Exploring the influence of early screen use in the home on psychological development from an ecological perspective

Chloé Beatty B.Sc.

Thesis submitted to

Mary Immaculate College, University of Limerick

For the degree of

Doctor of Philosophy

Supervisor: Dr Suzanne Egan

Submitted to Mary Immaculate College, University of Limerick, May 2023

Abstract

Exploring the influence of early screen use in the home on psychological development from an ecological perspective

Chloé Beatty

The present research focuses on the influence that early screen use in the home has on young children's psychological development. While a large body of research has been conducted on the influence that screens have on physical health factors, there is a paucity of literature focusing on early psychological development. Furthermore, the little research that has been conducted in this area has not considered early screen use from a fully ecological perspective. To explore this topic, the current research draws on Bronfenbrenner's bioecological model while using a nationally representative birth cohort study, as well as primary data, to assess the unique contribution early screen use has on developmental outcomes.

The empirical studies in this thesis suggest that screen use had varying influences on children's cognitive and socio-emotional development. However, the effect sizes were small in comparison to those seen for environmental factors, such as household income or parent-child relationships. Longitudinal analyses also indicated reverse-causal effects, which suggests screen time to not be the initial causing factor for the children's later developmental outcomes. Further ecological factors, such as parental screen beliefs and engagement during screen time were also found to be associated with the prevalence and type of early screen use, highlighting the importance of controlling for such factors in the analyses.

These findings highlight the screen use factors, and the ecological factors related to this, that are important to measure in future research to provide a more nuanced understanding of screen time's unique role in early development. The findings are discussed within the context of the bioecological model and provide evidence-based guidelines for caregivers, educators, practitioners, and policymakers, on best early screen use practices. The findings also add to the debate on what influence, if any, early screen use has on the young developing child – an area that has been under-researched to date.

Declaration

College: Mary Immaculate College, University of Limerick

Department: Psychology

Degree: Ph.D.

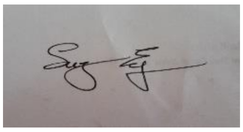
Name of Candidate: Chloé Beatty

ID number: 16192958

Title of Thesis: Exploring the influence of early screen use in the home on psychological development from an ecological perspective.

Declaration: I hereby declare that this thesis is the result of my own original research and does not contain the work of any other individual. All sources that have been consulted have been identified and acknowledged in the appropriate way.

Signature of Candidate: 

Signature of Supervisor: 

Acknowledgements

I would like to firstly thank the families who volunteered their time to participate in both the GUI and PLEY studies. Without their interest and participation, the current research would not have been possible. Thank you to the members of the Psychology Department in MIC (past and present), and fellow postgrad Nuala, for the continued words of encouragement and advice given over the years. It was an honour to be a part of such a supportive and dynamic department. Thanks also go to my external examiner Professor Margaret Sutherland and internal examiner Dr Niamh Higgins for kindly giving their time to be a part of this important life chapter.

A special thanks goes to my supervisor Dr Suzanne Egan, who has always been much more than a supervisor to me. Thank you for guiding me through the various stages of this research, and through the initial early years of my career. Most importantly though, thank you for believing in me during the times when I had lost belief in myself. Your extensive feedback, advice, and encouragement have all been invaluable in the completion of this thesis.

My final thanks go to my front row cheerleaders, Blaž, Leanne, Megan, and Laura, all of whom were a vital part of this process. Thank you for being the people who not just supported me through this journey but made me the person that I am today. I truly could not have done it without you.

Table of contents

List of tables

List of figures

List of appendices

List of publications

Conference presentations

Beatty, C., & Egan, S. M. (2017). Exploring Screen-Time in Young Children: Passive Exposure versus Active Use. *Psychology Society of Ireland's Student Congress, National University of Ireland, Galway, April 17th, 2017.* Oral Presentation.

Beatty, C., & Egan, S. M. (2017). The Cognitive and Socio-Emotional Impact of Screen-Time on Young Irish Children. *Limerick Postgraduate Research Conference, Limerick Institute of Technology, May 24th, 2017.* Oral Presentation.

Beatty, C., & Egan, S. M. (2017). An Exploration of Interactive Screen Time and its impact on Children's Cognitive and Social Development. *22nd Annual CyberPsychology, CyberTherapy & Social Networking Conference (CYPSY22), University of Wolverhampton, UK, July 28th, 2017.* Oral Presentation.

Beatty, C., & Egan, S. M. (2018). Nature vs Cyber-Nurture: The role of screen time in young children's development. *European Federation of Psychology Students' Associations Congress, Malta, April 25th, 2018.* Oral Presentation.

Beatty, C., & Egan, S. M. (2018). An Exploration of Interactive Technology's Impact on Young Irish Children's Cognitive and Socio-Emotional Development. *Irish Research Methods Summer School, Mary Immaculate College, May 26th, 2018.* Oral Presentation.

