intercept | -2.02 | 2.65 | .13 | .444 |
| Child temp: PAS | **.33** | **.09** | **1.39** | **<.001** |
| Child gender (female) | **-.49** | **.12** | **.61** | **<.001** |
| Hyperactivity/inattention at 2 years (abnormal range) | **1.18** | **.16** | **3.26** | **<.001** |
| Verbal hostility/discipline (mother) | **.44** | **.11** | **1.55** | **<.001** |

*Note*. The statistically significant predictor(s) in each model are printed in bold. PAS = Positive affect/surgency; Coeff = Coefficient; SE= Standard Error; OR = odds ratio; REF= Reference category; temp = temperament. [a]Critical *p*-value adjusted using Benjamini and Hochberg's (1995) method for controlling the false discovery rate.

## 4.7 Discussion

Our analyses enabled us to: 1) identify variables that are associated with children's cool and hot EFs, and inattention/hyperactivity at 54 months; and 2) test our hypotheses that the content of preschool children's media exposure at age 2 years (adult-directed versus child-directed) and the involvement of parents in their children's media use (i.e., co-viewing) would be stronger predictors of hot EFs, cool EFs, and symptoms of inattention/hyperactivity at 54 months, compared to the amount of screen *time* children are exposed to. After controlling for demographic variables and other likely predictors of EFs and inattention/hyperactivity, we found that the amount of *time* that children were exposed to TV on a weekday at age two (including background and foreground TV) was associated with hot EFs at 54 months, but none of the other screen exposure measures were related to EFs or inattention at 54 months except for eating meals in front of TV at 45 months. Below we address our hypotheses and discuss our findings related to screen media use.

Contrary to our hypotheses, our study found that early co-viewing (at 2 years of age) was not related to hot and cool EFs or inattention/hyperactivity during the later preschool years, i.e., 54 months. Two past studies have examined similar relationships, with Acevedo-Polakovich et al. (2007) finding that co-viewing was more prevalent for older preschool children aged 4–6 years who had been diagnosed with ADHD, while Radesky et al. (2014b) found no relationship between difficulties with self-regulation and co-viewing for children aged 9 months to 2 years. The general trend is for co-viewing to be higher when children are very young, while parents of older children are more likely to set rules to manage their children's screen time (Nikken & Jansz, 2014). However, co-viewing may be more likely to continue at a higher rate for children who have difficulties with inattention/hyperactivity, as these children often experience difficulty with peer interactions, and screen time may provide an activity that the child can easily take part in with others (Acevedo-Polakovich et al., 2007). This may explain why a concurrent relationship between inattention/hyperactivity and parental co-viewing was identified by Acevedo-Polakovich and colleagues for children at age four, while a longitudinal relationship between co-viewing at 2 years and inattention/hyperactivity at 54 months was not evident in our study, and concurrent and longitudinal relationships between co-viewing and self-regulation were also not found for children aged 9 months and 2 years in Radesky et al.'s (2014b) study.

Also contrary to our hypotheses, we found no evidence that content of screen media exposure at 2 years (specific to adult-directed versus child-directed) is related to EFs or inattention/hyperactivity at 54 months. Only one study, conducted by Barr et al. (2010), has taken a longitudinal approach to investigating the effects of different types of media content on EFs and operationalised screen content as hours of adult-directed versus child-directed, as we did. Both our study and Barr et al.'s study found no association between exposure to child-directed programming during the early preschool years and later EFs. However, while we found no relationship between hours of exposure to adult-directed content at age two and EFs at 4.5 years, Barr et al. found there was a significant association between children's exposure to adult-directed content at age one and EFs at age four.

This apparent discrepancy between our finding and that of Barr et al. (2010) may be due to methodological differences between our studies. Firstly, our measure of exposure to adult-directed content did not include background TV, while Barr et al.'s measure of adult-directed TV did. Therefore their measure is arguably more similar to our measure of exposure to TV on a weekday, which also encompasses both foreground and background TV, which we did find to be related to hot EFs. Another difference between the measures employed by our respective studies was the age of the children at the time that hours of exposure to adult-directed content was measured, with Barr et al. measuring this when children were age one and our study measuring this when children were age two. As adult-directed content is believed to be incomprehensible to a one year old, all adult-directed content is essentially equivalent to background TV for this age group (Anderson & Subrahmanyam, 2017), so it makes sense that Barr et al. did not distinguish between foreground and background adult content for children at one year of age. Then, as children get older and their linguistic and cognitive skills develop, children's capacity to comprehend TV programming and video increases (Anderson et al., 1986; Pempek et al., 2010), and some forms of adult-directed content may move into the "foreground" for some children (Anderson & Pempek, 2005). Hence exposure to adult-directed content in our study comprised content that, according to mothers' judgement, their 2-year-old children were watching. Nonetheless, the findings of Barr et al. essentially align with our own, in that longer periods of exposure to TV in the same room as children during early childhood is associated with poorer EFs. Our finding also has similarities with those of Linebarger et al. (2014), Munzer et al. (2018) and Nathanson et al. (2014), who found that background TV was related to poorer EFs.

One reason why longer periods of exposure to TV may be associated with poorer EFs is that continually orienting to the attention-grabbing formal features of screen media, including changes in light, sound and movement, may strain the attentional capacity of young children at a crucial time in their development (Christakis, 2009; Lillard et al., 2015b; Zimmerman & Christakis, 2007), which may lead to later difficulties in maintaining focus on less stimulating "real life" activities (Christakis, 2010; Gentile et al., 2012). Another possible explanation is the "displacement" hypothesis, in which the time spent using screen media displaces activities that might give young children more of a chance to develop their self-control and ability to pay attention (Gentile et al., 2012). A relevant example of this might be when upset or boisterous children are pacified by the provision of a screen-based device such as TV, thereby reducing their opportunities to learn how to self-soothe, cope with delays and boredom, and manage their own behaviour (Radesky et al., 2014b; Radesky et al., 2015b). This may be particularly relevant for the development of hot EFs, which implicitly requires that children develop the ability to manage their behaviour when emotionally aroused. Such opportunities may become more important throughout the preschool years, as behaviours that underpin EFs are gradually internalised and children become less reliant on external factors to help them regulate their behaviour (Barkley, 2001).

Further, for a very young child, TV playing for long periods of time in their immediate environment delivers a continual stream of noise that may distract them and hinder learning. For instance, processing background noise uses cognitive resources, therefore learning may be impaired through a reduction in available cognitive resources for the child to complete other tasks (Erickson & Newman, 2017). In particular, background noise may impair children's learning of language, as noise can "mask" the target language children need to attend to (Werner, 2007). This problem is usually more pronounced if the background noise includes speech, as TV frequently does (Erickson & Newman, 2017). Young children may be more affected by "masking" due to a lack of knowledge of and experience with language, making them relatively less able to "fill in gaps" compared to older children and adults (Erickson & Newman, 2017, p. 4; Newman, 2006). Language ability appears to support the development of EFs (e.g., Hughes & Ensor, 2009; Schneider et al., 2005; Vallotton & Ayoub, 2011), which provides a further explanation for the relationship between higher exposure to TV on a weekday at age two and poorer EFs at 54 months identified in the current study.

Allowing the child to eat meals in front of TV at 45 months was found to have a negative association with cool EFs at 54 months. Similarly, a study conducted by Munzer et al. (2018) found that frequency of adults eating meals in front of TV is negatively associated with self-regulation of preschool children living in the household. Eating meals in front of TV is an example of a family practice that promotes higher levels of screen time in children (Birken et al., 2011). Previous research has shown that parental screen media use and background TV can reduce the quantity and quality of parent-child interactions and parental utterances (Hiniker et al., 2015; Kirkorian et al., 2009; Okuma & Tanimura, 2009; Radesky et al., 2015a). If it is a frequent family practice to eat meals in front of TV, the quantity and quality of parent-child conversation may be impaired on a regular basis, at a time that might otherwise present opportunities for "family time" and parent-child conversation (Hiniker et al., 2016a). As responsive parent-child conversation plays an important role in scaffolding early children's language development (Topping et al., 2013), and children's language development is positively associated with EFs (Hughes & Ensor, 2009), this provides one possible explanation for our finding.

Further, meal-times are one of the contexts in which parents often teach children about family and social norms of behaviour through rules, e.g., don't play with your food, don't chew with your mouth open, don't pass a dish of food over a person's head (Māori tikanga or traditional practice) (Mead, 2016). Therefore, meal-times can provide an opportunity for children to practise appropriate behaviour, with parental guidance and encouragement, as they gradually internalise norms about how to behave appropriately at meal-times and learn to regulate their own behaviour in this context (Gralinski & Kopp, 1993). In this way, meal-times may provide children with an opportunity to develop their

EFs. However, when TV is on during meal-times, older family members may be watching or distracted by TV, which may result in fewer meal-time rules, or less enforcement of rules. As meal-times occur every day, allowing meals in front of TV might repeatedly reduce children's opportunities to have experiences that support the development of EFs, which may explain the negative relationship we found between eating meals in front of TV and cool EFs.

Three of the demographic variables in our analyses were significantly associated with our outcome measures, i.e., child ethnicity and gender, and parity. As noted above, the child being of Asian ethnicity was associated with higher cool EFs compared to European children, which is in line with the previous research (e.g., Lewis et al., 2009; Oh & Lewis, 2008; Sabbagh et al., 2006). Similarly, our finding that boys are more likely to display symptoms of inattention/hyperactivity and poorer EFs at 54 months aligns with gender disparities in diagnosis of ADHD. Boys have been found to be approximately three times more likely to be diagnosed with this disorder than girls (Mental Health Foundation of New Zealand, 2017), and boys perform more poorly on hot executive control tasks compared to girls (Denham, 2015). Our findings suggest that girls may also have an advantage in the performance of cool EF tasks at 54 months compared to boys, which aligns with the finding of Kochanska et al. (1996) that boys exhibit poorer inhibitory control during the preschool years compared to girls. Finally, our finding that firstborn children have poorer performance on both hot and cool EFs tasks compared to subsequent children aligns with previous work (McAlister & Peterson, 2013) and may be because interacting with multiple siblings in the preschool years enhances the development of theory of mind (Perner et al., 1994) which is predictive of EFs (McAlister & Peterson, 2013).

We also controlled for children's inattention/hyperactivity at 2 years, their language development, and concerns with health and physical development. Of these, we found that inattention/hyperactivity at 2 years was positively associated with inattention/hyperactivity and cool EFs at 54 months, and language development at 2 years was positively associated with hot and cool EFs.

It is not surprising that inattention and hyperactivity symptoms at 2 years are predictive of inattention/hyperactivity at 54 months, as these symptoms persist over time (Greenhill et al., 2008). The poorer performance of children with symptoms of ADHD on the Hand Clap task (measuring cool EFs) may reflect a decreased ability to sustain attention to the task. Alternatively, since the inattention/hyperactivity subscale of the SDQ also measures impulsivity, higher levels of impulsivity in these children may have impaired their ability to inhibit their prepotent responses on the Hand Clap task. Our finding that children with more advanced language skills at 2 years have greater odds of performing well on the tests of both hot and cool EFs aligns with previous findings of positive associations between language skills and EFs (e.g., Hughes & Ensor, 2009; Schneider et al., 2005). As children's language develops, it enables their behavioural control to become increasingly internalised, facilitated by the child's ability to engage in self-directed speech (Barkley, 2001). Therefore, our finding that language ability increases the odds of performing well on EFs regardless of whether the context is "hot" or "cool" seems logical, as neither context should preclude the ability to engage in self-talk.

We found that the child's score on the temperament factor of positive affect and surgency (PAS) and maternal parenting styles were associated with cool EFs and/or inattention/hyperactivity. Children high on PAS tend to be exuberant and active, and as they are strongly reward oriented, they tend to be more impulsive (Derryberry & Tucker, 2006; Rothbart, 2011). These tendencies may have caused children who scored higher for PAS in the 9-month DCW to also score higher on the hyperactivity/impulsivity component of the SDQ inattention/ hyperactivity subscale at 54 months, compared to children with other temperaments.

We had several findings relating parenting styles to EFs or inattention/hyperactivity. Note that the results that follow pertain to parents who may have scored higher on a particular dimension of parenting compared to other parents, but this does not mean that these parents do not also demonstrate the other parenting styles, such as warmth/affiliation.

We found that the permissive/low parenting confidence parenting style in mothers increased the odds of children having poorer cool EFs. Previous research has shown that permissive or lax parenting is positively related to ADHD symptoms, hyperactivity and difficulties with EFs, perhaps due to a lack of rules or enforcement of rules (Goldstein et al., 2007; Muñoz-Silva et al., 2017), or lack of scaffolding of children's behaviour (Hutchison et al., 2016). Parental guidance and training is likely to play a key role in the development of children's EFs, as children gradually develop their capacity to interpret and respond adaptively to the demands of their environment (Barkley, 2001).

Mothers' use of a verbally hostile parenting style was associated with greater difficulties with inattention/hyperactivity. According to Robinson et al. (1995), verbal hostility is one of the factors included in the authoritarian parenting style. As authoritarian parents tend to place and enforce more restrictions on their child's behaviour, allowing their child little autonomy (Baumrind, 1971), it follows that verbal hostility can be used as a method for increasing parental control over their children. As previously noted, if a child is displaying symptoms of hyperactivity, inattention, or impulsivity, it may lead to a range of difficulties for the child. This may prompt parents to use a more forceful verbal approach, in an attempt to control their child's behaviour and try to limit the negative outcomes for their child. This provides a potential explanation for the positive relationship between verbal hostility/discipline parenting and symptoms of inattention/hyperactivity identified in our study. Alternatively, the use of a controlling parenting style might interfere with the child's ability to learn effective ways of improving their own self-management, which may be a particularly important focus for children with, for example, symptoms of ADHD, who are more likely to exhibit higher levels of impulsiveness (American Psychiatric Association, 2013).

Our study also identified a positive relationship between higher maternal use of verbal hostility/discipline and children's cool EFs at 54 months. It seems likely that verbal hostility would occur as a consequence when a child fails to follow a parent's behavioural expectations (Kiff, 2011), rather than when the child is compliant. However, when children pay attention to and adhere to parents' instructions, an absence of verbal hostility may reward the child's compliant behaviour and increase the likelihood it will occur (Hineline & Rosales-Ruiz, 2013). Hence, these children may become practiced in paying careful attention to and trying to conform with their parents' instructions. This effect may transfer to other adults or authority figures, which may explain why these children were more likely to inhibit prepotent incorrect responses on the Hand Clap task compared to children whose mothers scored lower on verbal hostility/discipline. However, previous work conducted by Hutchison et al. (2016) found a negative relationship between authoritarian parenting and EFs for children aged 7–18 years, which suggests that any such benefit to EFs may not persist beyond the preschool years.

We also found that physically punitive parenting was associated with poorer cool EFs. This is in line with Roskam et al. (2014), who found that physical punishment is associated with poorer development of EFs in children aged 2–8 years. Parents who use physical punishment are less likely to explain why a behaviour is wrong and should be avoided, likely decreasing the opportunity for verbal interactions (Straus & Paschall, 2009), which are associated with improved cognitive gains in young children (Huttenlocher et al., 1991; Page et al., 2010). In line with this, Roskam et al.'s results suggest that development of EFs is promoted when parents have discussions, encourage, and spend time with their children. This may create a safe environment in which children can gradually "internalize rules and values" that may assist them in controlling their own behaviour (p. 179).

### *4.7.1 Strengths and Limitations*

A strength of this study is that we employed a measure of screen time (patterns of screen time) that is more representative of today's screen media landscape, while many of the previous studies have focused exclusively on children's exposure to TV. We also included a range of other media-related variables that describe various media parenting behaviours that children may experience in the home, i.e., frequency of co-viewing, having rules restricting media use, allowing meals in front of TV, allowing the child to watch adult- or child-directed content, and leaving the TV playing in the same room as the child whether the child is watching it or not. Therefore, our findings are likely to provide relevant information about how preschool children's screen media use in today's context may relate to the development of EFs, and symptoms of inattention/hyperactivity.

Another strength of this study was our longitudinal design that allowed us to consider children's screen time across the preschool years, rather than at a single point in time. This is important as children's capabilities and developmental needs undergo significant changes during this time period, and children may be more vulnerable to the effects of environmental influences such as screen media exposure at different ages (Zelazo & Carlson, 2012). Further, the majority of our predictor variables were obtained at the 2-year DCW, allowing us to assess their ability to predict EFs and inattention/hyperactivity at a later time point, i.e., 54 months. However, related to this, we acknowledge that our study did not employ an experimental design, which precludes the ability to determine causation. For example, it has long been acknowledged that the effects of parents on children are bi-directional (e.g., Bell, 1968). Hence, due to our study design, it is not possible to identify the direction of the relationships between cool EFs, inattention/hyperactivity and parenting styles identified in our study. Further, we cannot rule out the possibility of additional confounding variables contributing to our results; however, the extensive range of covariates that we controlled for in our models may go some way to protecting against this effect.

A further strength of this study is the inclusion of father's data, matched to mother's data on all parental predictor variables, with the exception of maternal parenting styles. Fathers have an important role to play in their children's development (Pleck, 2010); therefore our inclusion of fathers' data provides a more authentic view of the context in which development occurs. However, this approach is likely to have reduced the proportion of sole parents included in our sample, which may affect the generalisability of our results to families with sole parents.

A strength of this study is that it drew on a large sample from the GUiNZ cohort that is broadly representative of children in the wider population in terms of ethnicity and SES. As New Zealand is a Western society with growing ethnic diversity (Belich et al., 2008), our findings may therefore be applicable to other Western countries. However, as noted above, our results may be more relevant to children who have two parents involved in their parenting.

Another important strength of our study is that we used observational measures of both hot and cool EFs by trained interviewers. However, the other measures included in our study were obtained by parent report, which can be affected by social desirability bias (Nederhof, 1985). Still, as parents have made a long-term commitment to be involved with the GUiNZ study and as such are likely to view the involvement as important, we believe this would motivate them to try to give accurate information. With regard to the accuracy of our screen time measures, which were provided by mother report, Borzekowski and Robinson (1999) found that although this method of data collection can introduce measurement error, no systematic bias was evident.

A limitation of our study is that our measure of content was divided into two broad categories of hours of viewing "adult" or "child" directed content. Although it is informative to examine whether content intended for different audiences (i.e., adults or children) may relate differentially to children's EFs, classifying content in more specific ways, as demonstrated in some of the previous research, e.g., aggressive, prosocial or neutral content (Friedrich & Stein, 1973) and fantastical versus realistic content (Lillard & Peterson, 2011), may have captured differences in type of content that are more relevant to the development of children's EFs. For instance, Friedrich and Stein (1973) found that viewing of aggressive screen media content was associated with tolerance of delay, or hot EFs. Therefore the null findings related to content may be due to this limitation of our study.

### *4.7.2 Next Research Steps*

Our findings demonstrate that some of the predictors of cool EFs were not related to hot EFs, which is perhaps to be expected as hot and cool EFs develop independently (Zelazo & Carlson, 2012). As noted by Kerr and Zelazo (2004) and Tsermentseli and Poland (2016), past research in this field has predominantly focused on cognitive, or cool, aspects of EFs, which signals an opportunity to further explore the range of variables that may be specifically associated with hot EFs.

### *4.7.3 Implications for Practice*

Our study identified two media parenting behaviours (allowing children to have meals in front of TV and children having higher levels of exposure to TV) that could potentially be targeted to try to improve the outcomes of hot and cool EFs for preschool children. While not asserting causal relationships, the prospective relationships of screen time during meals at 45 months with poorer cool EFs at 54 months and higher levels of weekday TV exposure at 2 years with poorer hot EFs at 54 months does at least suggest the possibility that reducing screen time levels in these contexts may protect against experiencing these difficulties for some children. Parents of preschool children may therefore wish to err on the side of caution and limit their children's exposure to TV in their environment. For instance, present guidelines from the World Health Organisation advise limiting sedentary screen time for 2-year-old children to less than an hour per day (World Health Organisation, 2019). Our findings also suggest that keeping meal-times free of the interruption of screens might support the development of cool EFs in preschool children.

## 4.8 Conclusion

Our study investigated the relationships between screen media use and the development of EFs and inattention/hyperactivity during the preschool years, and included data from mothers, fathers and children ($N$ = 3,787) participating in the GUiNZ study when the children were preschool age. Contrary to our hypotheses, the content of screen media and whether or not parents co-viewed with their children were not found to be associated with either EFs or inattention/hyperactivity at 54 months. However, there were two significant findings related to other screen exposure measures, i.e., eating meals in front of TV at 45 months, and exposure to TV on a weekday at 2 years. Our findings provide evidence that associations between TV exposure and poorer EFs persist in the modern media landscape that children experience today.

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Please see:

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# Chapter 5. Associations Between Technoference, Quality of Parent-infant Interactions, and Infants' Vocabulary Development (Study 4)

Distraction from interpersonal activities by screen technologies, in particular mobile technologies, has been labelled "technoference" (McDaniel & Radesky, 2018). There is growing evidence that technoference occurs in the context of parent-child interactions, and may impact negatively on parents' interactions with their children. The present research was conducted to explore associations between potential sources of technoference, parental interactions with their infants, and early language development.

Converging evidence from a growing number of studies suggests that parents' use of mobile screen technologies can distract them from attending to and interacting with their children. In a naturalistic study conducted by Radesky et al. (2014a), caregivers and children were observed in a family restaurant. The majority (73%) of caregivers used technology during the meal, which appeared to reduce the adults' attention to the children in their care. Golen & Ventura (2015) found that mothers who became distracted while bottle feeding their infants in a laboratory setting, including by use of mobile technology, were less sensitive to the cues of their infants and more prone to over-feeding compared to mothers who were not distracted, if their infants were low on orienting/regulation or surgency/extraversion. Radesky et al. (2015a) conducted a study in which parents tried different foods with their 6-year-old children in a laboratory setting. During this task, some mothers spontaneously used their phones. Mothers who did so interacted less and spoke less to their children during the task compared to mothers who did not use their phones. In a naturalistic study of caregivers and children conducted at a playground, the majority of caregivers (approximately 60%) were observed using their phones and there were 32 occurrences of children trying to attract their caregiver's attention while the caregiver was involved with using their phone (Hiniker et al., 2015). Similarly, parents observed in waiting rooms and at playgrounds with their preschool child aged 0–5 years were five times less likely to respond to their child's bids for attention whilst using their phones compared to when they were not using their phones. Responses to bids were delayed, lower in positive affect and less focused on the child (Vanden Abeele et al., 2020).