Beatty, C., & Egan, S. M. (2018). Nature vs Cyber-Nurture: The Effect of Technology on Cognitive and Socio-Emotional Development in Irish Children. *Children's Research Network PhD Symposium, University College Dublin, August 24th, 2018.* Oral Presentation.

Beatty, C., & Egan, S. M. (2018). Screen-Time versus Screen Type: The impact of screen engagement on cognitive development in Irish 5-year-olds. *10th Annual Growing Up in Ireland Conference, Dublin, November 8th, 2018.* Oral Presentation.

Beatty, C., & Egan, S. M. (2018). The Impact of Screen Engagement on Young Children's Cognitive Development. *Children's Research Network Conference 'Growing up in the digital environment', Dublin, December 6th, 2018.* Oral Presentation.

Beatty, C., Egan, S. M., & Hoyne, C. (2019). Play and Learning in the Home Environment. Research Findings from Growing Up in Ireland Study. *International Family Learning Conference, Ennis, March 28th, 2019.* Symposium Workshop.

Beatty, C., & Egan, S. M. (2019). The impact of screen use on the socio-emotional development of Irish 5-year-olds. *11th Annual Growing Up in Ireland Conference, Dublin, November 21st, 2019.* Oral Presentation.

Beatty, C., & Egan, S. M. (2021). Screen Use and Early Socio-Emotional Development: Findings from the Growing Up in Ireland Study. *The International Psychological Forum - Child in the Digital World, Online, June 2nd, 2021.* Oral Presentation.

Beatty, C., & Egan, S. M. (2021). The Longitudinal Impact of Screen Use on Socio-Emotional Development in Early Childhood. *British Psychological Society's Cyberpsychology Section Annual Conference, Online, July 7th, 2021.* Oral Presentation.

Refereed journal papers

Beatty, C., & Egan, S. M. (2018). Screen-time and vocabulary development: Evidence from the Growing Up in Ireland study. *ChildLinks-Children and the Digital Environment*, *3*, 18-22.

Beatty, C., & Egan, S. M. (2020). Screen-time and non-verbal reasoning in early childhood: Evidence from the Growing Up in Ireland Study. *Children's Research Digest, 6*(1) 32-39.

Beatty, C., & Egan, S. M. (2020). Screen time in early childhood: A review of prevalence, evidence and guidelines. *An Leanbh Óg, 13*(1), 17-31.

Beatty, C., & Egan, S. M. (2020). The role of screen time and screen activity in the nonverbal reasoning of 5-year-olds: cross-sectional findings from a large birth cohort study. *Cyberpsychology, Behavior, and Social Networking*, *23*(6), 406-411.

Book chapters

Egan, S. M., Hoyne, C., & Beatty, C. (2020). The Home Play Environment: The Play and Learning in Early Years (PLEY) Study. In M. Nohilly & A. Leahy (Eds.), *Perspectives on Childhood*. Cambridge Scholar Publishing.

Beatty, C., & Egan, S. M. (2023). Approaching Early Screen Time Research from a Developmental Psychology Perspective: Integrating Theory, Research and Practice. In M. Wright (Ed), *Research Handbook on Cyberpsychology*. In preparation.

News article

Egan, S. M., & Beatty, C. (2020, May 18). How much screen time is too much for young children? *RTÉ Brainstorm*. https://www.rte.ie/brainstorm/2020/0518/1139039-children-screen-time/

List of acronyms and abbreviations

AAP	American Academy of Paediatrics
ANOVA tests	Analysis of Variance tests
BAS II	British Ability Scales II
CBCL	Child Behaviour Checklist
ECE	Early Childhood Education
GUI Study	Growing Up in Ireland Study
HSE	Health Service Executive
IBM SPSS	IBM Statistical Package for the Social Sciences
NLSY	National Longitudinal Survey of Youth
PLEY Study	Play and Learning in the Early Years Study
PPCT model	Process-Person-Context-Time model
RCPCH	Royal College of Paediatrics and Child Health
RQ	Research Question
SDQ	Strengths and Difficulties Questionnaire
SES	Socio-Economic Status

Chapter 1:

Overview and rationale

The objective of this thesis is to explore the influence of various types of early screen use in the home on early psychological development, namely early cognitive and socio-emotional development. Throughout the thesis, the term child development is used to relate to the sequence of psychological changes that occur between birth and adolescence, while early development is used to refer to the development that takes place specifically in early childhood (from infancy to 6 years; Kail, 2021). The term psychological development relates to the sequence of changes that happen across cognitive and socio-emotional domains (Burman, 2017), with the influence of screen use on both of these developmental domains being explored individually throughout the thesis.