There is evidence to show that some parents recognise that their use of screen technology impacts on their parenting. Ten percent of parents of 0- to 4-year-old children surveyed in a study conducted by Ante-Contreras (2016) reported that their use of social media had on occasion impaired the quality of the supervision they provided to their child, or increased the risk of danger to their child. Further, at least 20% of mothers of children aged up to 3 years reported that their use of technology had impacted on time spent with their child in the following domains: during playtime and educational activities, at meal times and bed time, spending time with their child, and when setting limits or disciplining their child (McDaniel & Coyne, 2016).

Technoference may not only affect parents' behaviour towards their young children, but may also shape children's expectations of their interactions with their parent. This is demonstrated by a study conducted by Myruski et al. (2018), which utilised a modified still face paradigm (Tronick et al., 1978) in which mothers first played with their infant (aged 7–20 months) (free play), had 2 min in a modified still face condition (paying attention to their phone, not the child), and then returned to play with their child (reunion). In addition, mothers were asked to report on their use of mobile screen technologies in the family context and in front of their infant. During the still face/phone use condition, children engaged less with their parents compared to the free play condition, but made more bids compared to both the free play and the reunion phase. Importantly, children of mothers who reported greater *habitual* use of mobile technology, or reported higher frequency of using their devices in front of the child or other family members, engaged less with their mother during the reunion phase.

As demonstrated by the studies to date, parental use of mobile technology may decrease the quality and quantity of parent-child interactions (e.g., Myruski et al., 2018; Radesky et al., 2014a; Vanden Abeele et al., 2020). There are several possible reasons why this may occur. A parent's attention be captured by or focused on their mobile device, diminishing their ability to focus their attention on their child (McDaniel & Coyne, 2016a). Another possibility is that mobile technology use may render the parent "unavailable" (Myruski et al., 2018), with parent-child interactions being put "on hold" until the parent disengages from their device (Nakamura, 2015). Alternatively, parents may interact with their child while using their device, but these interactions may be cursory, brief and/or delivered without eye contact (Aagaard, 2016; Radesky et al., 2014a). Hence technoference is likely to impact negatively on parents' ability to respond appropriately and contingently to their children's needs, as parents may be less aware of their children's social cues and less able to respond in a timely manner (Radesky et al., 2016; Vanden Abeele et al., 2020).

It is also possible that technoference might occur even when parents are not actively using their mobile device. According to Misra et al. (2014), mobile technology users may habitually divide their attention between their devices and people in their immediate environment due to an "urge" to keep up to date with incoming communication and information, and opportunities to connect with others via the internet. There is some support for this mechanism of technoference, as Misra et al.'s study showed that simply having a mobile device nearby and visible during face-to-face conversations diminished participants' self-evaluations of empathetic concern and connectedness towards their social partners. The potential for technoference arising in mothers' interactions with their toddlers and infants even in the absence of active use may be particularly pertinent, given that most new mothers report going on the internet or using computers on a daily basis, for 3 hr per day (p/day) on average (McDaniel et al., 2012). This may in many cases be beneficial to mothers, as it may enable them to maintain their connections with others outside the home and receive social support (McDaniel et al., 2012); however, it may increase the risk of technoference impacting on their interactions with their child.

Although several studies have investigated the associations between infant and toddlers' language skills and the amount of screen time and background television (TV) that children are exposed to (e.g., Byeon & Hong, 2015; Lin et al., 2015; Masur et al., 2016; Ribner et al., 2017; Tomopoulos et al., 2010; Zimmerman & Christakis, 2005) (predominantly finding negative associations), we found only one study that specifically investigated the connections between parents' use of mobile screen media, parent-child interactions, and language development in children aged up to 2 years (i.e., Reed et al., 2017). Using a within-subjects design, Reed and colleagues asked mothers to teach their 2-year-old children two new words in two different conditions, interrupted versus uninterrupted. In the interrupted condition, mothers received a phone call while in the process of teaching their children one of the words, while in the uninterrupted condition the teaching of the new word proceeded without the mother receiving a phone call. Although there was no difference in the number of times children heard the word repeated in either the interrupted versus uninterrupted condition, children were more likely to learn the word in the uninterrupted condition. The authors attributed the reduction in effective word learning in the interrupted condition to a break in maternal responsiveness to the child (Reed et al., 2017). This result is to be expected, as the links between parental responsiveness and language development in early childhood are well established (Tamis-Lemonda et al., 2006). When parents provide contiguous, contingent and appropriate responses to their young child's cues and bids for interaction, this provides information that can help the child construe the meanings of words and how they relate to the world around them (Tamis-LeMonda et al., 2014).

There are other dimensions of parent-child interaction that are related to language development, which might also be compromised if a parent pays less attention to their young child due to technoference. For instance, parental ability to enter into periods of coordinated joint attention (CJA) with their child, when both attend to the same objects and activities, has been shown to support vocabulary development in young children (Carpenter et al., 1998; Tomasello & Farrar, 1986). However, CJA is arguably less likely to occur if parents are distracted by screen technologies and unaware of what their child is attending to. Scaffolding, which occurs when parents adjust their behaviour during interactions with their child to provide a supportive framework for their child's learning and development, has also been linked to language development (Wasik & Jacobi-Vessels, 2017). Successful scaffolding occurs when parents are "emotionally available" to their child (Biringen et al., 2000), which again is less likely to occur when parents are distracted by screen-technologies. Conversely, directive or restrictive parenting is related to slower acquisition of language during the preschool years compared to responsive parenting (Landry et al., 1997). Directive parenting may be *more* likely to occur during technoference, as a means of managing children's behaviour with minimal interruption of the parent's screen usage. Radesky et al.'s (2014a) naturalistic study in a restaurant provides some evidence for this, as caregivers absorbed in their phones were observed giving brief and sometimes harsh instructions to the children in their care before focusing again on their phones.

To date, no research has investigated whether parents who frequently experience technoference via their mobile devices might establish less optimal patterns of interacting with their children, even when their mobile devices are not in use or unavailable. The possibility of this is supported by studies conducted by Masur et al. (2016), who showed that parents who habitually play with their child in the presence of background TV demonstrate poorer quantity and quality of speech when speaking to their child, even when there is no TV present; and by Myruski et al. (2018), who found evidence that habitual use of screen devices by parents may reduce children's ability to re-engage with their parent after their parent has been distracted by cell phone use. Examining the effects of technoference on early parent-child interactions and child outcomes is particularly important given that, in today's media context, many people have their devices with them constantly (Rainie & Zickuhr, 2015). Hence mobile technology may have even greater scope to intrude on parent-child interactions throughout the day compared to children's own use of screen media, potentially increasing the risk of detrimental effects on children's language development.

The present study addresses this gap in the literature by investigating the effects of technoference on key markers of high-quality parent-infant interactions (i.e., increased responsiveness, scaffolding, CJA; reduced directiveness). We hypothesised that higher levels of technoference via screen technologies would be associated with lower levels of parent-child CJA, parental responsiveness and scaffolding, and higher levels of directiveness during a play interaction in which parents are not actively using devices. To enhance our understanding of the ways in which technoference may influence parent-child interaction variables, we included different measures of screen exposure that parents experience when with their infant, including the time the parent spends on their mobile device per hour (p/hour) when with their infant; the number of audible notifications the parent receives p/hour on average, the number of times p/hour they check their device; having their device within easy reach; and parents' score on the Distraction In Social Relations and Use of Parent Technology (DISRUPT) scale (McDaniel, 2020). We also explored associations between parent-child CJA, parental responsiveness, scaffolding, directiveness and vocabulary, and other screen usage variables that may vary across parents and households, i.e., parent consciously deciding to put phone their away when with their infant; parent co-using screens with their infant; parent's average amount of screen time when with their infant, and infant's screen time.

Given the established links between parent responsiveness, directiveness, and scaffolding on children's early language development, a second goal of this research was to test the extent to which parental technoference is negatively associated with infants' language development and, if so, whether the association is mediated by our parent-child interaction variables of interest.

## 5.1 Method

### *5.1.1 Participants*

Eighty-two infants and their parents visited a specially designed research laboratory in a large city in Australasia to participate in a study investigating digitally mediated interactions between parents and infants aged approximately 20 months. Participants were drawn from a database of parents who have previously expressed an interest in participating in child development studies. Potential participants are recruited through the lab website, Facebook page, and various child-focused public events. Participants reside in Auckland, New Zealand. Parents were entered into a draw for a $50 petrol or supermarket voucher and the infants received a small prize (e.g., book) for their participation. Thirty-nine infants were not included in the final sample of the present study for the following reasons: technical errors (e.g., sound recording not working) ($n$ = 13), infant fussing out during the interaction ($n$ = 1), parent did not complete the critical online questionnaire ($n$ = 23), parent not being the primary caregiver ($n$ = 1), and infant born before 37 weeks ($n$ =2). Thus, our final sample was comprised of 43 infants (21 females, 22 males, $M_{age}$ = 20.84 months, $SD_{age}$ = 2.07, range = 18–25 months) who were all born full-term and exposed to a minimum of 80% English; and their primary caregivers. Twenty-two had siblings and 21 were only children. Parents comprised 41 females and 2 males who ranged in age from 29–45 years ($M_{age}$ = 34.74 years, $SD_{age}$ = 3.41). There was an effect of parental age on completion of the questionnaire at the $p < .05$ level, [F(1, 81) = 5.92, $p$ = .017] and on inclusion in the sample at the $p < .10$ level, [F(1, 81) = 2.99, $p$ = .087], with older parents more likely to complete the questionnaire or be included in the sample. There was no effect of education.

Thirty-three parents identified their infant's ethnicity as New Zealand European (NZE); four as Asian; two as NZE and Asian; one as Māori; one as NZE, Māori and Chinese; one as NZE and Pacific peoples; and one as NZE and Canadian European. Five parents reported that they had completed Year 11 ($n = 2$), or Year 13 ($n = 3$) at school (or equivalent); eight had post-school qualifications (trade/apprenticeship, certificate or diploma), 20 had bachelors' degrees and 10 had higher degrees. As the participants in this study were also participating in a broader study on digitally mediated communication, only the tasks directly relevant to this study are described in detail below.

### *5.1.2 Procedure*

Upon arrival at the laboratory, the experimenter described the study to the parent and gave the parent the information sheet, consent form, and demographic questionnaire to complete. During this time, the infant played with the main experimenter and a secondary experimenter. Once the experimenter answered any questions the parent may have had and the parent provided informed consent, the experimenter escorted the parent and infant to the room where the first half of the experimental session took place. All procedures were approved by the University of Auckland Human Participants Ethics Committee.

Approximately halfway through the session, an experimenter led the parent and infant to the room where the parent-infant interaction relevant to the present research took place. In the room was a small table with a box containing a jigsaw puzzle, a set of different coloured plastic stacking cups, and a wire bead maze (i.e., beads are threaded onto different coloured plastic-coated wires that are moulded into different shapes) beside it (refer to Figure 5.1). The room also contained two cameras and a microphone to record the parent-infant interaction. Once inside the room, the experimenter said to the parent: "We've got some toys here, feel free to play just like you would do at home, for about three minutes. I'll pull this curtain and be back here. If you need anything let me know. Otherwise, I'll let you know when the time is up." The experimenter remained hidden behind the curtain for 3 min before returning to escort them back to the other room for the next phase of the research (not pertinent to the current study). After the final phase of the study, the experimenter escorted the parent and infant back to the waiting room where they answered any questions the parent had, and the infant selected their prize.

**Figure 5.1**

*Photograph of the Toys Provided for the Parent–Infant Interaction in the Early Learning Laboratory, University of Auckland*

*Note*. This photo has been taken in the room where parents and infants played. The toys were not set out on the table when the parent and infant entered the room; they were on the floor beside the table in a container with no lid and parent and/or infant took out some, or all, of the toys. The experimenter hid behind the curtain visible in the background while the parent and infant played for approximately 3 min.

**5.1.2.1 Online Questionnaire.** After the completion of the laboratory session, the parent was sent a link to an online questionnaire hosted on the Qualtrics platform to complete at their convenience. The questionnaire included questions on the parent's and the infant's screen media usage on weekdays and weekends, general questions about technology use, questions designed to measure potential sources of technoference and problematic use of mobile technology (refer to Table 5.1), and the infant's language development. The questionnaire required approximately 25 min to complete. Parents were sent an automated reminder to complete the questionnaire 7 days after the laboratory session if the questionnaire had not been submitted. Independent variables used in this study were derived from information provided by the infants' caregivers in the online questionnaire, or the hard copy demographics questionnaire completed by caregivers during the lab session. Technoference variables were reported by parents and included the amount of time the parent spends on their mobile device p/hour when with their infant; the number of audible notifications the parent receives p/hour on average; the number of times p/hour they check their device; how much screen time they have on average when with their infant; having their mobile device within easy reach; and parents' score on the Distraction In Social Relations and Use of Parent Technology (DISRUPT) scale (McDaniel, 2020).

**Table 5.1**

*Questions Administered to Parents and Variables Used in the Current Study.*

| Question administered to parents | Response options | Construct/Variable | Manipulation |
|---|---|---|---|
| 4-item Distraction In Social Relations and Use of Parent Technology (DISRUPT) scale (McDaniel, 2020). Sample item: "During time I spend with my C… I find it difficult to stay away from checking my phone or mobile device." | 1) Strongly disagree; 2) Disagree; 3) Somewhat disagree; 4) Somewhat agree; 5) Agree; 6) Strongly agree | Problematic use of mobile technology | Mean score was calculated. Cronbach's alpha = .86. |
| "On average, how many times PER HOUR do you receive audible notifications on your mobile phone or another mobile device when you are with your C? (Note: Please only include time when your C is awake.) (If not applicable, put NA in the box below.)". | Ps responded with the number of notifications p/hour or NA. | P's average audible notifications p/hour | |
| "Please estimate how many times PER HOUR you check your mobile phone or another mobile device when you are with your C? (Note: Please only include time when your C is awake.) (If not applicable, put NA in the box below.)." | Ps responded with the number of mobile checks p/hour or NA. | P's mobile checks p/hour | |
| "Approximately how many MINUTES PER HOUR on average do you spend using your mobile phone or other mobile device when you are with your C? (Note: Please only include time when your C is awake.) (If not applicable, please put NA in the box below.)". | Ps could respond with the number of minutes p/hour or NA | P's minutes of mobile technology use p/hour | |
| "Please indicate (in hours and minutes) YOUR average amount of screen time when you are with your C on each day of the week. (Note: Please include time spent using ANY type of screen-based technology, and only include time spent on a screen when your C is awake. Please include ANY time you use screen-based technology, whether your C is using it with you or not.)" | Ps provided responses for each day of the week in hours and minutes. | P's screen time when with their C | P's total screen time when with C during the week was calculated. |

| Question administered to parents | Response options | Construct/Variable | Manipulation |
|---|---|---|---|
| "How often would you have your mobile phone or other device within easy reach when spending time with your C?" | 1) All of the time; 2) Most of the time; 3) Half of the time; 4) Less than half of the time; 5) Hardly any of the time or never; 6) Not applicable. | Accessibility of mobile device | Responses 1 and 2 were recoded to Most or all of the time (REF); responses 3 - 5 were recoded as half the time or less. |
| "How often do you usually PARTICIPATE in your C's screen use, i.e. you are both watching or using the same device at the same time?" | 1) All of the time; 2) Most of the time; 3) Half of the time; 4) Less than half of the time; 5) Hardly any of the time or never; 6) Not applicable. | P-C co-use of media | Responses 1 and 2 were recoded to Most or all of the time (REF); responses 3 - 5 were recoded as half the time or less. |
| "How often do you consciously decide not to use your mobile device when with your C, and then turn it off or put it away for a while?" | 1) Everyday; 2) Several times a week; 3) Once a week; 4) Once every two weeks; 5) Occasionally or never; 6) Not applicable. | P making conscious decision to put phone away | Responses 1 - 2 were recoded as Several times a week/everyday (REF); Responses 3 - 5 were recoded as Once a week or less/never. |
| Please indicate (in hours and minutes) YOUR C's average amount of screen time when you are with your C on each day of the week. (Note: Please include ANY time your C uses screen-based technology, whether your C is using it with you or not.)" | Ps provided responses for each day of the week in hours and minutes. | C's screen time when with their P | C's total screen time when with P during the week was calculated. |
| "How often is a TV left playing in your home, when your C is present but not actually watching it? (Note: Only include times when he/she is in the vicinity of the TV and would be able to see it or hear it.)" | 1) All of the time; 2) Most of the time; 3) Half of the time; 4) Less than half of the time; 5) Hardly any of the time or never. | C's exposure to background TV (background TV). | Responses 1 – 3 were recoded as Half the time or more; responses 4 – 5 were recoded as Less than half the time (REF). |
| "Please indicate (in hours and minutes) how much time on average you usually spend with your C on each day of the week. (Note: Please ONLY include time when your C is awake.)" [c] | Ps provided responses for each day of the week in hours and minutes. | Total time spent with the C per week | Total for the week was calculated. |
| "Which of the following mobile devices do you mostly use?" | 1) Mobile phone, 2) Tablet; 3) Smart watch; 4) Blackberry; 5) Other (please specify), 6) Not applicable | P's main mobile device. | |

| Question administered to parents | Response options | Construct/Variable | Manipulation |
|---|---|---|---|
| "Which of the following does your C have access to in the home? | 1) Computer; 2) Mobile phone; 3) Tablet/iPad; 4) video games; 5) TV; 6) Other (please specify). Ps were able to select all options that apply. | C's access to screen technology. | |
| "How often does your C use any type of mobile device?" | 1) occasionally or never; 2) once every two weeks; 3) once a week; 4) several times a week; 5) every day. | Frequency of C's mobile use | |
| "Which statement best describes YOUR C's screen time on weekdays, i.e. Monday – Friday?" and "Which statement best describes YOUR C's screen time on weekdays, i.e. Saturday – Sunday?" | 1) It is mainly for entertainment; 2) It is mainly for educational purposes; 3) It is mainly to interact with other people, e.g. Skype, Facetime; or 4) Other (please specify). | Reasons for C's screen time. | Responses were differentiated for weekdays and weekends. |
| "Which statement best describes your use of your mobile phone or another mobile device when you are with your C on a weekday, i.e. Monday to Friday?" and "Which statement best describes your use of your mobile phone or another mobile device when you are with your C on a weekend day, i.e. Saturday - Sunday?" | "I mainly use it… 1) to keep in contact with friends and family, e.g., Facebook, text messaging; 2) for entertainment, e.g., watching videos, playing games; 3) for my paid employment, communicating with clients, completing work; 4) for family/household matters, e.g. arranging appointments, online purchases, searching for information that will benefit the family; 5) I do not use it; 6) Other (Please specify). | Reasons for P's mobile use. | Responses were differentiated for weekdays and weekends. |

*Note.* C = Child; P = Parent; REF = Reference category.

Other variables related to the home media environment also included frequency of: a) parent consciously deciding to put phone away when with their infant; b) parent co-using screens with their infant; c) how much screen time infants have on average when with their parent; and d) infant's exposure to background TV (refer to Table 5.1 for details). The infant's vocabulary size, our dependent measure of infants' language development, was assessed via the 100-item MacArthur-Bates Short Form Vocabulary Checklist: Level II (Form A) (M-CDI Level IIA) (Fenson et al., 2000) completed by the primary caregiver.

**5.1.2.2 Coding and Parent-Infant Interaction Variable Creation.** Two coders simultaneously coded 68 parent-infant interactions offline using a coding scheme that was developed with reference to Adamson et al. (2012); Bakeman et al. (1984); Biringen et al. (2000) Emotional Availability Scale 3rd edition; Carpenter et al. (1998); Hobson et al. (2004), adapted from Murray et al. (1996); Pine (1994); Tamis-LeMonda et al. (2001) and two previous coding schemes employed in the ELLA lab (Allen, 2018; Low et al., 2019). Of these, 43 cases were ultimately included in our sample, for reasons previously outlined. The key variables of interest that were coded include: parental responsiveness, scaffolding, CJA and directiveness (available from first author on request). The coding process for each interaction was as follows. First, two trained coders together watched the first half of the interaction to familiarise themselves with the interaction. The coders then watched the same video segment at least four more times, each time focusing specifically on one aspect of the coding scheme (i.e., responsiveness, scaffolding, CJA and directiveness) and recorded their initial codes for each dimension. Next the researchers shared their codes and discussed their reasons for assigning that code. The researchers then independently decided on their personal final codes for each dimension and recorded them. Where the coders' final scores did not agree, their scores were averaged. This process was repeated for the second half of each recording, resulting in separate final codes for the first and second halves of the interaction for each dyad. The final scores assigned during the first and second halves of the interactions were averaged, and these scores were used as the outcome variables for responsiveness, scaffolding, CJA and directiveness. Note that the reliability of the coding was based on the initial codes independently assigned by each researcher *prior* to discussion, using the absolute Intraclass Correlation Coefficient (ICC) method. The ICC indicates the extent to which measurements made by different coders 1) are correlated and 2) agree (Koo & Li, 2016) and as the variability between coders was of interest, we used the two-way mixed model with measures of absolute agreement (Nichols, 1998).

### *5.1.3 Definitions and ICCs for the Parent-Child Interaction Variables*

**5.1.3.1 Parental Responsiveness.** Responsive parents are aware of their child's activities and cues, follow their lead, and respond appropriately and in a timely manner (Wilson & Durbin, 2013). Responsiveness was rated on a scale of 1 (*Not responsive at all*); 2 (*Rarely responsive*); 3 *(Inconsistently responsive*); 4 (*Often responsive*) and 5 (*Extremely responsive*). For the first half of the interaction ICC = .978, 95% CI [.964, .986]; for the second half ICC = .990, 95% CI = [.984, .994]; final averaged score ICC = .984.

**5.1.3.2 Scaffolding.** Scaffolding refers to a range of strategies that support children's learning. Effective scaffolding is contingent on children's current abilities and enables them to learn and develop new skills (Carr & Pike, 2012). Strategies include asking questions, giving feedback and creating opportunities for children to practise new skills (Wasik & Jacobi-Vessels, 2017). Scaffolding was rated on a scale of 1 (*Never scaffolds*); 2 (*Rarely scaffolds*); 3 (*Inconsistently scaffolds*); 4 (*Often scaffolds*) and 5 (*Always scaffolds*). For the first half of the interaction ICC = .971, 95% CI [.953, .982]; for the second half ICC = .964, 95% CI [.941, .978]; final averaged score ICC = .967.

**5.1.3.3 Coordinated Joint Attention.** CJA occurs when parent and infant are interacting together and coordinating their attention towards an object of interest (Bakeman

& Adamson, 1984). CJA was rated on a scale of 1 (*Never engaged in CJA*); 2 (*Rarely engaged in CJA*) 3 (*Somewhat engaged in CJA*); 4 (*Often engaged in CJA*) and 5 (*Always engaged in CJA*). For the first half of the interaction ICC = .984, 95% CI [.975, .990]; for the second half ICC = .976, 95% CI [.962, .985]; final averaged score ICC = .980.

**5.1.3.4 Directiveness.** Parents display directiveness when they lead interactions with their infant by giving verbal or non-verbal directives about what the child should do (Landry et al., 2000). Directiveness was rated on a scale of 1 (*Not directive*); 2 (*Rarely directive*); 3 (*Inconsistently directive*); 4 (*Often directive*) and 5 (*Always directive*). For the first half of the interaction ICC = .985, 95% CI [.975, .991]; for the second half ICC = .991, 95% CI [.985, .995]; final averaged score ICC = .988.

### *5.1.4 Preliminary Data Analyses*

**5.1.4.1 Data Screening and Assumption Testing.** The Shapiro-Wilks test was used to test if our data for vocabulary, responsiveness, directiveness, CJA and scaffolding come from normal distributions. Vocabulary passed the Shapiro-Wilks test, W(43) = .977, $p$ = .522, but the remaining variables failed this test. However, as skewness and kurtosis scores for these variables were within the range ±1, with the exception of responsiveness whose kurtosis score was ±1.16, it is reasonable to assume that their sample distributions are sufficient to meet the assumption of normality, whereby skew and kurtosis scores need to be within the range ± 2 (George & Mallery, 2016).

Data was checked for outliers and multicollinearity. Most maximum values for variables in our dataset were deemed to be plausible. However, we found that one parent had entered scores > 24 for the amount of time they use screens when with their child, on Saturdays and Sundays. Both values were replaced using mean substitution based on other parents' responses on time spent using screens when with their child on Saturdays and Sundays.

Two additional outliers were identified. One parent indicated that they spend on average 56.5 hr per week using screen technology when with their child, which equates to over 8 hr p/day. We found that this variable exceeded three standard deviations (*SD*) above the mean and so this score was winsorised to 35, which was the next score down. Similarly, one parent reported that they checked their mobile device 30 times p/hour. This score also exceeded three *SD*s from the mean and was winsorised to 10.

All parent-infant interaction codes were inter-correlated. Responsiveness was significantly correlated with scaffolding ($r_p = .756$, $p < .01$), CJA ($r_p = .661$, $p < .01$) and directiveness ($r_p = -.611$, $p < .01$). Scaffolding was also correlated with CJA ($r_p = .657$, $p < .01$) and directiveness ($r_p = -.651$, $p < .01$), and CJA was correlated with directiveness ($r_p = -.556$ $p < .01$). However, as these variables were not intended for use in the same regression analyses, there was no concern that they would cause multicollinearity.

We also tested the correlations of forms of technoference and other variables to be used in regression analyses (refer to Table 5.2). The correlation between ‘Time infant uses screens when with parent per week’ and ‘Frequency of exposure to background TV’ was strong ($r_p = .733$, $p < .01$). However, as these variables were not to be used in the same regression analyses, there was no risk of multicollinearity. No other correlations exceeded .7 (Tabachnick & Fidel, 2013).

**Table 5.2**

*Pearson Correlations for Technoference and Screen Variables Used as Predictor Variables in Regression Analyses*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. DISRUPT score | - | | | | | | | | | | | | |
| 2. Audible notifications p/hour | .069 | - | | | | | | | | | | | |
| 3. Mobile checks p/hour | .394$^{**}$ | .083 | - | | | | | | | | | | |
| 4. Minutes p/hour using mobile device | .283 | .223 | .626$^{**}$ | - | | | | | | | | | |
| 5. P’s time using screens when with C | .357$^{*}$ | .105 | .446$^{**}$ | .436$^{**}$ | - | | | | | | | | |
| 6. Device in easy reach half the time or less | -.382$^{*}$ | -.168 | -.516$^{**}$ | -.274 | -.215 | - | | | | | | | |
| 7. P-C co-use screens half the time or less | .029 | .150 | -.111 | -.119 | .137 | -.169 | - | | | | | | |
| 8. Less freq. P screen-free decision | .271 | -.174 | .238 | .113 | -.003 | -.309$^{*}$ | -.282 | - | | | | | |
| 9. C’s time using screens when with P | .129 | .125 | .327$^{*}$ | .323$^{*}$ | .551$^{**}$ | -.174 | .255 | -.055 | - | | | | |
| 10. C’s exposure to background TV | .195 | .176 | .340$^{*}$ | .353$^{*}$ | .470$^{**}$ | -.196 | .040 | -.031 | .733$^{**}$ | - | | | |
| 11. Time P and C spend together p/week | -.098 | -.084 | -.149 | .103 | .272 | .208 | .241 | -.101 | -.040 | -.125 | - | | |
| 12. P’s highest education (lower than a degree) | -.091 | .049 | -.068 | .081 | .013 | -.025 | -.014 | -.195 | .258 | .474$^{**}$ | -1.43 | - | |
| 13. Child age | .178 | -.091 | .066 | .383$^{*}$ | .195 | -.017 | .128 | .238 | .455$^{**}$ | .201 | .161 | -.047 | - |

*Notes.* P = Parent; C = Child; Freq.= frequency.
$^{**}$Correlation is significant at the .01 level (2-tailed) $^{*}$Correlation is significant at the .05 level (2-tailed)

**5.1.4.1 Missing Data Analysis.** A dataset was prepared of the variables to be included in regression analyses. The number of missing values in our dataset was very low (*n* = 5, 0.73%). Three variables (*n* = 19%) were missing data, with three missing data points on the variable 'Frequency of parent co-using screens with the child' (7%) and one missing datum (2.3%) on each of the variables 'Parent's average mobile notifications p/hour' and 'Parent consciously deciding to turn off or put away their mobile device when with their infant'. Due to the small proportion of missingness overall, we conducted regression analyses on complete cases.

### *5.1.5 Descriptive Analyses*

Descriptive analyses were conducted on the outcome variables parental responsiveness, scaffolding, CJA, directiveness and vocabulary. Descriptive analyses were also conducted on the predictor variables related to the screen media environment that infants experience in the home, infants' patterns of usage and parents' own media use.

### *5.1.6 Regression Analyses*

We first ran bivariate regression analyses to test if any of the different sources of technoference and other screen-related variables were significantly associated with responsiveness, directiveness, CJA, scaffolding, or vocabulary. If a predictor variable was found to be significantly associated with any of these variables in bivariate regression, we proceeded to test whether this relationship held in hierarchical linear regression, controlling for age of the child, the time parent spends together with the child per week, and parental education (dummy coded as 0 = bachelor's or higher university degree and 1 = school qualifications, trade/certificate or diploma). Control variables were entered in the first step and the relevant predictor was entered in the second step (each in separate hierarchal regressions).

### *5.1.7 SEM Analyses*

Where any technoference or screen measures were related to *both* vocabulary, and one of the measures of responsiveness, directiveness, scaffolding and CJA in hierarchical regression, this indicated that one of the parent-infant interaction variables of interest might mediate the relationship between technoference and vocabulary (Baron & Kenny, 1986). In these cases, we used structural equation modelling (SEM) in Mplus version 8.1 to determine whether there was a significant mediation effect. Confidence intervals were derived using the bias corrected boot-strapping method with 10000 samples (MacKinnon et al., 2004). Control variables were not included in the SEM analyses due to the small sample size. Due to our small sample size and exploratory nature of our study, a less conservative *p*-value was employed in all analyses ($p < .1$) (Cohen, 1992; Schumm et al., 2013).

## 5.2 Results

### *5.2.1 Descriptive Analysis*

On scales of 1–5, parents displayed fairly high levels of responsiveness ($M = 3.47$, $SD = 1.02$), CJA ($M = 3.70$, $SD = 0.99$), and directiveness ($M = 3.87$, $SD = 1.19$), but scored around the mid-point for scaffolding ($M = 2.60$, $SD = 1.08$). The mean score for vocabulary, out of a possible score of 100 words, was 42.86 ($SD = 24.13$), with a minimum of 1 and a maximum of 95.

On average, parents reported spending 60.64 hr with their infants per week ($SD = 16.44$) when their infant was awake. This equates to 8.66 hr p/day. During this time, parents use screens on average 23% of the time, while their infants use screens on average 11% of the time. The average amount of time infants spent using screens over the week was 6.40 hr ($SD = 5.27$), with a range of 0–17 hr per week. This suggests that, on average, infants in our study had 55 min of screen time p/day.

The majority of parents (62.5%, *n* = 25) take part in their infant's screen time most or all of the time, while 37.5% (*n* = 15) take part half the time or less. Frequency of mobile technology use by infants in our sample was: every day (*n* = 4, 9.3%); several times a week (*n* = 10, 23.3%); once a week (*n* = 4, 9.3%); once every two weeks (*n* = 4, 9.3%), occasionally or never (*n* = 21, 48.8%). Twenty-eight infants in our sample (65.1%) were exposed to background TV in the home less than half the time, and 15 (34.9%) were exposed half the time or more.

Parents identified the reason that best described why they used their mobile phones when they were with their infants on weekdays and weekend days. These included: keeping in contact with friends and family e.g., Facebook, text messaging (on weekdays, 67.4%, and weekends, 58.1%); for entertainment, e.g., watching videos, playing games (on weekdays, 2.3%, and weekends, 14.0%), for paid employment, communicating with clients, completing work (on weekdays, 11.6%, and weekends, 2.3%), and for family/household matters, e.g., arranging appointments, online purchases, searching for information that will benefit the family (on weekdays, 14.0%, and weekends 18.6%). Two parents reported a mix of these reasons for their weekday use and two parents reported taking photos as their main reason, in both cases, one for weekdays and one for weekend days. One parent reported not using their phone when with their infant on weekend days.

Infants in our sample had access to the following screen devices in the home: TV (88.4%); mobile phone (60.5%); tablets or iPads (37.2%); computers (23.3%); and video games (2.3%). According to parents, the main reason that their infant used screens on a weekday was for entertainment (52.4%), interacting with other people (16.7%), for educational purposes (7.1%) and other reasons (23.8%). On weekends parents reported that their infant used screens mainly for entertainment (61.9%), interacting with other people (7.1%), for educational purposes (7.1%) and other reasons (23.8%). Other reasons for infants' screen use included: equally entertainment and educational purposes; being around other family members using screens/having screens or having screens going in the background; Skyping; taking and looking at photos. Two parents responded that their child had not yet started to use screens.

Parents reported that, on average, when they are with their infant: a) the number of audible notifications they receive on their mobile p/hour is 1.06 ($SD$ = 1.32) with a maximum of 5; b) they check their mobiles 3.26 times p/hour ($SD$ = 2.49) with a maximum of 10; and 3) they spend 10.21 min using their phones ($SD$ = 7.27) with a maximum of 30.

### *5.2.2 Regression Analyses*

**5.2.2.1 Bivariate Analyses.** In simple linear regression analyses, we found that three variables were associated with infants' vocabulary, three with directiveness, two with responsiveness and scaffolding, and one with CJA (refer to Table 5.3).

**Table 5.3**

*Summary of Significant Results of Bivariate Analyses Testing Associations between Measures of Technoference and Other Screen Variables with Outcomes of Parental Responsiveness, Directiveness, Scaffolding, Infants' Vocabulary, and Parent-Infant Coordinated Joint Attention at 20 Months Using a Critical P-Value of .10*

| Outcome | Predictor | Coeff. | *SE* | 95% CI | *p*-value |
|---|---|---|---|---|---|
| Vocabulary | Audible notifications p/hour | -5.45 | 2.80 | [-11.12, 0.22] | .059 |
| | Less frequent P-screenfree decisions | 20.83 | 7.58 | [5.51, 36.16] | .009 |
| | Less frequent co-use | -13.35 | 7.65 | [-28.83, 2.14] | .089 |
| Directiveness | Audible notifications p/hour | 0.25 | 0.14 | [-0.03, 0.53] | .084 |
| | Mobile checks p/hour | -0.07 | 0.04 | [-0.15, 0.01] | .074 |
| | Less frequent P-screenfree decisions | -0.95 | 0.38 | [-1.73, -0.17] | .018 |
| Responsiveness | Audible notifications p/hour | -0.21 | 0.12 | [-0.45, 0.03] | .079 |
| | Score on DISRUPT scale | 0.27 | 0.14 | [-0.02, 0.56] | .065 |
| Scaffolding | Audible notifications p/hour | -0.25 | 0.13 | [-0.50, 0.004] | .053 |
| | C's exposure to background TV | -0.66 | 0.34 | [-1.34, 0.01] | .054 |
| CJA | Less frequent P-screenfree decisions | 0.60 | 0.33 | [-0.07, 1.27] | .078 |

*Notes.* P = Parent; C = Child.

**5.2.2.2 Hierarchical Linear Regression Analyses.** 'Frequency of audible notifications received p/hour' was significantly associated with three of our parent-infant interaction variables of interest, responsiveness, directiveness and scaffolding, as well as infants' vocabulary (refer to Tables 5.4–5.7). (Note that the models with scaffolding and responsiveness as the outcomes were not significant overall; however, adding audible notifications into the models did result in a statistically significant change in variance accounted for.) Hence, we conducted three SEM mediation analyses to investigate the possibility that responsiveness, directiveness and scaffolding might mediate the relationship between audible notifications and vocabulary (Baron & Kenny, 1986). We found that larger infant vocabulary size was associated with parents making a conscious decision to turn off or put away their mobile device when with their infant once a week, less than once a week, or never, compared to parents who put away their phones more frequently when with their infant (refer to Table 5.8). We found that parents co-using screens with their infants half the time or less compared to most or all of the time was associated with lower infant vocabulary (refer to Table 5.9).

Finally, while the overall model did not account for a significant amount of variance in scaffolding, background TV was a significant negative predictor of scaffolding (refer to Table 5.10). The other significant associations identified in bivariate regression analyses were found to be statistically non-significant in the adjusted hierarchical regression analyses.

**Table 5.4**

*Summary of Hierarchical Regression Analysis Testing the Relationship Between Frequency of Audible Notifications and Parental Responsiveness Using a Critical P-Value of .10 (N = 42)*

| Variable | Step 1 | | | | Step 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | B | SE(B) | β | *p*-value | B | SE(B) | β | *p*-value |
| Infant age | 0.05 | 0.08 | 0.11 | .506 | 0.04 | 0.08 | 0.09 | .584 |
| Parental education (lower than a degree) | -0.39 | 0.35 | -0.18 | .274 | -0.37 | 0.34 | -0.17 | .287 |
| Together p/week | -0.01 | 0.01 | -0.14 | .398 | -0.01 | 0.01 | -0.16 | .330 |
| **Audible notifications p/hour** | | | | | **-0.21** | **0.12** | **-0.27** | **.088** |
| $R^2$ | 0.05 | | | 0.13 | | | | |
| **F(change in $R^2$)** | 0.70 | | | .556 | **3.07** | | | **.088** |

**Table 5.5**

*Summary of Hierarchical Regression Analysis Testing the Relationship Between Frequency of Audible Notifications and Parental Scaffolding Using a Critical P-Value of .10 (N = 42)*

| Variable | Step 1 | | | | Step 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | B | SE(B) | β | *p*-value | B | SE(B) | β | *p*-value |
| Infant age | 0.01 | 0.09 | 0.01 | .951 | -0.01 | 0.08 | -0.02 | .926 |
| Parental education (lower than a degree) | -0.21 | 0.38 | -0.09 | .582 | -0.18 | 0.36 | -0.08 | .616 |
| Together p/week | -0.01 | 0.01 | -0.20 | .232 | -0.01 | 0.01 | -0.22 | .171 |
| **Audible notifications p/hour** | | | | | **-0.26** | **0.13** | **-0.32** | **.047** |
| $R^2$ | 0.04 | | | | 0.14 | | | |
| **F(change in $R^2$)** | 0.04 | | | .651 | **0.10** | | | **.047** |

**Table 5.6**

*Summary of Hierarchical Regression Analysis Testing the Relationship Between Frequency of Audible Notifications and Parent Directiveness Using a Critical P-Value of .10 (N =42)*

| Variable | Step 1 | | | | Step 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | B | SE(B) | β | *p*-value | B | SE(B) | β | *p*-value |
| **Infant age** | **-0.19** | **0.09** | **-0.33** | **.029** | **-0.18** | **0.08** | **-0.31** | **.035** |
| Parental education (lower than a degree) | 0.63 | 0.37 | 0.25 | .099 | 0.61 | 0.36 | 0.24 | .101 |
| **Together p/week** | **0.02** | **.01** | **0.30** | **.048** | **0.02** | **0.01** | **0.32** | **.033** |
| **Audible notifications p/hour** | | | | | **0.24** | **0.13** | **0.26** | **.075** |
| $R^2$ | 0.22 | | | | 0.28 | | | |
| **F(change in $R^2$)** | 3.48 | | | .025 | **3.35** | | | **.075** |

**Table 5.7**

*Summary of Hierarchical Regression Analysis Testing the Relationship Between Frequency of Audible Notifications and Infant Vocabulary Using a Critical P-Value of .10 (N = 42)*

| Variable | Step 1 | | | | Step 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | B | SE(B) | β | *p*-value | B | SE(B) | β | *p*-value |
| **Infant age** | **5.50** | **1.65** | **0.47** | **.002** | **5.25** | **1.59** | **0.45** | **.002** |
| Parental education (lower than a degree) | -7.76 | 7.26 | -0.15 | .292 | -7.26 | 6.97 | -0.14 | .304 |
| **Together p/week** | **-0.45** | **0.21** | **-0.31** | **.035** | **-0.48** | **0.20** | **-0.33** | **.021** |
| **Audible notifications p/hour** | | | | | **-5.08** | **2.47** | **-0.27** | **.047** |
| $R^2$ | .28 | | | | .36 | | | |
| **F(change in $R^2$)** | 4.96 | | | .005 | **4.24** | | | **.047** |

**Table 5.8**

*Summary of Hierarchical Regression Analysis Testing the Relationship Between Parents making a Conscious Decision to Put Away their Mobile Device when with their Infant and Infant Vocabulary Using a Critical P-Value of .10 (N =42)*

| Variable | Step 1 | | | | Step 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | B | SE(B) | β | *p*-value | B | SE(B) | β | *p*-value |
| **Infant age** | **5.10** | **1.67** | **0.44** | **.004** | **4.31** | **1.68** | **0.37** | **.014** |
| Parental education (lower than a degree) | -8.61 | 7.23 | -0.17 | .241 | -5.92 | 7.18 | -0.12 | .415 |
| **Together p/week** | **-0.43** | **0.21** | **-0.30** | **.046** | **-0.36** | **0.20** | **-0.25** | **.086** |
| **Phone put away once a week or less/never** | | | | | **13.73** | **7.57** | **0.26** | **.078** |
| $R^2$ | .26 | | | | .32 | | | |
| **F(change in $R^2$)** | **4.35** | | | **.010** | **3.29** | | | **.078** |

**Table 5.9**

*Summary of Hierarchical Regression Analysis Testing the Relationship Between Parents Co-using Screens With Their Infant Half the Time or Less and Infant Vocabulary Using a Critical P-Value of .10 (N =40)*

| Variable | Step 1 | | | | Step 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | B | SE(B) | β | *p*-value | B | SE(B) | β | *p*-value |
| **Infant age** | **5.13** | **1.79** | **0.44** | **.007** | **5.37** | **1.73** | **0.46** | **.004** |
| Parental education (lower than a degree) | -8.81 | 7.93 | -0.17 | .274 | -8.43 | 7.66 | -0.16 | .279 |
| Together p/week | -0.43 | 0.23 | -0.30 | .063 | -0.34 | 0.22 | -0.23 | .136 |
| **Co-using screens half the time or less** | | | | | **-13.58** | **7.18** | **-0.28** | **.067** |
| $R^2$ | 0.23 | | | | 0.30 | | | |
| **F(change in $R^2$)** | **3.48** | | | **.026** | **3.57** | | | **.067** |

**Table 5.10**

*Summary of Hierarchical Regression Analysis Testing the Relationship Between Child Exposure to Background TV and Scaffolding Using a Critical P-Value of .10 (N = 43)*

| Variable | Step 1 | | | | Step 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | B | SE(B) | β | *p*-value | B | SE(B) | β | *p*-value |
| Infant age | 0.01 | 0.08 | 0.01 | .944 | 0.06 | 0.08 | 0.11 | .508 |
| Parental education (lower than a degree) | -0.21 | 0.37 | -0.09 | .579 | 0.22 | 0.40 | 0.10 | .579 |
| Together p/week | -0.01 | 0.01 | -0.20 | .223 | -0.02 | 0.01 | -0.24 | .133 |
| **Background TV (half the time or more)** | | | | | **-0.88** | **0.40** | **-0.39** | **.032** |
| $R^2$ | 0.04 | | | | 0.15 | | | |
| **F(change in $R^2$)** | 0.57 | | | .640 | **4.93** | | | **.032** |

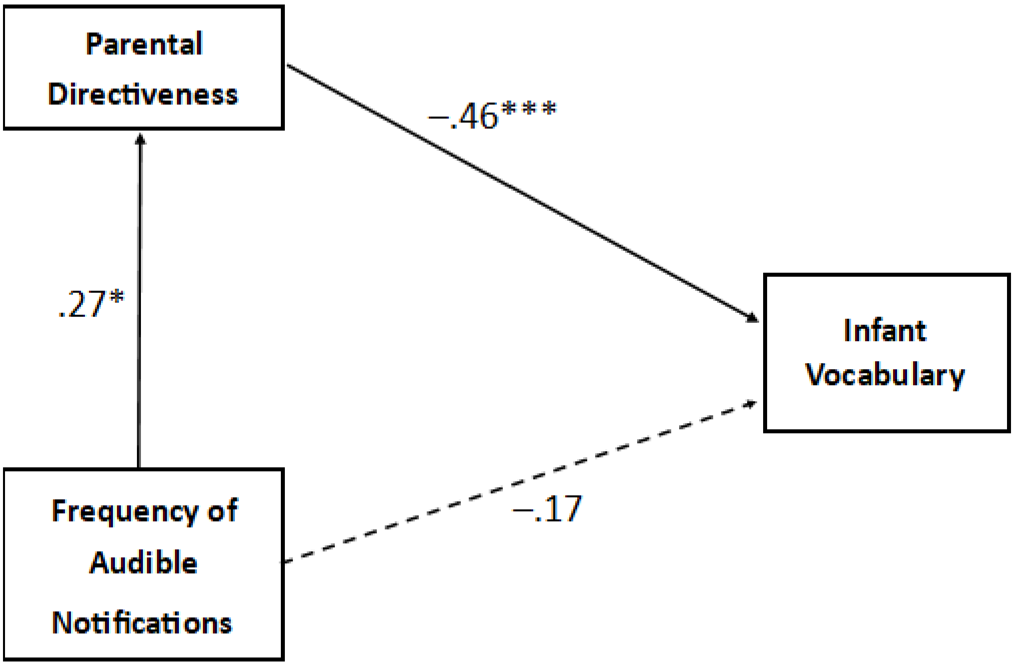
### *5.2.3 Structural Equation Modelling*

SEM revealed a significant indirect effect of audible notifications on vocabulary, mediated by parental directiveness (β = -.13, 95% CI [-.23, -.03], *p* = .012), and a non-significant path from audible notifications to vocabulary (see Figure 5.2). Hence, we re-ran the model without the path from audible notifications to vocabulary to test whether the relationship between audible notifications and vocabulary was fully mediated by directiveness (Geiser, 2010). There was evidence this was the case, as the chi-square value was not statistically significant, $\chi^2$ (1, *N* = 42) = 1.52, *p* = .217. Although the RMSEA index was .111, where > .1 is generally indicative of poor model fit, the RMSEA is unreliable for SEMs with small sample sizes and low degrees of freedom (Kenny et al., 2015). However, the Comparative fit index (CFI) was .964 and the SRMR was .059, meeting Hu and Bentler's (1999) combinational criteria for acceptable model fit of CFI > .96 and SRMR < .09.