Screen use is the term used to describe the forms of engagement with a screen device explored in Chapter 3 and 4. This engagement relates to the time spent on a screen (separately referred to as screen time throughout the thesis), and the activity being engaged in (separately referred to as screen activity in the thesis). The screen device being used (i.e., television, computer, or touchscreen) and screen content being engaged in (i.e., educational or entertainment) are also forms of screen use explored in Chapter 5. Educational content, in the context of this research, relates to any age-appropriate content viewed on a screen device that has specific educational purpose (i.e., TV programmes or screen-based games that aim to teach skills or provide new knowledge). Additionally, entertainment content is any screen-based content that is created for purely entertainment purposes and holds little educational value (e.g., fast-paced cartoons/content with the primary intention of holding a child's attention).

Rationale for the research

Children's screen time has long been of interest to researchers and parents alike. However, young children are now exposed to more technologies than in the previous decades, and have more devices readily available for their use, resulting in increased screen time over the years (Dinleyici et al., 2016). This is largely due to the presence of more screen-based games and touchscreen devices, such as tablets and smartphones, in the average household compared to a generation ago (Strasburger et al., 2013; Dinleyici et al., 2016). Since this rise in electronic and handheld device use, there has been a range of research addressing various screen activities in older cohorts, such as adolescents' engagement with social media and video games (e.g., Przybylski & Weinstein, 2017). However, few studies have explored the influence of screen time and various screen activities in the home on early psychological development (Burns & Gottschalk, 2020; Li et al., 2020). This has resulted in a dearth of knowledge on the role that screen use in a naturalistic setting plays in this developmental stage. Given the rising prevalence of screen devices in the early home environment, and therefore the growing rate of early screen engagement, it is therefore a timely endeavour to explore the level of engagement young children have with these devices and what influence this may have on their early development.

Additionally, very few screen use researchers have adopted an ecological approach, where the role of screen use in early development is considered within the context of factors in the children's ecological systems that are also known to influence development. The importance of accounting for such variables allows for inferences to be made on the unique contribution early screen use has on development, which is otherwise difficult to interpret when not accounting for influencing ecological factors. The empirical research in this thesis therefore considers early screen use from an ecological perspective by utilising Bronfenbrenner's (1993) bioecological model as a theoretical framework. Factors such as the families' socio-economic status, parental education attainment, and parent-child closeness are considered and examined in conjunction with screen use factors to identify what influence early screen use, independent of ecological factors, has on psychological development. Exploring the associations between parental factors in the home (such as engagement during screen time and screen beliefs) and early screen use is also of interest, to provide empirical knowledge on the factors within parents' control that may contribute to early screen use behaviours.

These ecological considerations are important in contemporary screen time research as many of the studies in this area have been noted to be atheoretical in their methodological approach (Herodotou, 2018), despite developmental theory noting the importance of children's environment (e.g., Vygotsky, 1978; Bronfenbrenner, 1974) when measuring the influence of a process (such as screen use) on developmental outcomes. The ecological factor of time is additionally important to measure given that development does not occur instantaneously, and so measuring the influence of screen time on later development is a consideration that has theoretical importance (Bronfenbrenner, 1989). Longitudinal analysis in screen time research has also been noted as an approach that is underutilised in early screen time research (Elson & Ferguson, 2015; Bell et al., 2015), further highlighting the importance of measuring what longitudinal influence, if any, early screen time has on later psychological development.

In response to the evident gaps and limitations in the existing literature, the current research therefore aims to address the following research questions:

1. What cross-sectional influence does early screen use have on various measures of cognitive and socio-emotional development?
2. Does screen time have a longitudinal influence on these psychological development measures?
3. Do the findings remain significant after controlling for ecological factors (e.g., families' socio-economic status, parental education attainment, and parent-child closeness)?
4. What other ecological factors are associated with early screen use (e.g., parental engagement/screen time beliefs, and children's age)?

Overview of the research

As the empirical studies in this research are framed by Bronfenbrenner's bioecological model, they utilise the research model within this framework known as the Process-Person-Context-Time model. This theoretical framework and research model is introduced and discussed in Chapter 2 of this thesis, where research on screen time and early development is also outlined. Firstly, research on the role of television viewing in early psychological development and the correlates of screen time in early childhood are considered. This is followed by the introduction of the screen time classifications that encourage researchers to measure beyond screen time and consider wider factors such as screen activity and content, the context in which screen time is happening, and the possible connections being made during screen time. The importance of considering these variables in contemporary research, given the wide variety of screen devices and activities now available to young children, is then discussed.