Responsiveness (β = -.07, 90% CI [-.23, 0.002], *p* = .287) and scaffolding (β = -.06, 90% CI [-.16, .009], *p* = .285) did not mediate the relationship between audible notifications and vocabulary.

**Figure 5.2**

*Results of SEM in Mplus Testing for an Indirect Effect of Frequency of Audible Notifications on Infant Vocabulary, Mediated by Parental Directiveness*




*Notes*. Path coefficients are standardised and model is saturated. Dashed line = statistically non-significant. CFI = .1, RMSEA = 0, SRMR = 0, $R^2 = .29$. CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardised root mean square residual. *$p < .05$. ***$p < .001$.

## 5.3 Discussion

The goals of this research were two-fold. Firstly, we hypothesised that higher levels of technoference via screen technologies would be associated with lower levels of parent-infant CJA, parental responsiveness and scaffolding, and higher levels of directiveness even when parents were not actively using mobile devices. Secondly, we wanted to test whether any sources of technoference were associated with infants' vocabulary, and if so, whether these associations were mediated by the key parent-child interaction variables. There was some evidence to support our hypothesis, as frequency of audible notifications was associated with higher levels of directiveness, and lower levels of scaffolding and responsiveness in hierarchical regression. Further, SEM revealed a significant indirect effect of audible notifications on vocabulary that was fully mediated by parental directiveness.

Our finding that higher frequency of audible notifications was associated with lower infant vocabulary scores has some similarities with the findings of Reed et al.'s (2017) laboratory study which found that technoference caused by mobile devices affected vocabulary acquisition in toddlers. In Reed and colleagues' study, the source of technoference was the parent taking a call on their mobile phone while teaching a new word to their child, while in the present study, the source is the frequency with which parents receive audible notifications on their mobile device when they are with their infant. Our two studies highlight two different mechanisms by which different sources of technoference might impair the acquisition of infant vocabulary. Reed et al.'s results suggest that the interruption caused by a phone call may impair word learning due to the parent briefly disengaging from their interactions with the child. The mediation effect identified in our study suggests that habitually receiving higher numbers of audible notifications p/hour may result in parents becoming more directive in general, which in turn may result in lower infant vocabulary (Landry et al., 1997). Accordingly, we observed that parents who reported that they receive more audible notifications p/hour were more directive in a parent play interaction compared to parents who receive fewer notifications, even when phone use was not available. Due to our small sample size, the possibility that responsiveness or scaffolding may also mediate the relationship between audible notifications and vocabulary cannot be ruled out; however, our results suggest that an increase in parental directiveness associated with audible notifications may be more important to the development of infant vocabulary than reductions in responsiveness or scaffolding.

A study conducted by Kushlev et al. (2016) may shed some light on why frequency of audible notifications is associated with parental directiveness, responsiveness and scaffolding even when screen technology is not in use. Using a 2-week within-subjects design, Kushlev et al. (2016) found that participants reported more symptoms of inattention and hyperactivity at the end of a week when audible phone notifications had been turned on compared to a week when they were turned off. This suggests that parents receiving audible notifications may be left with fewer attentional resources to allocate to their infants on an ongoing basis, not only during the period when an audible notification occurs. This technoference effect would arguably intensify as the number of audible notifications received p/hour increases.

The use of directives may be a strategy parents use when technoference leaves them less able to concentrate on interpreting their infant's social cues and respond accordingly (Radesky et al., 2016). Instead, parents might direct children to activities that require reduced levels of parental involvement, or to desist from activities that *would* require parental involvement (Masur et al., 2005). This may explain why some parents who were absorbed in their devices during a meal in a family restaurant were observed to give brief directives to their children, sometimes without looking up, instead of providing more appropriate responses to their behaviour (Radesky et al., 2014a). Similarly, our findings suggest that audible notification are a source of technoference that may lead parents to become more directive towards their infants in general, while more desirable qualities of parent-infant interactions such as responsiveness and scaffolding decline.

We found an association between larger infant vocabulary size and parents making a conscious decision to turn off or put away their mobile device when with their infant once a week, less than once a week, or never. Note that parents were not asked if they had a *regular* time set aside to go "mobile-free", but the frequency with which they made a conscious decision to put their mobile device away while with their child (refer to Table 5.1). This suggests that parents may have identified problems with their current mobile use around their infant that they wish to halt or prevent. Hiniker et al.'s (2015) survey of 154 caregivers of children under 10 years provides support for this supposition. When asked to identify situations that would lead them to decide to "put down the phone", parents cited safety reasons, to be more responsive to their child, and to set a good example (p. 731). The desire to increase their responsiveness to their child may be most pertinent here, given the previously established association between parental responsiveness and children's language development (Tamis-Lemonda et al., 2006). Further, Hiniker et al. found that a sizeable proportion of parents (36%) could be described as confident that their phone use is minimal when around their child. Parents who use their phones minimally around their infants are arguably less likely to perceive a need to put their phone away compared to parents who use mobile devices around their children more frequently. If this is indeed the case, minimal use of mobile technology may provide parents with more opportunities to interact with their infant, which may support the development of infant vocabulary (Zimmerman et al., 2009). Our finding should certainly not be interpreted to mean that parents should avoid putting their phone away when with their infant; rather, it may mean that parents should consider the circumstances that might lead them to decide to put away their phones while with their infant and take steps to pre-empt these circumstances if necessary.

We found that parents co-using screens with their infants half the time or less compared to most or all of the time was negatively associated with infant vocabulary. This aligns with the findings of Mendelsohn et al. (2010) and Strouse et al. (2013) that parent-child interactions during use of child-directed screen media can improve language outcomes during infancy. However, Elias and Sulkin's (2019) finding that 72% of parents with children aged 1.5–3 years in their study use screens as a "babysitter" suggests that leaving children to their own devices whilst using screen media is not uncommon. Further, the portability of newer screen technologies has made it possible for parents to employ screens as a babysitter when "out and about", not just in the home setting, which potentially exacerbates this situation (Radesky et al., 2015b). While allowing infants to use screens by themselves may be understandable due to the time pressures that many parents of infants face (Corkin et al., 2018), our finding suggests that parents should try to minimise the amount of time their infants spend using screens without parental involvement.

We found that the higher levels of infant exposure to background TV (half the time or more) was associated with decreased scores on parental scaffolding. Optimal scaffolding requires parents to "invest" in their infant's activities, be aware of their cues, and provide a "supportive frame" appropriate to the child's current ability level (Biringen, 2000; Carr & Pike, 2012). The distraction caused by background TV may tax parents' attentional resources (Craik et al., 1996) and impair their ability to fully involve themselves in their children's activities, ascertain their needs and scaffold successfully. If parent and child frequently interact with TV going in the background, parents may have fewer suitable opportunities to develop effective scaffolding skills.

### *5.3.1 Strengths and Limitations*

A strength of this study is that our measures of key aspects of parent-infant interactions are observational, and that we were able to achieve very high reliability on coding these measures. Correlations between these measures emerged as expected (i.e., positive correlations between responsiveness, scaffolding and CJA, and negative correlations between these three measures and directiveness). Another strength is that we included multiple potential sources of technoference in our investigations, as well as other screen media variables. Hence we were able to use this wide range of technoference and screen media variables to investigate a novel premise, i.e., that these variables may influence parent-child interactions even when parents are in a situation where they are not using any mobile technologies, i.e., playing together in a lab setting. Our finding that frequency of audible notifications was associated with parental directiveness, responsiveness and scaffolding observed during a parent-infant play interaction in the lab provides some evidence that this may occur.

A limitation is that parents were aware that their interactions with their infant were being observed, which raises the risk of social desirability bias occurring (Vanden Abeele et al., 2020). Social desirability bias may also be an issue with answers provided on the questionnaire, as higher levels of screen exposure during early childhood is often viewed negatively (Plowman, 2016). Parents may also have had difficulty estimating the time typically spent in different activities when with their child on different days of the week.

It was unfortunate that the restrictions put in place because of the Covid-19 outbreak have impacted considerably on our ability to collect data for this study, resulting in a small sample size of 43. Hence it is likely that our analyses are likely to have been underpowered and only have been able to identify large effect sizes (Howell, 1987; Soper, 2020). However, the use of a less conservative critical *p*-value may have ameliorated this situation somewhat, allowing us to identify and report trends (Schumm et al., 2013) that could be explored further with larger samples. The use of small sample sizes such as ours in SEM may increase the incidence of improper solutions and non-convergence (Ding et al., 1995). However, Fritz and MacKinnon (2007) have shown that using bias-corrected boot-strapping, as we did, can greatly reduce the sample size required to achieve power of .8 if the mediation effect size is large.

Another clear limitation is the homogeneity of our sample, with virtually all participants of NZE ethnicity. As New Zealand is an ethnically diverse Western country (Belich & Wevers, 2008), any conclusions that could be drawn from our study may not be applicable to the wider population. Nevertheless, our findings provide an insight into the media use of both parents and infants in a contemporary media context where use of mobile technologies has become commonplace.

### *5.3.2 Implications for Practice*

Our key finding demonstrated that parental directiveness fully mediated a negative relationship between the frequency of audible notifications that parents receive when with their infant and infants' vocabulary. A concerning aspect of this finding is that the frequency of audible notifications appears to influence parents' directiveness even when they are not actively using their phones, perhaps intensifying the effects that audible notifications might indirectly have on infants' vocabulary. In light of this, health professionals who support families with young children might wish to advise parents to turn off the audible notifications on their phones when with their child, or suggest that parents consider checking their devices at times that fit in with what they and their child are doing.

### *5.3.3 Future Research Steps*

Our findings support the possibility that sources of technoference may influence key markers of parent-child interactions even when the parent is not actually using their phone or any other screen technology. This may come as a surprise to many parents and warrants further investigation. As our findings can be considered trends due to the small sample size and use of a less conservative critical *p*-value, we hope that this study will inspire other researchers to explore such associations and the mechanisms by which they may occur with larger and more diverse samples.

## 5.4 Conclusions

Our study aimed to extend the literature by investigating an interesting premise, i.e. that habitual technoference may be related to changes in the ways that parents interact with their infants even when the parent is not actively using screen devices. We also tested the relationships of several potential sources of technoference with infants' vocabulary development. We found evidence that technoference was related to three key markers of parent-child interactions, i.e. parental directiveness, responsiveness and scaffolding. Importantly, we found that parental directiveness fully mediated a negative relationship between frequency of parent receiving audible notifications and infant vocabulary. Infant vocabulary was also negatively associated with the parent consciously deciding to put their mobile device away when with their infant, and co-using screens with their child half the time or less. These possible associations warrant further investigation, due to the important role that language plays in children's development of executive functions (Hughes & Ensor, 2009), early literacy skills (Pempek & Lauricella, 2017), and school readiness (Prior et al., 2008). Our findings contribute to a growing body of research into the nature and effects of sources of technoference on children's development.

## Chapter 6. General Discussion

The over-arching goal of this thesis was to investigate the role of screen media in early childhood development and parental influences on preschool children's screen exposure and use. As noted by Irwin et al. (2007), the greatest investment that a nation can make is in the development of its youngest members; thus, given the omnipresence of screen media in the environments in which today's children live and grow, and the uncertainty about the potential effects of these media on early childhood development, continued research in this field is crucial (Barr , 2019, p. 1). Further, now that modern societies are "saturated" with screen media (Mazmanian & Lanette, 2017, p. 2273), parents of young children are compelled to make choices about the role screen media will play in the early years of their child's development (Hiniker et al., 2016b), which may be a daunting task in the face of contradictory societal messages about the effects of screen time and what is expected of them as parents (Kucirkova & Radesky, 2017). Hence the research contained in this thesis, which has investigated some of the potential effects of screen use for preschool children using a large, nationally representative sample of children in NZ, and empirical evidence from the DIME study, may be useful to parents who are concerned about how screen use might affect their preschool child.

The topic of whether screen time is associated with detrimental effects on children's development is a contentious one and gaining consensus amongst researchers in this field is an ongoing challenge (Hiniker et al., 2019). For instance, some researchers are dubious about a focus on screen *time* as opposed to other measures of screen time such as media content (e.g., Blum-Ross & Livingstone, 2016; Guernsey & Levine, 2016), while others note concerns about higher levels of screen time being problematic (e.g., Haughton et al., 2015; Kostyrka-Allchorne et al., 2017a). As outlined in Section 1.5.2, there is now a growing body of evidence suggesting that higher levels of comprehensive measures of screen time may have adverse effects on children's development, including cognitive, behavioural, socio-emotional, health, physiological and physical outcomes. Together these findings suggest that there are indeed risks associated with higher levels of screen time during the preschool years. Therefore, keeping screen time to appropriate levels (although, admittedly, what is appropriate may be hard to define), or at least avoiding excessively high levels of screen time, may be a valid concern. An understanding of modifiable factors associated with children's screen time is therefore imperative as it may help parents achieve a reduction in their children's screen time where needed and potentially avoid negative outcomes associated with higher levels of screen time.

An over-arching goal of the current research was therefore to explore parental influences on preschool children's screen exposure, and, indirectly, children's development. This field of research is complicated. Past research has shown that a range of factors such as the context (e.g., background or foreground media) and content (e.g., adult-directed or violent) of screen media provided to children, and the nature of parental mediation, can affect whether screen media use is ultimately beneficial or detrimental to children's development (refer to Sections 1.5.5 and 1.6). This emphasises the importance of the parenting media practices parents choose to use. Adding to this complexity is the rapid assimilation of newer screen media into children's home environments, which is argued to increase children's own screen use (Rodrigues et al., 2020) and their exposure to background media (as background media may now incorporate their parents' use of mobile technologies as well as TV (S. L. Golden et al., 2020). This suggests a need to consider how different media parenting practices might contribute to preschool children's developmental outcomes, and learn more about how parents can promote positive outcomes for their children.

Having identified a need to identify modifiable factors associated with preschool children's screen time in today's media context, learn more about how screen exposure might influence children's development, and simultaneously explore parental influences on both screen time and developmental outcomes, three key research questions (RQs) were formed for this thesis:

1. What are the predictors of screen time for children during the preschool years?
2. What is the role of media exposure in the development of executive functions and symptoms of inattention/hyperactivity?
3. Is parental technoference associated with preschool children's vocabulary and is this relationship mediated by key markers of high-quality parent-child interactions?

In the following sections, I first summarise the findings of the studies reported in Chapters 2–5 individually, show how each addresses the RQs, and highlight novel findings that contribute to the literature. Secondly, I synthesise the findings of the studies to consider how the findings may be applied collectively to enhance understanding of the role of screen media in children's development and parental influences on their children's screen media use and developmental outcomes, again, highlighting novel findings that advance the literature in this field. Finally, I discuss potential research applications and implications for the field, strengths and limitations of the research, future research directions, and conclusions.

## 6.1 Chapter Summaries

### *6.1.1 Summary of Study 1 (Chapter 2)*

The primary aim of the first study included in this doctoral research was to identify the predictors of total screen time on a weekday for children at approximately 2 years of age. A secondary aim of Study 1 was to describe children's screen use and prevalence of screen media practices at 2 years of age. The results of these descriptive analyses are discussed in Section 6.2.1, along with descriptive analyses of children's screen media use obtained in the other studies contained in this thesis.

The predictors of screen time at 2 years were investigated using data from the GUiNZ study. A comprehensive measure of screen time was employed, based on mother-reported estimates of children's use of different forms of screen media. This measure differs from measures of screen time that focus exclusively on use of TV; TV, DVDs and video; or video games, which have been employed by the majority of past research in this field. Using a comprehensive measure of screen time is arguably the best approach in today's media environment, since the increasing convergence of different forms of screen media and technologies (Peil & Sparviero, 2017) suggests a need for research that can be "generalised to multiple platforms" (Troseth et al., 2016, p. 60). The current research contributes to a small body of research that has addressed the predictors of screen time for this age group using a comprehensive measure of screen time (refer to Table 2.2).

Wherever possible, variables investigated by previous studies were also investigated in the current study (refer to Tables 2.1 and 2.2), as well as variables suggested by the wider parenting literature. Child's time spent outdoors; total behavioural difficulties; child temperament; concerns about the child's physical health; parents' self-rated parenting efficacy; and reading to the child on a daily basis were investigated for the first time. The inclusion of these novel variables offered an opportunity to extend the understanding of which factors might influence children's screen time at 2 years of age.

A large number ($N = 45$) of potential predictors of screen time were identified. The selected variables were assigned to contextual levels within Kotchick and Forehand's (2002) Ecological Model of Parenting. Screen time was the focal parenting behaviour, as parents can control the screen time of their children when they are very young (Barr, 2019; Duch et al., 2013). Within the model, parent and child characteristics were depicted as the proximal factors that can influence (or be influenced by) children's screen time; other variables used in the study were assigned to family (e.g., family stress) and social (e.g., ethnicity) levels, which, although they are more distal variables, may also exert an influence on screen time.

I hypothesised that screen media parenting practices would be the strongest predictors of screen time, as providing screen time is in fact a parenting practice that serves to regulate how much screen time a child can have (Kostyrka-Allchorne et al., 2017b). There was partial support for this hypothesis, as two of the four media parenting practices were the strongest predictors of screen time on a weekday, with reference to the IRRs. These included positive associations between the TV environment the child experiences in the home (moderate to high, or heavy, versus low TV environment) and whether the child watches adult-directed content. Ethnicity, a societal-contextual variable, was the third strongest predictor, whereby children of Asian ethnicity tended to have higher screen time than children of European ethnicity. Child being of Pacific ethnicity had a marginally positive association with screen time. Always co-viewing with the child compared to less than half the time or never, and having rules about how much time the child can watch TV, DVDs or video, had negative associations with screen time, and were the next strongest predictors after ethnicity. This placed the four screen media parenting practices amongst the five strongest predictors, again, highlighting the importance of media parenting practices in predicting 2-year-old children's screen time. Also significant were three child variables, specifically, not attending childcare regularly, which had a positive association with screen time, and child age and child health concerns over the last month, which had marginally significant positive associations.

As discussed in Chapter 2, the findings of Study 1 had some similarities to those identified by previous research; however, the current study makes a substantial contribution to the literature as the first to identify associations between a *comprehensive* measure of screen time and having a moderate to high or heavy TV environment compared to a low TV environment, and co-viewing with the child. Importantly, it is also the first to uncover a marginal trend where mothers having concerns about their child's health over the past month is associated with higher screen time; this association has not previously been identified with any form of screen media. The findings identified for the first time in the current study add to the literature by offering new insights into the factors that may influence 2-year-old children's screen time in a modern media landscape, using a large, socio-economically and ethnically diverse sample.

Overall, the findings of Study 1 emphasise the strong influence that parents have on their children's screen time, as four of the five strongest predictors were screen media parenting practices. Notably, media parenting practices are the only significant predictors identified in this study that are readily modifiable and, if adjusted, may lead to a reduction children's screen time or help to keep it low. Although past research has also found associations between modifiable screen media practices and comprehensive measures of screen time, the current study makes a valuable contribution to the literature by identifying two further parenting practices that could be modified: specifically, providing the child with a low TV environment compared to a moderate to high or heavy TV environment, and parent always co-viewing TV, DVDs or videos with their child compared to co-viewing less than half the time or never, which were associated with 2-year-old children having lower levels of comprehensive screen time.

A greater awareness of modifiable factors associated with higher levels of screen time during early childhood, such as those identified in the current study (i.e., heaviness of TV environment, child viewing adult-directed TV, having rules about screen time, and co-viewing with the child), is important, as this information could be leveraged to prevent children accruing excessively high screen time or establishing persistently high levels of screen use. This may pre-empt adverse developmental effects that might otherwise occur (e.g. Supanitayanon et al., 2020).

### 6.1.2 *Summary of Study 2 (Chapter 3)*

The aim of Study 2 was to build on and extend Beyens and Eggermont's (2017) Observed Life Logistics Model to advance the understanding of the predictors of screen time during the latter preschool years. After investigating the predictors of screen time at 2 years (in Study 1), I chose to conduct an additional study examining the predictors of screen time at 4.5 years, because the predictors of screen time at 2 years and 4.5 years may vary due to developmental differences between the age groups and differences in the way that parents parent their children during early childhood and the latter preschool years (Barnard & Solchany, 2002).

Very little attention has been paid to potential relationships between mothers' hours of work and children's screen time (Beyens & Eggermont, 2017) (recall that Beyens and Eggermont's model focused specifically on mothers, as mothers generally take greater responsibility for child-rearing than fathers (Argyrous & Rahman, 2017)). Beyens and Eggermont's (2017) review of TV studies and work-family literature suggested two possible mechanisms by which mothers' work hours might influence preschool children's screen time, and developed a model to test these relationships empirically. Essentially, one possible pathway was that mothers' work hours could cause mothers to experience parenting time pressure, then parenting time pressure could result in poorer maternal wellbeing, and finally, poorer well-being could lead mothers to provide more TV to their children, due to the inverse relationship between maternal wellbeing and children's' screen time (D. A. Thompson & Christakis, 2007). The second pathway was that mothers' work hours could result in an increase in well-being (e.g. Moen et al., 1995), which could result in less TV time provided to the child. Beyens and Eggermont's final results suggest that mothers' work hours are not directly associated with preschool children's TV time but mothers provide more TV to their children when there is conflict between mothers' family demands and work demands.

The current study extended Beyens and Eggermont's (2017) model by including screen media variables found to be predictive of screen time in Study 1 and other variables suggested by the wider literature. These included child variables and media parenting practices. The addition of these variables deviates from Beyens and Eggermont's unidirectional model, which only considered how maternal variables (mothers' life logistics) might influence children's screen time, and did not examine how child factors might influence the amount of screen time provided to the child; nor did it examine media parenting practices apart from allowing the child to view TV. However, it is important to remember that the child is the consumer of the screen media and therefore parents are likely to consider the needs or preferences of the child, not just their own, in deciding how much screen time their child should have (Nabi & Krcmar, 2017).

Our augmented model used data from the GUiNZ study, and, like Study 1, employed a comprehensive measure of screen time based on mother-report of their child's time spent using different forms of screen media on the last weekday. The time that children spent using TV or DVDs, computers, laptops, computer systems such as Leapfrog, iPads, tablets, smartphones and electronic gaming devices was included. To my knowledge, the current study is the first to employ a large, ethnically diverse sample and a comprehensive measure of screen time to test whether a model contingent on mothers' life logistics, and inclusive of child factors, predicts preschool children's screen time.

Surprisingly, in the current study, when the adjusted version of the Observed Life Logistics model (Beyens & Eggermont, 2017) was tested, the mothers' observed life logistics component of the model did not predict children's screen time at 54 months. However, four screen media parenting practices were associated with screen time, again highlighting the influence media parenting practices may have on preschool children's screen time. Three screen media parenting practices were associated with higher screen time, including allowing meals in front of TV and total TV exposure provided to the child on a weekday (which were the second and third strongest predictors with reference to the IRRs), and having rules restricting screen time. Another media parenting practice, reading to the child daily, was associated with lower screen time. Attending childcare was only a marginally significant predictor of lower screen time, and child health was not statistically significant. Child's symptoms of inattention/hyperactivity were a positive predictor of screen time. Ethnicity was included as a control variable in the model, but actually emerged as the strongest predictor of screen time overall for children at 54 months, with reference to the IRRs.

Past research suggests that parents have numerous reasons for allowing their children to use screens (refer to Section 1.3.1), but the results of the current study indicate that higher work hours, parenting time pressure and poorer wellbeing are not statistically significant contributors. It is possible that parents do find relief from parenting time pressure through allowing their children to use screens (e.g., Bentley et al., 2016; de Decker et al., 2012) but if this does occur it may be a "side effect" of children's screen use rather than the motivation for allowing screen use.

Several findings of the current study align with those of previous research in this field. Specifically, negative associations between screen time and having screen time rules (Downing et al., 2017), reading to the child (K. S. Khan et al., 2017) and child attending childcare (Gottfried & Le, 2017; Hinkley et al., 2013; Tandon et al., 2011) and a positive association between screen time and child's symptoms of inattention/hyperactivity (Ansari & Crosnoe, 2016; Ebenegger et al., 2012; C. J. Miller et al., 2007) (refer to Table 3.1). However, the current study is the first to identify a negative association between a comprehensive measure of screen time and reading to the child for children aged 4–5 years. This novel finding is noteworthy as it suggests that in a modern media environment, reading to 4.5-year-old children regularly may safeguard them from accruing higher levels of screen time, perhaps due to one form of media displacing the other (Christakis, 2009). (However, note that father or mother reading to the child daily at 2 years was not associated with screen time at 2 years. This may mean that screen time and book reading may have similar functions for 4.5-year-olds, e.g., relaxing, entertainment, and therefore one may displace the other, whereas screen time and book reading for 2-year-olds may be functionally less similar (Huston et al., 1999).) Further, my review of past literature suggests that the current study is the first to identify the TV environment provided to the child (the amount of time the TV is on in the same room as the child regardless of whether they are watching it), and allowing the child to eat meals in front of TV, as predictors of a comprehensive measure of screen time for preschool children aged 4 to 5 years of age. Together these novel findings serve to advance the understanding of which factors are associated with screen time for children in this age group.

Similarly to Study 1, Study 2 has identified four potentially modifiable media parenting practices that are related to children's screen time in the latter preschool years, again highlighting the important role that parents can play in determining their children's screen media use. Each of these could be modified by parents wishing to reduce their children's screen time, and, as outlined above, this may benefit children by potentially reducing the risk of adverse effects that may be associated with higher levels of screen time.

### *6.1.3 Summary of Study 3 (Chapter 4)*

The aim of Study 3 was to investigate the relationships between screen media variables at 2 and 4 years of age and hot and cool executive functions (EFs), and symptoms of inattention/hyperactivity at 4.5 years. The hypothesis was that the content of preschool children's media exposure at age two (i.e., child-directed or adult-directed) and the involvement of parents in their children's media use (i.e., co-viewing) would be stronger predictors of hot EFs, cool EFs, and symptoms of inattention/hyperactivity, compared to the amount of screen time to which children are exposed. This is in line with the commonly held view that content and context of screen media are more important factors in children's development than the amount of time they use screens for.

Data for the outcome variables were collected during the 54-month GUiNZ data collection wave (DCW) by trained interviewers. Data for both types of EFs were observational. The Luria Hand Clap Task (Luri͡ia, 1973; Luri͡ia, 1980) was used to measure cool EFs and the Gift Wrap Task (Kochanska et al., 2000; Mischel & Ebbeson, 1970) was used to measure hot EFs (refer to Sections 4.5.3.1.1 and 4.5.3.1.2 for a full explanation of each task). The Hand Clap task is an affectively neutral "conflict task" and the Gift Wrap Task is an emotionally evocative "delay of gratification" task (Kochanska et al., 2000), arguably reflecting the contrasting natures of the two types of EFs. The outcome measure for attention was the inattention/hyperactivity subscale of the Strengths and Difficulties Questionnaire (Goodman, 1997), administered to mothers in the 54-month child-proxy questionnaire.

A large number of predictor variables were investigated in Study 3, including seven screen media variables, as well as other variables identified as predictive of EFs and symptoms of ADHD in a review of the literature. In line with the aim of the study, screen media variables were of foremost interest. To explore the longitudinal effects of screen *time* on EFs and inattention/hyperactivity, I designed a novel variable that showed the consistency of children's "pattern" of screen time levels from early childhood (2 years) to the latter preschool years (4 years). This variable had four categories: LL showed that the child had had $<$ 2 hr of screen time at both time points, HH represented $\geq$ 2 hr at both time points, LH represented $<$ 2 hr at 2 years and $\geq$ 2 hr at 4 years, and HL represented $\geq$ 2 hr at 2 years and $<$ 2 hr at 4 years.

Other screen media variables included in our analyses included content of screen media (viewing of adult-directed vs child-directed) (note that the adult-directed and child-directed variables are separate variables), hours of total exposure of child to weekday TV (background and foreground), allowing meals in front of TV, having restrictive rules about TV, and frequency of co-viewing (measured at the 2-year DCW), and allowing meals in front of TV (measured at the 45-month DCW). The examination of seven different screen media variables within the same study, with the added benefit of using a comprehensive measure of screen time, is unprecedented within this field of research. By investigating how a broad set of screen media parenting practices might be related to EFs and inattention/hyperactivity, this study advances the understanding of which practices could potentially be modified to support the development of EFs and attention during the preschool years.

There was no support for the hypothesis that co-viewing with the child and the content of screen media viewed at age two (adult-directed vs child-directed) were associated with poorer EFs, and higher symptoms of inattention/hyperactivity at 4 years. It may be that the relationships between co-viewing and these particular outcomes are not longitudinal, but instead parents may contemporaneously allow children with poorer EFs more screen time as a way of managing more difficult behaviours (Radesky et al., 2014b). This theory is expanded upon below in Section 6.2.2. Study 3 found that neither viewing of child-directed nor adult-directed content was longitudinally associated with these outcomes. However, specific aspects of screen content such as fantastical scenes may be contributing factors, rather than adult- or child-directed content in general (e.g., Lillard & Peterson, 2011).

The key findings of Study 3 were that Total TV exposure on a weekday (the time that the TV was on in the same room as the child whether or not they were watching it) was longitudinally associated with poorer hot EFs, and allowing the child to eat meals in front of TV was longitudinally associated with poorer cool EFs. In both these scenarios, TV exposure incorporates both background and foreground TV, meaning that children are not necessarily actively watching TV, but nevertheless, the TV is a feature of their environment.

As the physical features of a preschool child's environment influence their development (Bronfenbrenner, 1979), longer or more frequent exposure to environmental TV when children are undergoing a period of heightened neuroplasticity (Conway & Stifter, 2012; Kolb & Fantie, 2009) may increase the likelihood that it could affect the development of EFs.

These findings suggest to me that a different mechanism underpins the relationship of environmental screen media to cool EFs compared to hot EFs. It may be that the context of screen media exposure (in this case, during a meal) may be more important for the development of cool EFs, whereas the total amount of *time* that the child experiences screen media in their surroundings may be more important for the development of hot EFs. The underlying mechanisms could be that cool EFs may be more vulnerable to interruptions to parent-child interactions via environmental screen media in contexts where parent and child might otherwise be interacting, such as a meal (Hiniker et al., 2016a). Fewer responsive parent-child interactions may then impact on language development, which is associated with EFs (Hughes & Ensor, 2009), or forestall opportunities to help children learn self-management skill, e.g. through learning to follow social norms around meal-times. In contrast, where TV is left going for a long time in the child's environment, it does not necessarily displace parent-child interactions, but it does continuously emit sound and light, which attract children's attention and require the allocation of cognitive resources to process (Craik et al., 1996; Erickson & Newman, 2017; Setliff & Courage, 2011). As background TV distracts children from their play, which promotes socio-emotional development (Schmidt et al., 2008), and hot EFs are associated with socio-emotional competence (Di Norcia et al., 2015), this provides a plausible explanation for this finding. While these are only my suggestions of possible mechanisms to explain the different findings for hot and cool EFs, they may offer a promising new direction for future research.

No screen media variables were found to be significant predictors of inattention/hyperactivity. Perhaps in general non-significant findings are not seen as being as important as significant ones; however, the relationship between attention and preschool children's screen use (specifically screen *time*) has been an extremely contentious one (Guernsey, 2012). The findings of the current study were that higher levels of screen time at 2 years and 4 years are not associated with symptoms of inattention/hyperactivity at 4.5 years, thereby adding to the evidence that there is no longitudinal association between screen time and attention deficits. To my knowledge, this is also the first study to identify longitudinal non-associations using a comprehensive measure of screen time, apart from a study conducted by Parkes et al. (2013), which used a composite measure of time spent viewing TV, DVDs and video, and playing electronic games.

Taken together, these findings imply that environmental TV exposure is a risk for EFs rather than the total amount of screen time preschool children have, and, given that seven various screen media variables did not predict inattention/hyperactivity with a comprehensive measure of screen time, it appears that screen media may not contribute to children's inattention/hyperactivity. In practical terms, this may come as a relief to parents who may have been worried that they have caused their children to develop ADHD by allowing them to have too much screen time (Guernsey, 2012).

### *6.1.4 Summary of Study 4 (Chapter 5)*

Study 4 was an empirical study designed to investigate whether technoference might impact on "key markers" of high-quality parent-child interactions known to support language development in young children, including higher levels of responsiveness, scaffolding and CJA, and lower levels of directiveness (e.g., Biringen et al., 2000; Carpenter et al., 1998; Landry et al., 1997; Tamis-Lemonda et al., 2006). A second goal of this study was to investigate whether any of these key markers were related to vocabulary size (our measure of language development), and if so, whether technoference mediated these relationships. The hypothesis was that higher levels of technoference would be associated with lower levels of parent-child coordinated joint attention (CJA), parental responsiveness and scaffolding, and higher levels of directiveness, during a play interaction in which parents are not actively using devices.

To date, only a small body of research has examined relationships between technoference and parent-child interaction (Zimmerle, 2019). Study 4 extended this literature by investigating a novel premise, i.e., that technoference may be associated with changes in the ways that parents interact with their infants even when the parent is *not* actively using screen devices. Whether this routine or "habitual" technoference might be indirectly associated with infants' vocabulary was also explored. Further, the first three years of life are the most "sensitive" years for language development (Linebarger & Vaala, 2010) and vocabulary development during this period relies on quality interactions with a parent or caregiver, including the amount of time they spend speaking to their child (Hart & Risley, 1995). Hence, by focusing on the relationships between technoference, key markers of quality parent-child interactions and vocabulary for infants under 2 years who are still in this critical time period, the potential for any significant findings to make a substantial difference to children's vocabulary development was arguably increased.

Although several studies have found evidence that parents' use of mobile technology can distract them from interacting with their children (e.g., Hiniker et al., 2015; Radesky et al., 2014a; Vanden Abeele et al., 2020), only one study, conducted by Reed et al. (2017), has investigated the relationship between technoference and infants' learning of vocabulary, as we did. However, their study investigated the effect of technoference (taking a phone call) that occurred *during* a teaching task in a laboratory setting (i.e., parent attempting to teach the infant one new word), and the authors only speculated on the mechanism that might underpin the effects of technoference on the diminished vocabulary learning they observed.

Thus, the current study has offered a new direction for the research in this field by conceptualising technoference in a new way, i.e., postulating that it can have an ongoing effect on parent-child interactions, not only when mobile technology is being used; and empirically testing the mechanisms by which parents' use of mobile screen media might affect their infants' vocabulary development.

Data were collected via observations of parent-infant play, which were coded for responsiveness, directiveness, CJA and scaffolding. An online questionnaire was also administered, which included questions about potential sources of technoference including the time the parent spends on their mobile device p/hour when with their infant; the number of audible notifications the parent receives p/hour on average, the number of times p/hour they check their device; having their device within easy reach; parent and child's screen time; parents' score on the Distraction In Social Relations and Use of Parent Technology (DISRUPT) scale (McDaniel, 2020); and the child's parent-reported vocabulary score on the short form M-CDI Level IIA (Fenson et al., 2000) (See Table 5.1 for specific details on the questions asked). Examining a range of potential sources of technoference is strong point of this study because it enhances the understanding of which sources of technoference may be problematic for parent-infant interactions and which may not.

There was some support for the hypothesis, as the results showed that 'Frequency of audible notifications received p/hour' was significantly associated with lower levels of responsiveness and scaffolding, higher levels of directiveness, and smaller infants' vocabulary. The fact that audible notifications was associated with three different aspects of parent-infant interactions observed in a lab setting provides corroboratory evidence that technoference may affect the quality of parent-infant interactions even when mobile devices are not in use or unavailable. This novel finding makes a vital contribution to the field as it broadens the definition of technoference to include periods of non-use of mobile technology and provides evidence that parents' engagement with their mobile devices may change the nature of parent-infant interactions in general.

An important goal of our study was to find if any key markers of high-quality parent-child interactions mediated associations between potential sources of "habitual" technoference and infants' vocabulary. Frequency of audible notifications was the only source of technoference found to be significantly associated with vocabulary as well as any of these key markers, and, further, we found that the relationship between audible notifications and vocabulary was fully mediated by directiveness. This is the first time that the mechanisms underpinning relationships between sources of "habitual" technoference and children's vocabulary have been investigated. Until now, it was not known that "habitual" technoference might influence parents' general manner of interacting with their infants and perhaps lead to smaller vocabulary. This finding suggests the possibility of a "carryover" effect whereby technoference is a factor in all parent-child interactions; hence, we cannot rule out that there may be effects on a range of other developmental outcomes as well as vocabulary. Further, past research has focused primarily on the effects of technoference on responsiveness, with only one study specifically addressing directiveness, (i.e., Radesky et al., 2014a). Thus, the current study met a need for broader consideration of how technoference may impact on parent-child interactions, and highlights an urgent need for research into whether technoference "carryover effects" might influence developmental outcomes other than vocabulary.

Finally, the findings of this study raise the question of whether types of mobile phone use that are "under the control of" the parent (e.g., talking on or checking their phone) may be less problematic to parent-child interactions than the unexpected interruptions that parent and child experience when the parents get an audible notification on their phone. In some ways this may seem counter-intuitive as some audible notifications are only a quick sound; however, it may be that the unexpected nature of audible notifications may keep parents, and also children, "on alert", and therefore be utilising cognitive resources on an *ongoing* basis, not only when attention is drawn by sounds emitted by the device (Kushlev et al., 2016). This state of heightened alertness may persist even after the parent puts their phone away. By comparison, the distraction caused by the parent talking to someone on their phone, checking their phone or sending a text, may be temporary, and cease when the parent has finished using their phone. Further, some parents report consciously using strategies to reduce or minimise any distraction from their child that could be caused when purposely using their phone, such as waiting until their child is safely occupied doing other things or using their phones only briefly (Hiniker et al., 2015).

Hence, by examining a wide range of potential sources of technoference, and being open to the possibility that technoference affects parent-child interactions even when mobile technology is not in use or being actively attended to by the parent, this current study is the first to find evidence that frequency of receiving audible notifications may potentially be more problematic to parent-infant interactions than deliberate use of mobile technology.

## 6.2 Synthesis and Explication of Findings

### *6.2.1 Patterns of Screen Use and Parental Mediation*

Each of the four studies reported in this thesis provide information about the screen use of preschool children in NZ and how their screen use is mediated by their parents. Below, I synthesise relevant data collected at more than one time point to gain a better understanding of how children in NZ engage with screens across the preschool years. (Although note that the 20-month-old children were participating in a different study to the children at 2, 4 and 4.5 years.)

The infants who took part in Study 4, which used data from the DIME study, had on average 0.92 hr of screen time per day. At 2 years of age, children participating in the GUiNZ study were having 1.20 hr of screen time on a weekday, and at 4.5 years they were having 2.20 hr. Together, these results indicate an increase in screen time from the early preschool years to the latter preschool years, which is in line with child age being a significant positive predictor of screen time (e.g., Carson & Janssen, 2012; Smith et al., 2010). There are multiple reasons why screen time may increase; based on my interpretation of the literature, however, the most likely reason is that screen time increases as maturation of the child enables them to comprehend and sustain their attention to screens for longer periods of time (Anderson & Hanson, 2010). Secondly, parents may be influenced by official guidelines or societal pressure to avoid screen time for children during the earlier preschool years. It is interesting, however, that children aged 20 months participating in the DIME study had started using screens before age two despite advice to the contrary from the NZ Ministry of Health (MoH; 2017). This may be because parents are unaware of the guidelines on screen time, or, when they are, do not automatically follow them but may consider their own family circumstances and the attributes of the child (He et al., 2005). Study 1 provides some evidence to support this, as the marginal finding that children with health concerns had higher screen time suggests that parents considered their child's health status (a child attribute) when deciding how much screen time they could have.

It appears that many children in the GUiNZ cohort experienced TV going in the same room as them whether or not they were watching it (environmental TV). At 2 years, 55% ($n$ = 1,985) had environmental TV ≥ 1 hr, and at 4.5 years, children had, on average, 2.14 hr of environmental TV per day. Similarly, 35% ($n$ = 15) of children at 20 months in the DIME study were exposed to background TV half the time or more. Thus, it appears that for many children, a proportion or all of their TV environment included background TV, which is in conflict with MoH (2017) guidelines of no background TV for preschool children. In the context of family life, however, some background TV might be hard to avoid as a parent may wish to watch "their" programme (Anderson & Hanson, 2010), yet a preschool-aged child needs constant supervision and consequently will be in the same room as the parent.

The results of Studies 1 and 4 suggest that the majority of parents of 20-month-olds (62.5%, $n$ = 25) and parents of 2-year- olds (55.2%, $n$ = 2,051) co-viewed or co-used screens with their child most of the time or always. This is the ideal, as co-viewing or co-using of screens provides a buffer against some of the negative effects of screen use and promotes positive effects for early childhood development (e.g., Jackson, 2018; Mendelsohn et al., 2010; Strouse et al., 2013).

Within the GUiNZ cohort, 61% of 2-year-olds lived in households where there were restrictions on screen time, and by 4.5 years of age this had increased to 69%. The increase may be due in part to the greater capacity 4.5-year-olds have to learn and follow rules. Also, some children may have become more interested in viewing or using screens in the latter preschool years, due to an increased ability to comprehend screen media (Anderson & Hanson, 2010), and to operate screen devices. Hence, their parents may have perceived that time rules were now necessary whereas previously they were not.

### *6.2.2 Predictors of Screen Time and Parental Influence*

The first RQ addressed in my doctoral research was "What are the predictors of screen time for children during the preschool years?" In exploring this question, I was not only interested in what the predictors actually were, but the extent to which parents might influence their preschool children's screen time. RQ 1 was assessed at two time points, 2 years and 4.5 years, using two quite different models as frameworks but both focused on children's screen time defined as a parenting practice. Both employed a comprehensive measure of screen time.

The first model adopted was Kotchick and Forehand's (2002) Ecological Model of Parenting, which was used to assess data collected when the children in the GUiNZ cohort were aged 2 years. Although my hypothesis was that screen media parenting practices would be the strongest predictors of screen time, I was aware that from an ecological perspective many contexts can impact on an individual's development and behaviour. Hence, Kotchick and Forehand's model was chosen to explore the relationships between a wide range of carefully selected potential predictors of screen time as it provided an opportunity for other variables to emerge as significant predictors from within different contexts, each posited to influence parental behaviour, including parent and child characteristics, family, and societal contexts (Kotchick & Forehand, 2002).

The second model was Beyens and Eggermont's (2017) Observed Life Logistics model, used to investigate the predictors of screen time when the cohort children were 4.5 years old. A sociological model, the focus was on the intersection between mothers' home life and work life, and how mothers' associated levels of well-being and work-life balance might influence the amount of screen time provided to the child. This focus was to the exclusion of nearly all other variables that might also have influenced children's screen time from an ecological perspective, with only one child variable (child age), family variable (number of children in the family), and maternal characteristic (education), which were used as control variables. Nevertheless, this model had successfully predicted screen time in Beyens and Eggermont's study and offered an opportunity to consider more closely the mechanisms underpinning parental influence on children's screen time. I did, however, augment the model with screen media parenting practices, and child characteristics, including child ethnicity as a control variable. I did this because screen media practices were found to be strong predictors of children's screen time in Study 1 (and their inclusion would provide further information about parental influence on screen time) and because parenting and child characteristics are bi-directional (Bell, 1968). Below I provide an overview of the predictors of screen time during the preschool years, and, in light of the two models described above, evaluate what the results of Studies 1 and 2 tell us about parental influence on screen time.

Firstly, for clarity, in Table 6.1 below, I list the significant predictors and the age at which they were found to be significant. Although there was not a perfect match between screen media parenting variables available in the 2-year and 54-month GUiNZ datasets, the significant predictors of children's screen time appear to be very much based on screen media parenting practices, and this was evident at both time points. Further, as half of the significant predictors at 2 years and 4.5 years were media parenting practices, and therefore modifiable, this gives parents of 2-year-olds and 4.5-year-olds some viable options for bringing about change in their children's screen time levels if they think this is warranted.

**Table 6.1**

*Significant Predictors of Screen Time for Children in the GUiNZ Cohort at Ages 2 Years and 4.5 Years, Organised into Ecological Contexts as per Kotchick and Forehand (2002)*

| | Significant predictor | 2 years | 4 .5 years |
|---|---|---|---|
| Parenting Behaviour | Heaviness of TV environment[a] | ✓ | ✓ |
| | Having rules restricting amount of screen time[a] | ✓ | ✓ |
| | Co-viewing with the child[a] | ✓ | |
| | Allowing child to view adult-directed content[a] | ✓ | |
| | Allowing child to eat meals in front of TV[a] | | ✓ |
| | Reading to the child daily[a] | | ✓ |
| Child Characteristics | Child health concerns | ✓[b] | |
| | Symptoms of inattention/hyperactivity | | ✓ |
| | Child age (marginal) | ✓ | |
| Family Characteristics | Child attending childcare | ✓ | ✓[b] |
| | Mother's hours of work | | ✓[c] |
| Social Context | Ethnicity | ✓ | ✓ |

*Notes*. [a] modifiable variable. [b] negligible effect size. [c] marginally significant.

The prominence of screen media parenting practices amongst the significant predictors indicates the magnitude of parental influence on children's screen time, and together Studies 1 and 2 provide evidence that the effectiveness of media parenting practices in managing children's screen time is sustained throughout the preschool years. This result was to be expected, as these practices are likely to reflect parental attitudes towards their preschool children's media use, and in turn help to establish the screen media environment that the child experiences in the home (Lauricella et al., 2015).

What was unexpected was that the Observed Life Logistics model (Beyens & Eggermont, 2017) was unsuccessful in predicting children's screen time at 4.5 years. In fact, from the original model, only mothers' workhours were (negligibly) associated with children's screen time. There is a commonly held perception, even amongst parents, that parents use screens to occupy their children in order to get a break, or time to do other things (e.g., A. Brown & Smolenaers, 2018; De Decker et al., 2012; Haughton et al., 2015; He et al., 2005). However, if this does occur, the results of Study 2 suggest that parents with poorer wellbeing or those experiencing work-family strain are not more prone to this. On this basis, the model did not hold for our cohort.

In contrast, Kotchick and Forehand's (2002) Ecological Model of Parenting offers valuable insights into why certain variables have emerged as predictors of screen time and why some predictors are stronger than others. The significant predictors of screen time identified in Studies 1 and 2 fell into four categories or contexts: parenting behaviours ($n$ = 6), child characteristics ($n$ = 2), family characteristics ($n$ = 2), and social context ($n$ = 1) (see Table 6.1) . The fact that: 1) the number of media parenting practices associated with children's screen time exceeded the number of all other significant variables combined, and 2) these variables were statistically amongst the strongest predictors of screen time, is testament to the influence parents exert over their preschool children's screen time. Kotchick and Forehand's model suggests this would be the case, as parenting behaviours are central to the model, and would therefore be expected to play a pivotal role in determining children's screen time. This is particularly relevant for preschool children, whose parents can control their screen activities (Barr, 2019). Further, parents generally demonstrate consistency in the ways in which they parent their children, which explains why multiple screen media parenting practices were related to screen time (Baumrind, 1971).

It has long been established that there are bi-directional relationships between parenting and child characteristics (Bell, 1968). This also is accounted for in Kotchick and Forehand's (2002) model, where parenting, parenting characteristics and child characteristics appear in adjacent contextual levels. These inter-relations are representative of the context (or microsystem) the child participates in most frequently, i.e., the home, the hallmarks of which are the interpersonal relationships, roles, and activities of both parent and child (Bronfenbrenner, 1979). Hence, within Kotchick and Forehand's model, there are reciprocal relationships between parenting and child characteristics. Firstly, consider child health, which is a novel finding identified in the current research for the first time as a (marginally) significant predictor of 2-year-olds' screen time. In response to the characteristics of the child (poorer health) parents may relax their typical parenting practices around screen time, leading to higher screen time. This scenario could be described as the child's characteristics "eliciting" more screen time (Ansari & Crosnoe, 2016), and demonstrates that even though parents are able to control the amount of time their preschoolers use screens for, children may also influence their own screen time levels. In line with this, other studies have found that child behaviours such as tantruming can elicit more screen time (e.g., Coyne et al., 2021; Hiniker et al., 2016b). The extent to which preschool children can influence their own screen time will probably vary, however. Some parents are permissive and some are more structured or directive in their parenting, hence some children may be permitted to exert more control over their own screen time than others (Baumrind, 1971).

Another child characteristic associated with higher screen time at 4.5 years was the child having symptoms of inattention/hyperactivity. This example is one I particularly want to draw attention to. Firstly, because there is controversy about whether screen time is associated with inattention/hyperactivity and, secondly, it is unclear whether any relationship is causal, or whether symptoms of inattention/hyperactivity elicit more screen time (Acevedo-Polakovich et al., 2007; Conners-Burrow et al., 2011). I believe the results of the current thesis make a critical contribution to this contentious field of research by providing some evidence that the relationship may not be causal, and symptoms of inattention/hyperactivity may "elicit" more screen time from the parent (perhaps, for instance, to settle the child). Evidence for this is provided by examining the results of Studies 2 and 3 together: Study 3 found no longitudinal relationships between screen time at 2 years and 4 years, and symptoms of inattention/hyperactivity at 4.5 years; yet in Study 2, when the children were 4.5 years old, I identified a concurrent association between symptoms of inattention/hyperactivity and screen time. This would suggest that screen time that has occurred previously might not affect later attention deficits, but parents of children who have more symptoms of inattention/hyperactivity may contemporaneously allow their children to have more screen time.

Kotchick and Forehand's (2002) Ecological Model of Parenting framework allows for indirect effects on parenting media practices via settings that may not involve the parent themselves, as depicted by the family and social contexts being non-adjacent to the central focus of parenting. This principle aligns with the concept of the "mesosystem" postulated by Bronfenbrenner (1979) in his famous Ecological Systems Theory, with the mesosystem being comprised of "interrelations between two or more settings" (p. 25). I classified the variable "not attending childcare regularly" into the family context level, as this represents one setting or context in which a family member (the child) participates. Although the parent does not interact with their child in the childcare setting, in the current thesis, child's attendance at childcare was found to be associated with screen time at 2 years and 4.5 years (marginally at 4.5 years), supporting the existence of an indirect relationship between these variables. The reduction in significance of childcare attendance as a predictor of screen time between 2 and 4.5 years may be due to some children undergoing "ecological transitions"

(Bronfenbrenner, 1979, p. 6), whereby their home or childcare contexts change, e.g., starting to attend childcare or decreasing/increasing hours at childcare. Of note, an increase in childcare is typical for NZ children in the latter preschool years (Stats NZ, 2017), most likely because 20 hours of free early childhood education become available when children turn three (New Zealand Immigration, 2020). This reinforces the point made earlier that parents' "responsiveness" to the changing circumstances, or characteristics, of their child may influence how much screen time they provide to their child.

Ethnicity was the strongest predictor of screen time at 4.5 years and the third strongest at 2 years. Although Kotchick and Forehand (2002) themselves strongly emphasised the importance of considering factors such as ethnicity, culture and SES in parenting research, I was very surprised at these findings, as I still expected a distal variable such as ethnicity, if significant, to be a weaker predictor of screen time compared to more proximal variables, and certainly did not expect it to be the most important predictor of screen time in Study 2. I was basing my presumption about ethnicity and other more distal variables on the microsystem being the immediate developmental context in Bronfenbrenner's (1979) model, but I was under-estimating the impact of wider contexts on the microsystem. As Bronfenbrenner points out, the connections within and between the different contexts can be equally strong and have equal consequence to those within a microsystem. In fact, Bronfenbrenner addresses cultural, ethnic, and socio-economic groups, and other groups within society, as "macrosystems" that provide a "blueprint for the organisation of every type of setting" (p. 4). Hence, within an ecological framework such as that provided by Kotchick and Forehand's model, it makes sense that ethnicity was a particularly strong predictor of preschool children's screen time at both time points throughout the preschool years. The relationship of ethnicity to children's screen time will be considered further in Section 6.5.

In summary, Kotchick and Forehand’s (2002) Ecological Model of Parenting aptly explains the dominance of screen media parenting practices as significant predictors of screen time, and also the emergence of ethnicity as an equal if not stronger predictor than most parenting practices. The model also suggests that, even though young children are not “in control” of their screen time, they may influence their own screen time levels, via their characteristics or behaviours. Finally, considering the results of Studies 2 and 3 together provides some evidence that the relationship between inattention/hyperactivity and higher levels of screen time is not causal; rather, these particular characteristics of the child may be eliciting more screen time. This novel finding makes a crucial contribution to the literature by potentially helping to clarify the association between screen time and attention, in what has been a contentious research area.

### *6.2.3 The Role of Screen Media in Early Childhood Development*

The second and third RQs addressed how screen media might be related to the development of preschool children. These included: “What is the role of media exposure in the development of EFs and symptoms of inattention/hyperactivity?” (Chapter 4); and “Is parental technoference associated with preschool children’s vocabulary and is this relationship mediated by key markers of high-quality parent-child interactions?” (Chapter 5). Both questions addressed important developmental outcomes that develop rapidly during early childhood (Diamond & Taylor, 1996; Linebarger & Vaala, 2010; Zelazo & Müller, 2011) and are likely to be affected by children’s environments (Haughton et al., 2015; Zelazo & Carlson, 2012). Below I explain how the results of Studies 3 and 4 considered together may contribute to a better understanding of how children’s and parents’ use of screen media might influence these aspects of children’s development during the preschool years.

At the onset of my doctoral research, I anticipated that any adverse effects of screen media for preschool children's development would be related primarily to their *own* use of screen media. This viewpoint was very much influenced by the way children's use of screen media was presented in the media, where negative outcomes of children's screen time were frequently reported. Also, despite noticing the growing practice of parents largely ignoring their preschool children while using their phones at restaurants and cafes etcetera, I had not given much thought to whether screen use by *other* people in the child's environment could impact their development. When I encountered literature that had identified links between parents' use of mobile phones around their child and less responsive parent-child interactions (e.g., Hiniker et al., 2015; Radesky et al., 2014a) (later named "technoference" by McDaniel and Coyne (2016)), I recognised the potential for technoference to affect preschool children's language development, which is supported by parent-child interactions (Hart & Risley, 1995). I also saw the possibility that technoference might have a "carryover" effect, potentially affecting parent-child interactions even when the parent was not using their phone. This led to Study 4 being conceptualised, in order to fill a gap in a small but growing body of literature on technoference.

Study 3 made a unique contribution to an established field of research, by investigating longitudinal associations between preschool children's EFs, symptoms of inattention/hyperactivity and multiple screen media variables *simultaneously*. These screen media variables essentially comprise the media parenting practices already investigated in Studies 1 and 2, which addressed the predictors of screen time, but in Study 3, I was interested in whether these variables were related to developmental outcomes. Study 4 investigated some of the same or similar screen media parenting variables. Considering the results of Studies 3 and 4 together allows for some insights beyond those I have already discussed when considering them individually.

Studies 3 and 4 both tackled the important questions of whether screen time itself is associated with hot and cool EFs, symptoms of inattention/hyperactivity, and vocabulary. Evidence from both studies suggests it is not. Instead, three parenting media practices that increased children's exposure to "environmental screen media" were associated with poorer scores on three of the four outcomes. In Study 3, providing higher levels of environmental TV to the child at 2 years (having the TV going in the same room as the child whether or not they were watching it) was associated with poorer hot EFs at 4.5 years, and higher frequency of allowing the child to eat meals in front of TV (another form of TV operating in the child's environment) at 4 years was associated with cool EFs at 4.5 years. Interestingly, these were the only media parenting practices investigated in Study 3 that were found to be associated with EFs or inattention/hyperactivity. In Study 4, there was also a negative association between vocabulary and a source of technoference, specifically, the parent receiving higher levels of audible notifications when with their child. Hence, three different facets of environmental screen media were associated with three of the key developmental outcomes of early childhood. Further, bringing the findings of Studies 1 and 2 into purview, the potential influence of environmental screen media can be seen even there, as having a moderate to high and heavy TV environment, and allowing meals in front of TV, were strong predictors of preschool children's screen time at 2 and 4.5 years respectively. This raises the possibility that background or environmental screen media may be indirectly related to an even greater range of developmental outcomes than those addressed here, through their association with total screen time.

It is noteworthy that screen time did not predict any EFs or language, although past research has identified associations between screen time and each of these cognitive outcomes. This is probably due to the changing nature of preschool children's screen time. Nearly all previous studies in this field have focused exclusively on TV or video viewing, which is predominantly a passive activity (although it is not uncommon for young children to sing and dance along to songs on TV programmes (He et al., 2005)). As newer screen technologies have become available, however, the capacity for "active" use of screen technologies has greatly increased, enabling preschool children to carry out a much wider range of activities, including communicating with others, taking photos, conducting educational and creative activities, and playing games. In fact, as Christakis (2014) pointed out, interactive touchscreen devices have characteristics that make them more similar to traditional toys than they are to TV. These similarities include their ability to react to what the child is doing, portability, and ability to promote coordinated joint attention (although I would argue that coordinated joint attention is certainly possible when parent and child watch TV together). In addition, activities on interactive touchscreen devices can be interactive, tailorable (adjusting to the needs of the individual child) and progressive (picking up where the child left off); features which, according to Christakis, are not typically offered by traditional toys or by TV. This leads me to suggest, if I may, that screen-based activities may even be superior to toy-play in some circumstances.

According to Sweetser et al. (2012), active screen time (which they define as cognitive or physical engagement with screen media) can be beneficial to children's development, whereas passively viewing screen media usually is not. Although viewing of TV and video still remains popular amongst preschool children (Rideout, 2017), it could be that the introduction of newer screen technologies has led to a decrease in passive use of screen media and an increase in more beneficial, active use, resulting in better "quality" of screen time overall. This may explain why previous research found negative effects between screen time and EFs and vocabulary, and the current study did not.

However, note that the results of Studies 3 and 4 pertain to certain cognitive abilities; it is therefore possible that even a contemporary, comprehensive measure of screen time may impact negatively on other developmental outcomes. A possible example is vision, where any effects are likely to be based on how long children's eyes are fixated on or close up to a screen (Huang et al., 2020; Yang et al., 2020), not what children are using the screen device for. Hence, high levels of screen time may still be problematic depending on which developmental outcome is under consideration.

Parents are potentially able to control the amount of environmental screen media that children are exposed to in the home, but unfortunately, perhaps due to the prominence of the "screen time" discourse, some parents think that if their very young child is not actively watching or using screen media themselves, there is no risk (A. Brown & Smolenaers, 2018). Similarly, parents might view long periods of using or talking on a mobile phone when with their child as problematic but not see the harm in having audible notifications going off in the background periodically. Another consideration is that as society becomes increasingly "mediatized" (Livingstone, 2009, p. 4), it becomes increasingly "normalised" to encounter environmental screen media in contexts outside the home, which may reinforce some parents' view that background media in their child's environment is safe. Therefore, the findings of Studies 3 and 4 are of great importance as they may alert parents of preschool children to the potential risks of environmental screen media exposure. In terms of the wider research, Studies 3 and 4 stand out by investigating a wide range of potential associations between screen media parenting practices and the developmental outcomes of interest – a shortfall of some of the past research has been a narrow focus on screen time to the exclusion of exploring possible associations with other screen media variables. Taken together, Studies 3 and 4 raise the possibility that environmental screen media may exert a greater influence on preschool children's development than previously recognised, as no other screen media variables from amongst a range of other potential predictors emerged as significant, including screen time. If so, the impact of environmental screen media might increase further if the use of mobile technologies becomes more prevalent.

Earlier in my discussion, I proposed that there might be two different mechanisms for the potential effects of environmental screen media on hot and cool EFs. In brief, these included fewer parent-child interactions for hot EFs, and the distraction caused by the formal features of environmental screen media, including light, sound and movement for cool EFs. However, in light of the findings of Study 4, I propose a further, novel explanation for these associations. As per previous work in the field of developmental psychology (e.g., Landry et al., 1997; Masur et al., 2005), a significant negative association between parental directiveness and 20-month-olds' vocabulary was identified in Study 4; and in Study 3, children's vocabulary at 2 years was associated with both hot and cool EFs at 4.5 years. This suggests the possibility that higher levels of environmental TV and allowing children to eat meals in front of TV may be associated with higher levels of parental directiveness, in the same way that higher levels of technoference (audible notifications) were associated with parental directiveness in Study 4; vocabulary may then mediate a relationship between directiveness and EFs. In support of this hypothesis, there is evidence that when the TV is on, parents and children interact less and parents speak less and in shorter sentences to their child (e.g., Christakis et al., 2009; Masur et al., 2016). This reduction in speech may correspond to an increase in parents' use of directive speech, a possibility that is supported by the findings of Radesky et al. (2014a), who observed parents answering their children briefly or harshly when using their phones. Essentially, it may be less taxing on parents' finite cognitive resources to provide short directives to their child when distracted by TV than to concentrate on interpreting their child's cues and responding contingently (Craik et al., 1996; Radesky et al., 2016). Hence, taken together, Studies 3 and 4 raise the possibility that an increase in parental directiveness in the presence of TV may underpin the relationships between environmental TV and both types of EFs. To my knowledge, this mechanism for the relationships between environmental TV and EFs has not been proposed before.

## 6.3 Research Applications and Implications for the Field

The current research has demonstrated the utility of conceptualising preschool children's screen time as a parenting behaviour and using an ecological model of parenting to 1) identify potential predictors of preschool children's screen time, and 2) provide explanations for the mechanisms underlying relationships between significant predictors and screen time. A model such as Kotchick and Forehand's (2002) model, therefore, could be used to investigate the wider cultural and societal contexts that may influence how much time parents allow their children to spend using newer screen technologies including tablets, mobile phones, or even time spent using particular genres of apps or websites, e.g., educational mathematics apps, literacy apps, games, YouTube. As there are early signs that some apps can promote numeracy and literacy, identifying factors that might promote use of such apps, instead of media that are less beneficial, could potentially enhance children's cognitive developmental and academic achievement when they enter school. Conversely, the model could be applied to explore factors that might lead to higher use of media associated with adverse developmental outcomes, such as violent content or adult-directed content. On the basis of the current research, I would encourage researchers in this field to examine a wide range of media parenting practices, as providing parents with more ideas of what they could do to manage their children's screen time could potentially translate into better outcomes for preschool children.

The present findings that ethnicity was a strong predictor of children's screen time at 2 years and 4.5 years highlights a need for future research in this field to consider the influence of ethnicity on preschool children's screen time. Key information about the factors that underpin children's screen use may be lost if ethnicity is relegated to being a control variable and not reported on, or even left out altogether, as I have observed in the literature.

Based on the results of the current research, it is advisable for future research into the role of screen media use in preschool development to avoid a narrow focus on screen time only, and also consider the potential effects of environmental screen media. Relatedly, the current research investigated the associations between children's vocabulary at 20 months and several potential "sources" of technoference, yet found only one form of technoference that was associated with vocabulary at 20 months. This result suggests the need for researchers in this new field to recognise that technoference can come in many forms, and to account for this in the design of their studies so that potential relationships between technoference and developmental outcomes are not overlooked.

## 6.4 Strengths and Limitations

Here I outline the strengths and limitations of the current research that have not been discussed in the preceding chapters.

Despite GUiNZ being a rich source of information on New Zealand children's development, all the data for Studies 1–3 had already been collected prior to the onset of my research, and not all of the information I would like to have used was available. For example, data about the children's use of screen media on a weekend day was not collected, and as shown by Elias and Sulkin (2019), the predictors of screen time for weekdays and weekends differ. Further, it would have been preferable for mothers to be asked about their children's use of tablets and smartphones explicitly in the 2-year DCW, as they were in the 54-month DCW, rather than asking them more generally about use of computers, laptops and children's computing systems. Although a measure of comprehensive screen time was able to be computed, and this was in line with measures used by other studies (e.g., Cliff et al., 2018; Wiecha et al., 2001; Xu et al., 2016), it is possible that some mothers whose children used tablets or smartphones would not have counted these as "computers" and may have underestimated their children's screen time.

A strength of the current research is its relevance to the NZ context, as very little research has been conducted into screen time and screen media use of preschool children in NZ. Therefore, the guidance provided by the MoH and health professionals working with families with young children would have been based chiefly on studies conducted in other countries, which may not be completely generalisable to a NZ population. Another strength of the current research is that it is of practical use to parents of preschool children, as it can provide valuable insights into the role of screen media use and exposure in their children's development, as well as parenting practices that could be effective in reducing their children's screen time, if they think it is necessary. Some of the findings of the current research have already been disseminated nationally through multiple news media, and there are plans to continue doing so, indicating there is a strong interest for information on the topic of children's screen media use.

Relatedly, the GUiNZ study is a contemporary longitudinal study that can provide new insights into the development of NZ children as they grow up in a mediatised society. In fact, the cohort children are still only 12 years old, and a DCW is in progress at the present time. There was also another DCW, conducted when the children were 8 years old, in which data was collected from both mothers and the children themselves on the child's screen media use and parenting media practices. Hence, the current research can serve as a foundation for future research into the evolving role of screen media in children's lives, the influence of parents on older children's screen use, and longer-term associations between screen use in the preschool years and children's ongoing development.

## 6.5 Future Directions

As observed in Studies 1 and 2, ethnicity was a particularly strong predictor of preschool children's screen time at 2 years and 4.5 years. Yet, we do not know the reasons why the screen time of preschool children in different ethnic groups in NZ may differ. It is important to note that in Study 1, area-level SES, parental education or age did not explain these differences. In line with this, in Study 1, children of Asian and Pacific ethnicities had the highest screen time (Pacific Peoples marginally), but based on the New Zealand Socioeconomic Index 2013 (NZEI-13; Fahy et al., 2017), people of Asian ethnicity have higher NZEI-13 scores than people of European ethnicity, and Pacific Peoples typically have lower NZEI-13 scores. In Study 2, children of Māori ethnicity were also found to have higher screen time, and they largely come from lower SES backgrounds (Fahy et al., 2017). Hence, the current research could be followed up with qualitative research to explore parents' own perspectives on the amount of screen time children have, and why they allow them to use screens, which could help researchers interpreting the data to identify factors that may lead to ethnic differences in children's screen time (Merriam, 2009). Research using qualitative data has been conducted using the GUiNZ sample before (e.g., Corkin et al., 2018), but alternatively, a new, ethnically diverse sample of current parents of preschool children in NZ could be recruited. Conducting qualitative work in NZ as outlined above, would contribute to a more "holistic picture of how childhood and media differ across varied social, cultural, and political contexts", compared to past research in this field, which has often presented the media use of children from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) (Henrich et al., 2010) backgrounds as the normal against which use by children from minority groups can be compared (Alper et al., 2016, p. 108). It would also further the understanding of the parenting goals that parents in general may be trying to meet when they allow their preschool children to have screen time.

In Study 3, environmental TV exposure was found to be associated with EFs but the amount of time the child was using screens (cumulatively) was not. It would have been very interesting to find out how often children were using more than one screen at a time, a practice referred to as "multi-tasking" (Kaye et al., 2020; Kostyrka-Allchorne, 2017b), and whether higher frequency of multi-tasking at 2 years and 4 years might have had different longitudinal effects on EFs at 4.5 years compared to using one form of media alone. Support for this theory is provided by Kostyrka-Allchorne et al.'s (2020) finding of a positive relationship between multitasking and symptoms of inattention/hyperactivity, mediated by lower levels of reading and non-digital games, for children aged 3–10 years. Higher levels of multi-tasking could potentially be more detrimental to EFs than using one device alone because 1) successful multi-tasking relies on "set-shifting" (or flexible thinking), an aspect of EFs that is under-developed in children under the age of four (Kloo et al., 2010), and 2) children's use of two or more devices together might provide a greater amount of distraction from activities that may be more beneficial to their development, such as speaking to and interacting with other people in their environment (Pea et al., 2014). I am not aware of any studies investigating whether multi-tasking and single device use might impact differentially and longitudinally on preschool children's EFs; this suggests an important new direction for the research, particularly as there is evidence that preschool children aged 2–4 years are multi-tasking with screen devices (Detnakarintra et al., 2019).

The findings of Study 4 suggest that technoference (audible notifications) may result in parents being more directive, in general, when interacting with their infants, not only when they are using their phones. Due to the bi-directionality of parent and child effects (Bell, 1968), parental technoference may also alter the way in which infants respond to and interact with their parents. In support of this, work by Myruski et al. (2018) showed that infants of parents who reported using their devices in front of the child or other family members more frequently in general, engaged less with their mother during the reunion phase of a modified "still face" task in the laboratory (as per Tronick et al., 1978). Further, children of parents who reported greater technoference in activities they carried out with their child were more likely to display externalising and internalising behaviours (McDaniel & Radesky, 2018). In light of the findings of Study 4, these findings raise the possibility that children might directly experience technoference themselves, perhaps through hearing audible notifications coming through on a parent’s phone, and this may have a “carry-over” effect on the way that children interact with their parents, and other people they interact with, including their peers. A next research step could be to investigate whether such an effect does exist, and the implications for children’s development if it does.

## 6.6 General Conclusions

The body of research contained in this thesis provides evidence that exposure to screen media during the preschool years may influence cognitive developmental outcomes including EFs and language; and highlights the influence parents may have on their children’s total screen time, EFs and vocabulary, via screen media parenting behaviours and their own use of screen media.

In line with my expectations, the majority of significant predictors of preschool children’s total screen time identified in Studies 1 and 2 were screen media parenting practices. These results indicate that screen time is primarily determined by proximal inter-relations between parent and child within the home environment, which is the microsystem in which the child participates most often (Bronfenbrenner, 1979; Kotchick & Forehand, 2002). The ability of parents to control their preschool children’s screen time levels was confirmed, as children had lower screen time if their parents restricted their access to screens, set time rules, kept environmental screen media at low levels, and made sure they always co-viewed with their child.

Conversely, a small number of children were exposed to a heavy TV environment or allowed to view adult-directed content; and eating meals in front of TV, having no time restrictions placed on their viewing, and viewing TV and video without an adult present were not uncommon. More permissive screen media parenting practices such as these were associated with higher screen time, which suggests that some parents create a home media environment that is conducive to their children spending more time using screen media.

Therefore, a key outcome of Studies 1 and 2 was the identification of several modifiable parenting screen media practices associated with preschool children's screen time. This information is likely to be valuable to parents looking for effective ways to manage their children's screen time.

The results of Studies 1 and 2 also show that media parenting behaviours may be influenced by child characteristics, such as the child's health status, or having difficulties with inattention or hyperactivity, which were associated with higher levels of screen time. This is most likely due to these child characteristics "eliciting" higher levels of screen time than parents might otherwise provide. Thus, parents may be willing to change their expectations of how much screen time is appropriate for their child based on their children's characteristics and adapt their media parenting practices accordingly. These findings also demonstrate the potential for children to influence their own screen time.

Ethnicity had stronger associations with children's screen time than I was expecting, emerging as the third strongest predictor of screen time when the children were 2 years old and the strongest when they were 4.5 years old. These findings seem in line with the notion that screen media is used by parents of preschool children to achieve various parenting goals or as a parenting tool in their child-rearing and everyday parenting practices (Elias & Sulkin, 2019). The associations between screen time and ethnicity identified in the current thesis may be underpinned by variations in the parenting goals that parents from different ethnic groups in NZ are endeavouring to meet when they allow their children to use screens. More research is needed to explore NZ parents' perspectives on their children's screen use, to identify and better understand ethnic differences that may exist.

This research also found that Kotchick and Forehand's (2002) Ecological Model of Parenting provided a suitable framework for conceptualising the relationships between the significant predictors of children's screen time outlined above, and children's screen time as a parenting behaviour. The results of Study 1 suggest that this model could be a fruitful addition to future research investigating different aspects of children's screen media use, such as their time engaging with positive media, e.g., educational apps, or with less desirable media, such as adult-directed content. Thus, the model could be used as a tool for identifying and understanding the factors that might support beneficial use of screen media and promote positive developmental outcomes during the preschool years.

Whether screen time, screen content, or the context in which children use screens is more important to preschool children's development has been a source of uncertainty (and discord) amongst researchers. The results of Study 3 bring some clarity to the roles that screen time, co-viewing and content of screen media may play in the development of hot and cool EFs, and symptoms of inattention/hyperactivity. Co-viewing and whether children view adult- or child-directed content at 2 years does not appear to longitudinally influence these outcomes. (However, this does not rule out the possibility that more specific forms of media content influence these outcomes, and indeed, there is evidence in the literature that fantastical content is a contributing factor (Lillard et al., 2015a; Lillard & Peterson, 2011)). Interesting, and contrary to much of the past research, higher levels of screen *time* were not longitudinally associated with EFs, and symptoms of inattention/hyperactivity. Likewise, higher levels of screen time in Study 4 were not associated concurrently with children's vocabulary at 20 months. These null findings do not imply that the significant associations between screen time and these outcomes identified by past research are spurious - their findings were predominantly based on TV use, whereas today's preschool children frequently engage with screen media other than TV. Newer interactive screen media have several features that TV does not have, that could make them more beneficial to children's development, e.g., reactivity to the child's actions, and the ability to tailor activities to the child's learning needs (Christakis, 2014). Now that interactive screen media have been incorporated into the screen media "diet" of most preschool children, many children may be having screen time that is, in general, of higher quality than that experienced in the past when the only form of screen time was TV. Thus, today's children may be less prone to certain adverse developmental effects previously associated with screen time, including poorer EFs, lower vocabulary, and symptoms of inattention/hyperactivity.

Relatedly, no longitudinal relationships between screen time and symptoms of inattention/hyperactivity were identified in Study 3, but a concurrent association between screen time and symptoms of inattention/hyperactivity was identified in Study 2. This implies there may be no causal relationship between screen time and symptoms of inattention/hyperactivity, but instead, children with more symptoms may be "eliciting" more screen time from their parents. This finding may help to resolve some of the enduring questions about these contested relationships.

Although children's screen time as such does not appear to be problematic for cognitive developmental outcomes such as EFs and vocabulary, based on the results of Studies 3 and 4, exposure to environmental screen does. One reason why environmental screen media may be detrimental to preschool children's development is that the involuntary processing of incoming stimuli emitted from screen media, including light and sounds, may deplete the cognitive resources that can be allocated to other cognitive processes (Christakis, 2009; Craik et al., 1996; Lillard et al., 2015b). Study 4 also provides evidence of a technoference "carryover" effect, whereby audible notifications that parents received on their mobile were positively associated with their directiveness, and negatively associated with their scaffolding and responsiveness, when interacting with their infants; and exposure to background TV was negatively associated with scaffolding, even when parents were not using their phones or around TV. In light of these findings, the proliferation of screen media throughout society is worrying, as today's children are left with very few environments that are completely free of screens.

Independently, Study 4 provides two new insights into the role of technoference in parent-infant interactions, and, potentially, infants' development. Firstly, there is the intriguing finding that the frequency of audible notifications, which can be as simple as a pinging noise, was associated with poorer-quality parent-infant interactions, whereas other types of phone use (e.g., speaking on the phone, checking for text messages) were not. Purposefully using screen media may be less disruptive than unexpectedly receiving an audible notification, perhaps because any distraction is sustained only during phone use, and parents are able to control when this occurs. Secondly, Study 4 suggests that "habitual" technoference associated with frequently receiving audible notifications may detract from quality parent-infant interactions on an ongoing basis, and poorer parent-infant interactions may in turn have adverse effects on developmental outcomes. As noted above, this new mechanism via which technoference may influence developmental outcomes was identified for the first time in the current research. In Study 4, higher levels of parental directiveness mediated a relationship between frequency of audible notifications and lower infant vocabulary; but of course, there may be other important developmental outcomes that are affected via the same mechanism, and other key markers of parent-child interactions that may act as mediators. This possibility should be addressed by further research. Further, the implications of this mechanism for children's development may be of even greater magnitude than it would first appear, because if several of the important people in a child's life are frequently receiving audible notifications on their mobile phones in addition to parents, a high proportion of children's interactions with others in their environment could potentially be compromised.

On final reflection, the current body of research tells a good news story and a bad news story. The bad news is that arguably some of the most important developmental outcomes of the preschool years (language and EFs) may be adversely affected by children's exposure to environmental screen media. Further, some children are having particularly high levels of screen time, which past research links to a range of other developmental outcomes, such as astigmatism (Huang et al., 2020) and myopia (Yang et al., 2020). The good news is the current body of research provides evidence that if parents keep their children's exposure to environmental screen media low (avoiding having the TV going in the same room as the child for long periods, and not allowing meals in front of TV), and minimise their exposure to audible notifications on their phones (perhaps by turning them off and checking their phone at a convenient time), the risks to children's development of hot and cool EFs, and vocabulary, may be reduced. The current thesis also provides parents with several options for reducing their preschool children's screen time, which could potentially mitigate risks of other developmental effects not addressed in the current study. Moreover, the current thesis provides a new perspective on the role of media exposure in early childhood development, where, potentially, environmental screen media is emerging as a key concern for the development of EFs and vocabulary, evidently more so than screen time itself.

# Appendix

## Study 3 Supplemental Material

**Table S1**

*Comparison of Means and Frequencies of Variables in the Original Dataset and Pooled Results of the Multiply Imputed Datasets for Variables with Missingness > 5%*

| | Original | Imputed | Original | Imputed |
|---|---|---|---|---|
| | *M* (*SD*) | *M* | *n* (%) | *n* (%) |
| Father's work hours | 43.56 (15.25) | 43.47 | | |
| Mother's work hours | 15.97 (17.67) | 16.00 | | |
| Father-child relationship environment | 5.75 (.60) | 5.74 | | |
| Adult-directed content | .09 (.43) | .09 | | |
| Child-directed content | 1.01 (1.11) | 1.03 | | |
| Father's efficacy | | | | |
| Low/Average | | | 724 (20%) | 820 (20%) |
| High | | | 2,934 (80%) | 3,241 (80%) |
| Hot executive functions | | | | |
| Lower hot EFs (peeked) | | | 1,009 (27%) | 1,100 (27%) |
| Higher hot EFs (never peeked) | | | 2,755 (73%) | 2,961 (73%) |
| Cool executive functions | | | | |
| Lower cool EFs (below median) | | | 1,534 (42%) | 1741 (43%) |
| Higher cool EFs (at or above median) | | | 2,088 (58%) | 2,320 (57%) |

**Table S2**

*Results of Binomial Logistic Regression Investigating the Factors that are Associated with Cool EFs for Children Aged 54 Months (N =2,725) Conducted Using Complete Case Analysis with an Adjusted Critical p Value ≤ .002*[a]

| Variable | (Likelihood ratio $X^2(57) = 245.61$, $p<.001$) | | | |
|---|---|---|---|---|
| | Coeff | *SE* | OR | *p* value |
| Intercept | -2.58 | 2.15 | .08 | .229 |
| Child's ethnicity | | | | |
| European | REF | | | **.<.001** |
| Māori | .07 | .16 | 1.08 | .641 |
| Pacific Peoples | -.21 | .19 | 0.81 | .250 |
| Asian | **.67** | **.16** | **1.96** | **<.001** |
| MELAA/NZ | .003 | .13 | 1.00 | .984 |
| Child age | .06 | .03 | 1.06 | .078 |
| Child gender (female) | .21 | .09 | 1.23 | .015 |
| Parity (subsequent child) | **.29** | **.09** | **1.33** | **.002** |
| Average parental age | -.003 | .01 | 1.00 | .716 |
| Maternal education | | | | |
| School qualifications or less | REF | | | .308 |
| Dip./trade cert NCEA L5-6 | -.10 | .12 | .91 | .421 |
| Bachelor's degree | .12 | .13 | 1.13 | .344 |
| Higher degree | .06 | .14 | 1.06 | .673 |
| Paternal education | | | | |
| School qualifications or less | REF | | | .264 |
| Dip./trade cert NCEA L5-6 | -.004 | .11 | 1.00 | .968 |
| Bachelor's degree | -.07 | .13 | .93 | .594 |
| Higher degree | .20 | .14 | 1.22 | .176 |
| SES (NZdep2006) | | | | |
| Low deprivation | REF | | | .119 |
| Medium deprivation | .11 | .10 | 1.11 | .278 |
| High deprivation | -.11 | .12 | .89 | .338 |
| Mother's work hours | -.002 | .003 | 1.00 | .553 |
| Father's work hours | .001 | .003 | 1.00 | .597 |
| Does not attend childcare | -.01 | .10 | .99 | .934 |
| Family stress | .27 | .14 | 1.30 | .055 |
| Patterns of screen time across the preschool years | | | | |
| LL | REF | | | .341 |
| HL | -.22 | .19 | .80 | .251 |
| LH | -.08 | .11 | .92 | .431 |
| HH | .07 | .19 | 1.07 | .739 |
| Allows meals in front of TV | -.20 | .09 | .82 | .026 |

| Variable | (Likelihood ratio $X^2(57)$ =245.61, $p$<.001) | | | |
|---|---|---|---|---|
| | Coeff | *SE* | OR | *p* value |
| Co-views < ½ the time or never | .01 | .12 | 1.01 | .932 |
| Exposure to TV on a weekday | -.04 | .02 | .96 | .132 |
| Adult-directed content | -.12 | .13 | .88 | .342 |
| Child-directed content | .02 | .08 | 1.02 | .772 |
| No rules restricting screen viewing | .05 | .13 | 1.06 | .690 |
| Hyperactivity/inattention at 2 years (abnormal range) | -.33 | .17 | .72 | .046 |
| Language development | **.01** | **.002** | **1.01** | **<.001** |
| Self-regulation score (CISC) | -.03 | .08 | .97 | .676 |
| Hours of sleep p/day | -.19 | .14 | .83 | .181 |
| Child physical, developmental or health condition | -.06 | .05 | .94 | .229 |
| Child temp: Affiliation | -.05 | .06 | .95 | .446 |
| Child temp: Fear | .004 | .03 | 1.00 | .881 |
| Child temp: Negative affect | .07 | .04 | 1.07 | .125 |
| Child temp: Orienting capacity | -.05 | .04 | .95 | .248 |
| Child temp: PAS | -.01 | .07 | .99 | .853 |
| Maternal agreeableness | .06 | .10 | 1.06 | .553 |
| Maternal conscientiousness | .09 | .08 | 1.10 | .262 |
| Maternal extraversion | -.04 | .07 | .96 | .527 |
| Maternal neuroticism | -.01 | .07 | .99 | .889 |
| Maternal openness | -.06 | .08 | .94 | .485 |
| Paternal agreeableness | .13 | .08 | 1.13 | .132 |
| Paternal conscientiousness | -.04 | .07 | .96 | .622 |
| Paternal extraversion | .02 | .06 | 1.02 | .790 |
| Paternal neuroticism | .01 | .07 | 1.01 | .886 |
| Paternal openness | .01 | .08 | 1.01 | .923 |
| Verbal hostility/discipline (mother) | .20 | .09 | 1.23 | .030 |
| Warmth/Affiliation (mother) | -.05 | .11 | .95 | .637 |
| Permissive/low parenting confidence (mother) | **-.27** | **.08** | **.76** | **.001** |
| Physically punishing (mother) | **-.30** | **.09** | **.75** | **.001** |
| Mother-child relationship environment | -.11 | .09 | .90 | .252 |
| Father-child relationship environment | -.07 | .08 | .94 | .400 |
| Average/low efficacy (father) | .06 | .11 | 1.06 | .596 |
| Average/low efficacy (mother) | -.13 | .10 | .88 | .192 |

*Note*. The statistically significant predictor(s) in each model are printed in bold. $R^2$ = .09 (Cox & Snell), .12 (Nagelkerke). MELAA = Middle Eastern, Latin American or African; PAS = Positive affect/surgency; SDQ = Strengths and Difficulties Questionnaire; Coeff = Coefficient; SE= Standard Error; OR = odds ratio; REF= Reference category; temp = temperament. [a]Critical *p* value adjusted using Benjamini and Hochberg's (1995) method for controlling the false discovery rate.

**Table S3**

*Results of Binomial Logistic Regression Investigating the Factors that are Associated with Hot EFs for Children Aged 54 Months (N = 2,816) Conducted Using Complete Case Analysis with an Adjusted Critical p Value ≤.002*[a]

| Variable | (Likelihood ratio $X^2(57) = 191.32$, *p*<.001) | | | |
|---|---|---|---|---|
| | Coeff | *SE* | OR | *p* value |
| Intercept | 3.48 | 2.32 | 32.51 | .134 |
| Child's ethnicity | | | | |
| European | REF | | | .027 |
| Māori | -.07 | .17 | .93 | .689 |
| Pacific Peoples | -.32 | .19 | .72 | .095 |
| Asian | -.34 | .16 | .71 | .033 |
| MELAA/NZ | -.37 | .14 | .69 | .008 |
| Child age | -.04 | .04 | .97 | .330 |
| Child gender (female) | **.55** | **.10** | **1.74** | **<.001** |
| Parity (subsequent child) | **.32** | **.10** | **1.38** | **.001** |
| Average parental age | -.03 | .01 | .98 | .012 |
| Maternal education | | | | |
| School qualifications or less | REF | | | .912 |
| Dip./trade cert NCEA L5-6 | -.03 | .13 | .98 | .843 |
| Bachelor's degree | -.03 | .14 | .97 | .834 |
| Higher degree | .06 | .16 | 1.07 | .696 |
| Paternal education | | | | |
| School qualifications or less | REF | | | .372 |
| Dip./trade cert NCEA L5-6 | -.10 | .12 | .91 | .403 |
| Bachelor's degree | -.14 | .14 | .87 | .321 |
| Higher degree | .09 | .16 | 1.10 | .575 |
| SES (NZdep2006) | | | | |
| Low deprivation | REF | | | .934 |
| Medium deprivation | .02 | .11 | 1.02 | .854 |
| High deprivation | -.02 | .13 | .98 | .861 |
| Mother's work hours | -.003 | .003 | 1.00 | .373 |
| Father's work hours | .01 | .003 | 1.01 | .062 |
| Does not attend childcare | .19 | .11 | 1.21 | .081 |
| Family stress | .01 | .10 | 1.01 | .914 |
| Patterns of screen time across the preschool years | | | | |
| LL | REF | | | .330 |
| HL | -.32 | .21 | .72 | .114 |
| LH | -.14 | .12 | .87 | .245 |
| HH | -.11 | .21 | .89 | .583 |
| Allows meals in front of TV | -.02 | .10 | .98 | .870 |

| Variable | (Likelihood ratio X²(57) =191.32, *p*<.001) | | | |
|---|---|---|---|---|
| | Coeff | *SE* | OR | *p* value |
| Co-views < ½ the time or never | -.13 | .13 | .88 | .328 |
| Exposure to weekday TV | -.07 | .03 | .93 | .006 |
| Adult-directed content | -.06 | .11 | .95 | .608 |
| Child-directed content | .11 | .07 | 1.11 | .130 |
| No rules restricting screen viewing | .09 | .14 | 1.09 | .537 |
| Hyperactivity/inattention at 2 years (abnormal range) | -.16 | .17 | .85 | .354 |
| Language development | **.31** | **.10** | **1.37** | **.002** |
| Self-regulation score (CISC) | .06 | .09 | 1.06 | .535 |
| Hours of sleep p/day | .06 | .04 | 1.07 | .074 |
| Child physical, developmental or health condition | .05 | .06 | 1.05 | .398 |
| Child temp: Affiliation | -.14 | .07 | .87 | .040 |
| Child temp: Fear | .04 | .03 | 1.04 | .162 |
| Child temp: Negative affect | -.01 | .05 | .99 | .785 |
| Child temp: Orienting capacity | .03 | .05 | 1.03 | .522 |
| Child temp: PAS | -.09 | .07 | .91 | .201 |
| Maternal agreeableness | .05 | .11 | 1.05 | .651 |
| Maternal conscientiousness | .03 | .09 | 1.03 | .749 |
| Maternal extraversion | -.06 | .07 | .95 | .454 |
| Maternal neuroticism | -.03 | .08 | .97 | .695 |
| Maternal openness | -.06 | .09 | .94 | .488 |
| Paternal agreeableness | -.13 | .09 | .88 | .168 |
| Paternal conscientiousness | -.07 | .08 | .94 | .408 |
| Paternal extraversion | .11 | .07 | 1.11 | .137 |
| Paternal neuroticism | -.05 | .08 | .95 | .522 |
| Paternal openness | .16 | .09 | 1.17 | .070 |
| Verbal hostility/discipline (mother) | .08 | .10 | 1.08 | .464 |
| Warmth/Affiliation (mother) | -.21 | .12 | .81 | .093 |
| Permissive/low parenting confidence (mother) | -.10 | .08 | .91 | .242 |
| Physically punishing mother | -.14 | .10 | .87 | .136 |
| Mother-child relationship environment | .20 | .10 | 1.22 | .047 |
| Father-child relationship environment | -.0001 | .08 | 1.00 | .999 |
| Average/low efficacy (father) | .18 | .12 | 1.20 | .134 |
| Average/low efficacy (mother) | -.09 | .11 | .91 | .409 |

*Note*. The statistically significant predictor(s) in each model are printed in bold. $R^2$ = .07 (Cox & Snell), .10 (Nagelkerke). MELAA = Middle Eastern, Latin American or African; PAS = Positive affect/surgency; SDQ = Strengths and Difficulties Questionnaire; Coeff = Coefficient; SE= Standard Error; OR = odds ratio; REF= Reference category; temp = temperament. [a]Critical *p* value adjusted using Benjamini and Hochberg's (1995) method for controlling the false discovery rate.

**Table S4**

*Results of Binomial Logistic Regression Investigating the Factors that are Associated with Inattention/hyperactivity for Children Aged 54 Months (N = 2,951) Conducted Using Complete Case Analysis with an Adjusted Critical P Value ≤.001*[a]

| Variable | (Likelihood ratio $X^2(57) = 324.65$, $p < .001$) | | | |
|---|---|---|---|---|
| | Coeff | *SE* | OR | *p* value |
| Intercept | -1.68 | 3.19 | .19 | .599 |
| Child's ethnicity | | | | |
| European | REF | | | .310 |
| Māori | .40 | .22 | 1.49 | .065 |
| Pacific Peoples | .27 | .25 | 1.31 | .287 |
| Asian | -.07 | .25 | .93 | .784 |
| MELAA/NZ | -.05 | .22 | .95 | .811 |
| Child age | -.01 | .05 | .99 | .814 |
| Child gender (female) | **-.49** | **.14** | **.61** | **<.001** |
| Parity (subsequent child) | -.08 | .15 | .92 | .563 |
| Average parental age | -.01 | .01 | .99 | .338 |
| Maternal education | | | | |
| School qualifications or less | REF | | | .192 |
| Dip./trade cert NCEA L5-6 | -.08 | .17 | .92 | .627 |
| Bachelor's degree | -.41 | .20 | .66 | .042 |
| Higher degree | -.11 | .23 | .90 | .639 |
| Paternal education | | | | |
| School qualifications or less | REF | | | .356 |
| Dip./trade cert NCEA L5-6 | .18 | .16 | 1.20 | .269 |
| Bachelor's degree | -.16 | .22 | .85 | .476 |
| Higher degree | -.02 | .24 | .98 | .928 |
| SES (NZdep2006) | | | | |
| Low deprivation | REF | | | .423 |
| Medium deprivation | .18 | .17 | 1.20 | .276 |
| High deprivation | .24 | .19 | 1.27 | .218 |
| Mother's work hours | .01 | .004 | 1.01 | .178 |
| Father's work hours | .002 | .004 | 1.00 | .679 |
| Does not attend childcare | -.31 | .16 | .73 | .053 |
| Family stress | .01 | .13 | 1.01 | .930 |
| Patterns of screen time across the preschool years | | | | |
| LL | REF | | | .415 |
| HL | -.07 | .31 | .93 | .820 |
| LH | .20 | .17 | 1.22 | .235 |
| HH | .28 | .28 | 1.33 | .312 |
| Allows meals in front of TV | -.19 | .14 | | .415 |

| Variable | (Likelihood ratio $X^2(57) = 324.65$, $p<.001$) | | | |
|---|---|---|---|---|
| | Coeff | *SE* | OR | *p* value |
| Co-views < ½ the time or never | -.07 | .19 | .93 | .718 |
| Exposure to weekday TV | .02 | .03 | 1.02 | .494 |
| Adult-directed content | .0003 | .13 | 1.00 | .998 |
| Child-directed content | .003 | .09 | 1.00 | .974 |
| No rules restricting screen viewing | .31 | .18 | 1.36 | .086 |
| Hyperactivity/inattention at 2 years (abnormal range) | **1.30** | **.18** | **3.68** | **<.001** |
| Language development | -.005 | .003 | 1.00 | .098 |
| Self-regulation score (CISC) | -.20 | .13 | .82 | .121 |
| Hours of sleep p/day | -.05 | .05 | .95 | .279 |
| Child physical, developmental or health condition | .19 | .07 | 1.21 | .006 |
| Child temp: Affiliation | -.14 | .09 | .87 | .139 |
| Child temp: Fear | -.01 | .04 | .99 | .771 |
| Child temp: Negative affect | .05 | .07 | 1.05 | .444 |
| Child temp: Orienting capacity | -.06 | .07 | .94 | .381 |
| Child temp: PAS | .23 | .11 | 1.25 | .031 |
| Maternal agreeableness | .10 | .15 | 1.11 | .477 |
| Maternal conscientiousness | -.16 | .13 | .85 | .205 |
| Maternal extraversion | .09 | .11 | 1.09 | .412 |
| Maternal neuroticism | .30 | .11 | 1.35 | .010 |
| Maternal openness | -.04 | .13 | .97 | .787 |
| Paternal agreeableness | .03 | .14 | 1.03 | .828 |
| Paternal conscientiousness | -.20 | .12 | .82 | .095 |
| Paternal extraversion | .03 | .10 | 1.03 | .761 |
| Paternal neuroticism | -.05 | .11 | .95 | .640 |
| Paternal openness | .01 | .13 | 1.01 | .926 |
| Verbal hostility/discipline (mother) | **.42** | **.13** | **1.53** | **.001** |
| Warmth/Affiliation (mother) | -.15 | .17 | .86 | .360 |
| Permissive/low parenting confidence (mother) | .28 | .15 | 1.32 | .055 |
| Physically punishing (mother) | .35 | .13 | 1.42 | .006 |
| Mother-child relationship environment | .02 | .14 | 1.02 | .893 |
| Father-child relationship environment | .02 | .12 | 1.02 | .858 |
| Average/low efficacy (father) | .07 | .16 | 1.07 | .685 |
| Average/low efficacy (mother) | -.05 | .15 | .95 | .738 |

*Note*. The statistically significant predictor(s) in each model are printed in bold. $R^2 = .10$ (Cox & Snell), .21 (Nagelkerke). MELAA = Middle Eastern, Latin American or African; PAS = Positive affect/surgency; SDQ = Strengths and Difficulties Questionnaire; Coeff = Coefficient; SE= Standard Error; REF= Reference category; temp = temperament. [a]Critical *p* value adjusted using Benjamini and Hochberg's (1995) method for controlling the false discovery rate.

**Table S5**

*Pooled Results of Binomial Logistic Regression Investigating the Factors that are Associated with Cool EFs for Children Aged 54 Months (N = 3,787) Conducted in Multiply Imputed Datasets (N=40) with an Adjusted Critical P Value* ≤ .005[a]

| | Coeff | *SE* | OR | *p* value |
|---|---|---|---|---|
| Intercept | -2.63 | 1.83 | .07 | .151 |
| Child's ethnicity | | | | |
| European | REF | | | |
| Māori | .04 | .14 | 1.04 | .747 |
| Pacific Peoples | -.15 | .16 | .86 | .351 |
| Asian | **.60** | **.14** | **1.82** | **<.001** |
| MELAA/NZ | -.06 | .12 | .94 | .588 |
| Child age | .07 | .03 | 1.07 | .022 |
| Child gender (female) | **.22** | **.08** | **1.25** | **.003** |
| Parity (subsequent child) | **.24** | **.08** | **1.27** | **.003** |
| Average parental age | -.003 | .01 | 1.00 | .671 |
| Maternal education | | | | |
| School qualifications or less | REF | | | |
| Dip./trade cert NCEA L5-6 | -.06 | .10 | .94 | .536 |
| Bachelor's degree | .15 | .11 | 1.16 | .174 |
| Higher degree | .13 | .13 | 1.14 | .317 |
| Paternal education | | | | |
| School qualifications or less | REF | | | |
| Dip./trade cert NCEA L5-6 | .0001 | .09 | 1.00 | .999 |
| Bachelor's degree | -.03 | .12 | .97 | .813 |
| Higher degree | .19 | .13 | 1.20 | .144 |
| SES (NZdep2006) | | | | |
| Low deprivation | REF | | | |
| Medium deprivation | .12 | .09 | 1.12 | .195 |
| High deprivation | -.07 | .11 | .94 | .535 |
| Mother's work hours | -.001 | .002 | 1.00 | .694 |
| Father's work hours | .001 | .003 | 1.00 | .744 |
| Does not attend childcare | -.04 | .09 | .96 | .654 |
| Family stress | .15 | .12 | 1.16 | .231 |
| Patterns of screen time across the preschool years | | | | |
| LL | REF | | | |
| HL | -.08 | .17 | .92 | .617 |
| LH | -.06 | .10 | .94 | .547 |
| HH | .03 | .16 | 1.03 | .848 |
| Allows meals in front of TV | **-.23** | **.08** | **.79** | **.004** |
| Co-views < ½ the time or never | .02 | .11 | 1.02 | .865 |

| | | | | |
|---|---|---|---|---|
| Exposure to TV on a weekday | -.03 | .02 | .98 | .239 |
| Adult-directed content | -.17 | .11 | .84 | .118 |
| Child-directed content | -.01 | .06 | .99 | .896 |
| No rules restricting screen viewing | .07 | .11 | 1.07 | .565 |
| Hyperactivity/inattention at 2 years (abnormal range) | **-.41** | **.14** | **.67** | **.005** |
| Language development | **.02** | **.002** | **1.02** | **<.001** |
| Self-regulation score (CISC) | -.05 | .07 | .95 | .474 |
| Hours of sleep p/day | -.11 | .13 | .89 | .367 |
| Child physical, developmental or health condition | -.07 | .05 | .93 | .107 |
| Child temp: Affiliation | -.05 | .05 | .95 | .366 |
| Child temp: Fear | .01 | .02 | 1.01 | .767 |
| Child temp: Negative affect | .07 | .04 | 1.08 | .069 |
| Child temp: Orienting capacity | -.05 | .04 | .95 | .163 |
| Child temp: PAS | -.06 | .06 | .94 | .297 |
| Maternal agreeableness | .07 | .09 | 1.07 | .413 |
| Maternal conscientiousness | .10 | .07 | 1.10 | .183 |
| Maternal extraversion | .02 | .06 | 1.02 | .803 |
| Maternal neuroticism | .04 | .06 | 1.04 | .582 |
| Maternal openness | -.08 | .07 | .93 | .288 |
| Paternal agreeableness | .04 | .08 | 1.04 | .614 |
| Paternal conscientiousness | -.02 | .06 | .98 | .711 |
| Paternal extraversion | .01 | .06 | 1.01 | .878 |
| Paternal neuroticism | -.02 | .06 | .98 | .692 |
| Paternal openness | .03 | .07 | 1.03 | .695 |
| Verbal hostility/discipline (mother) | **.24** | **.08** | **1.28** | **.003** |
| Warmth/Affiliation (mother) | -.08 | .10 | .92 | .408 |
| Permissive/low parenting confidence (mother) | **-.25** | **.07** | **.78** | **<.001** |
| Physically punishing (mother) | **-.26** | **.08** | **.77** | **.001** |
| Mother-child relationship environment | -.07 | .08 | .93 | .397 |
| Father-child relationship environment | -.07 | .07 | .93 | .327 |
| Average/low efficacy (father) | .02 | .10 | 1.02 | .819 |
| Average/low efficacy (mother) | -.13 | .09 | .88 | .142 |

*Note*. The statistically significant predictor(s) in each model are printed in bold. MELAA – Middle Eastern, Latin American or African; PAS = Positive affect/surgency; SDQ = Strengths and Difficulties Questionnaire; Coeff = Coefficient; SE= Standard Error; OR = odds ratio; REF= Reference category; temp = temperament. [a]Critical *p* value adjusted using Benjamini and Hochberg's (1995) method for controlling the false discovery rate.

**Table S6**

*Pooled Results of Binomial Logistic Regression Investigating the Factors that are Associated with Hot EFs for Children Aged 54 Months (N = 3,787) Conducted in Multiply Imputed Datasets (N=40) with an Adjusted Critical P Value ≤ .001*[a]

| | Coeff | *SE* | OR | *p* value |
|---|---|---|---|---|
| Intercept | 1.70 | 1.94 | 5.47 | .382 |
| Child's ethnicity | | | | |
| European | REF | | | |
| Māori | .05 | .15 | 1.05 | .741 |
| Pacific Peoples | -.24 | .16 | .79 | .148 |
| Asian | -.33 | .14 | .72 | .017 |
| MELAA/NZ | -.22 | .13 | .81 | .087 |
| Child age | -.02 | .03 | .98 | .420 |
| Child gender (female) | **.63** | **.08** | **1.88** | **<.001** |
| Parity (subsequent child) | **.32** | **.09** | **1.38** | **<.001** |
| Average parental age | -.02 | .01 | .98 | .029 |
| Maternal education | | | | |
| School qualifications or less | REF | | | |
| Dip./trade cert NCEA L5-6 | -.02 | .11 | .98 | .874 |
| Bachelor's degree | -.05 | .12 | .95 | .693 |
| Higher degree | .02 | .14 | 1.02 | .892 |
| Paternal education | | | | |
| School qualifications or less | REF | | | |
| Dip./trade cert NCEA L5-6 | -.04 | .10 | .97 | .726 |
| Bachelor's degree | .01 | .13 | 1.01 | .936 |
| Higher degree | .19 | .14 | 1.21 | .169 |
| SES (NZdep2006) | | | | |
| Low deprivation | REF | | | |
| Medium deprivation | .01 | .10 | 1.01 | .921 |
| High deprivation | .001 | .11 | 1.00 | .993 |
| Mother's work hours | -.001 | .003 | 1.00 | .819 |
| Father's work hours | .01 | .003 | 1.01 | .008 |
| Does not attend childcare | .18 | .10 | 1.20 | .055 |
| Family stress | .07 | .09 | 1.08 | .390 |
| Patterns of screen time across the preschool years | | | | |
| LL | REF | | | |
| HL | -.13 | .18 | .88 | .462 |
| LH | -.08 | .10 | .93 | .469 |
| HH | .09 | .17 | 1.10 | .592 |
| Allows meals in front of TV | -.04 | .09 | .96 | .639 |
| Co-views < ½ the time or never | -.08 | .11 | .93 | .493 |
| Exposure to weekday TV | **-.07** | **.02** | **.93** | **.001** |
| Adult-directed content | -.05 | .10 | .96 | .635 |

| | Coeff | *SE* | OR | *p* value |
|---|---|---|---|---|
| Child-directed content | .03 | .06 | 1.03 | .654 |
| No rules restricting screen viewing | .07 | .12 | 1.07 | .551 |
| Hyperactivity/inattention at 2 years (abnormal range) | -.26 | .15 | .77 | .073 |
| Language development | **.34** | **.09** | **1.41** | **<.001** |
| Self-regulation score (CISC) | .08 | .08 | 1.09 | .284 |
| *Hours of sleep p/day* | .08 | .03 | 1.08 | .010 |
| Child physical, developmental or health condition | -.03 | .05 | .97 | .562 |
| Child temp: Affiliation | -.12 | .06 | .89 | .045 |
| Child temp: Fear | .04 | .03 | 1.04 | .146 |
| Child temp: Negative affect | -.001 | .04 | 1.00 | .981 |
| Child temp: Orienting capacity | -.004 | .04 | 1.00 | .911 |
| Child temp: PAS | -.09 | .06 | .91 | .133 |
| Maternal agreeableness | .04 | .09 | 1.04 | .650 |
| Maternal conscientiousness | .03 | .08 | 1.03 | .755 |
| Maternal extraversion | -.04 | .07 | .97 | .585 |
| Maternal neuroticism | -.002 | .07 | 1.00 | .980 |
| Maternal openness | -.03 | .08 | .97 | .713 |
| Paternal agreeableness | -.08 | .08 | .92 | .331 |
| Paternal conscientiousness | .01 | .07 | 1.01 | .896 |
| Paternal extraversion | .09 | .06 | 1.10 | .134 |
| Paternal neuroticism | -.07 | .07 | .93 | .256 |
| Paternal openness | .08 | .08 | 1.08 | .303 |
| Verbal hostility/discipline (mother) | .06 | .09 | 1.06 | .473 |
| Warmth/Affiliation (mother) | -.10 | .10 | .91 | .353 |
| Permissive/low parenting confidence (mother | -.15 | .07 | .86 | .029 |
| Physically punishing mother) | -.07 | .08 | .93 | .369 |
| Mother-child relationship environment | .16 | .09 | 1.17 | .073 |
| Father-child relationship environment | -.02 | .08 | .98 | .773 |
| Average/low efficacy (father) | .20 | .11 | 1.22 | .074 |
| Average/low efficacy (mother) | -.04 | .10 | .97 | .712 |

*Note*. The statistically significant predictor(s) in each model are printed in bold. MELAA – Middle Eastern, Latin American or African; PAS = Positive affect/surgency; SDQ = Strengths and Difficulties Questionnaire; Coeff = Coefficient; SE= Standard Error; OR = odds ratio; REF= Reference category; temp = temperament. [a]Critical *p* value adjusted using Benjamini and Hochberg's (1995) method for controlling the false discovery rate.

**Table S7**

*Pooled Results of Binomial Logistic Regression Investigating the Factors that are Associated with Inattention/Hyperactivity for Children Aged 54 Months (N = 3,787) Conducted in Multiply Imputed Datasets (N=40) with an Adjusted Critical P Value < .001*[a]

| | Coeff | *SE* | OR | *p* value |
|---|---|---|---|---|
| Intercept | -2.02 | 2.65 | .13 | .444 |
| Child's ethnicity | | | | |
| European | REF | | | |
| Māori | .34 | .19 | 1.40 | .070 |
| Pacific Peoples | .21 | .22 | 1.23 | .332 |
| Asian | .03 | .21 | 1.03 | .887 |
| MELAA/NZ | .09 | .18 | 1.09 | .623 |
| Child age | -.02 | .04 | .98 | .621 |
| Child gender (female) | **-.49** | **.12** | **.61** | **<.001** |
| Parity | -.10 | .13 | .90 | .416 |
| Average parental age | -.01 | .01 | .99 | .225 |
| Maternal education | | | | |
| School qualifications or less | REF | | | |
| Dip./trade cert NCEA L5-6 | -.07 | .15 | .93 | .611 |
| Bachelor's degree | -.39 | .17 | .68 | .024 |
| Higher degree | -.21 | .20 | .82 | .300 |
| Paternal education | | | | |
| School qualifications or less | REF | | | |
| Dip./trade cert NCEA L5-6 | .03 | .14 | 1.03 | .829 |
| Bachelor's degree | -.28 | .19 | .76 | .148 |
| Higher degree | -.02 | .21 | .98 | .906 |
| SES (NZdep2006) | | | | |
| Low deprivation | REF | | | |
| Medium deprivation | .18 | .15 | 1.20 | .205 |
| High deprivation | .21 | .17 | 1.23 | .205 |
| Mother's work hours | .005 | .004 | 1.01 | .186 |
| Father's work hours | .002 | .004 | 1.00 | .628 |
| Does not attend non-parental childcare | -.28 | .14 | .75 | .039 |
| Family stress | .14 | .11 | 1.15 | .230 |
| Patterns of screen time across the preschool years | | | | |
| LL | REF | | | |
| HL | -.002 | .25 | 1.00 | .995 |
| LH | .29 | .15 | 1.34 | .050 |
| HH | .38 | .23 | 1.46 | .107 |
| Allows meals in front of TV | -.18 | .12 | .84 | .150 |
| Co-views < ½ the time or never | -.09 | .17 | .91 | .577 |

| | Coeff | *SE* | OR | *p* value |
|---|---|---|---|---|
| Exposure to weekday TV | .02 | .03 | 1.02 | .553 |
| Adult-directed content | -.01 | .11 | .99 | .922 |
| Child-directed content | .002 | .08 | 1.00 | .984 |
| No rules restricting screen viewing | .27 | .15 | 1.31 | .079 |
| Hyperactivity/inattention at 2 years (abnormal range) | **1.18** | **.16** | **3.26** | **<.001** |
| Language development | -.003 | .002 | 1.00 | .211 |
| Self-regulation score (CISC) | -.27 | .11 | .76 | .013 |
| Hours of sleep p/day | -.06 | .04 | .94 | .156 |
| Child physical, developmental or health condition | .12 | .06 | 1.13 | .039 |
| Child temp: Affiliation | -.12 | .08 | .89 | .114 |
| Child temp: Fear | -.03 | .04 | .97 | .421 |
| Child temp: Negative affect | .08 | .06 | 1.08 | .172 |
| Child temp: Orienting capacity | -.09 | .06 | .92 | .138 |
| Child temp: PAS | **.33** | **.09** | **1.39** | **<.001** |
| Maternal agreeableness | .04 | .13 | 1.04 | .768 |
| Maternal conscientiousness | -.13 | .11 | .88 | .231 |
| Maternal extraversion | .09 | .09 | 1.09 | .357 |
| Maternal neuroticism | .28 | .10 | 1.32 | .005 |
| Maternal openness | .05 | .11 | 1.05 | .681 |
| Paternal agreeableness | -.03 | .12 | .97 | .786 |
| Paternal conscientiousness | -.19 | .10 | .83 | .056 |
| Paternal extraversion | .16 | .09 | 1.17 | .074 |
| Paternal neuroticism | -.06 | .09 | .94 | .506 |
| Paternal openness | -.02 | .11 | .98 | .833 |
| Verbal hostility/discipline (mother) | **.44** | **.11** | **1.55** | **<.001** |
| Warmth/Affiliation (mother) | -.12 | .14 | .89 | .415 |
| Permissive/low parenting confidence (mother) | .33 | .12 | 1.39 | .007 |
| Physically punishing (mother) | .17 | .11 | 1.19 | .118 |
| Mother-child relationship environment | .06 | .12 | 1.06 | .648 |
| Father-child relationship environment | .04 | .11 | 1.04 | .740 |
| Average/low efficacy (father) | .09 | .15 | 1.09 | .566 |
| Average/low efficacy (mother) | .02 | .13 | 1.02 | .860 |

*Note*. The statistically significant predictor(s) in each model are printed in bold. MELAA = Middle Eastern, Latin American or African; PAS = Positive affect/surgency; SDQ = Strengths and Difficulties Questionnaire; Coeff = Coefficient; SE= Standard Error; OR = odds ratio; REF= Reference category; temp = temperament.
[a]Critical *p* value adjusted using Benjamini and Hochberg's (1995) method for controlling the false discovery rate.

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