Chapter 3 then reviews the literature available on the role of early screen use in cognitive development, specifically reasoning and language development. The review shows that little research has examined the role of screen activities in cognitive development (e.g., video games), with the majority of research still using the singular measure of screen time or TV watching in early screen use studies. The research that has considered wider screen use factors did not adopt a bioecological approach and therefore did not account for other influencing factors in the children's ecological systems. This is a major limitation discussed in the review. Additionally, Chapter 3 highlights that few studies have examined the longitudinal influence of early screen time and whether the existing statements in the literature relating to screen time's influence on cognitive development has been tested for directionality. To address these gaps in the knowledge, Study 1 and 2 in Chapter 3 draw upon data from the large cohort Growing Up in Ireland (GUI) Study to explore the influence of early screen use in the home on cognitive development, as measured by the Pictures Similarities task and the Naming Vocabulary test from the British Abilities Scale II (Elliott et al., 1997), from an ecological perspective. The findings of these studies are then discussed in light of the past research in the field. The role of the ecological factors and the importance in continuing to adopt an ecological approach when exploring other psychological domains, such as socio-emotional development, is also discussed.

Chapter 4 therefore reviews the existing research on the role of early screen use in socio-emotional development. Similar to the previous chapter, few researchers have explored the role of various screen activities, environmental factors, longitudinal effects, or directionality within a young, representative sample. Study 3 and 4 adopt the same research design as Study 1 and 2, where the unique contribution of screen time and activity on the 5-year-olds' internalised, externalised, and prosocial behaviour, as measured by the Strengths and Difficulties Questionnaire (Goodman, 1997), are explored cross-sectionally and longitudinally. By doing so, the key difference between the current research and past research is the utilisation of a bioecological research model that encourages ecological factors to be considered before creating inferences on the influence of screen use on development. However, further screen use and ecological factors (such as screen content and device, and the frequency of parental engagement during screen time and parent screen use beliefs) were not measured in the GUI Study. Measuring these factors would provide a holistic view on the associations between screen use and parental factors in the microsystem of the home.

For this purpose, primary data were collected, which also allowed for more fine-grained measures of screen use to be explored across a larger age range (6 months to 6 years of age). This data is explored and analysed in Chapter 5. The literature review in Chapter 5 highlights that screen use by children under 3 years of age is relatively under-researched, with little knowledge available on infants' natural and incidental screen use in the home. Additionally, while past research has shown parental engagement to be an important factor for beneficial outcomes during screen use, the frequency with which this happens in the home with young children has not been widely reported on. Furthermore, the factors associated with this frequency of parental engagement, such as parental screen beliefs, the children's age, or the screen activity being engaged in, have not been explored in the existing literature.

To address this, Study 5 provides empirical findings on the prevalence and type of young children's screen use in the home, and its influence on psychological development. These findings are of interest as infants' screen use in the home, and how this compares to the screen use of older children, is relatively unknown. The final study in this thesis explores the associations between parental screen beliefs, children's screen use, and parental engagement during screen time. The importance of the findings from these studies is then discussed at the end of Chapter 5, which highlights the need for more screen use research with children under the age of 3 years. The unique contributions of Study 5 and 6 are also discussed. This discussion relates to the expanded measures of screen use explored across a large age range, along with the consideration of ecological factors and their associations with early screen use within the microsystem of the home. The frequency of parental engagement during screen time in the home and the ecological factors that may influence this are also novel findings that contribute to the early screen use literature.

The final chapter of the thesis summarises the main findings reported throughout the research and discusses the research, theoretical, and practical implications of these findings. The strengths and limitations of the research are also considered. Through this, suggestions for future screen use and developmental researchers are made, along with the recommendation of utilising a bioecological framework to create more robust and holistic inferences on the role of early screen use in psychological development. The importance of considering screen activity, directionality, and ecological factors when assessing this role is also highlighted. Based on this, evidence-based guidelines on best early screen use practices are discussed and considered in light of the current recommendations from children's advocacy organisations and national health organisations.

Chapter 2:

Literature review

General introduction to the research

While research on the topic of early screen use has begun to gather pace in the last five years, how engagement with newer technologies in the home (i.e., screen-based games and touchscreen devices) influences young children's psychological development has been noted as an area that has received little attention in the literature (Strasburger et al., 2013; Hinkley et al., 2018). The little research that has been conducted on this cohort has produced mixed findings on whether early screen use has benefits, drawbacks, or any influence at all on the psychological development of young children (Kostyrka-Allchorne et al., 2017; Li et al., 2020). In order to make sense of this diversity of research and the complexity of its findings, it is important to recognise the range of different meanings that might be encompassed by the idea of 'screen time', and to separate the types of screen activities that children engage in during screen time.

The first section of this chapter therefore examines what is known from the earlier and foundational screen time research, regarding the role of television viewing in children's psychological development. The second section reviews the screen time literature from past to present to highlight how screen time has evolved, along with the definitions and classifications of screen time that have arose in response to its evolution. The third and final section of the chapter discusses Bronfenbrenner's bioecological model as a framework in which the influence of early screen use on development can be considered, and how the use of this framework potentially addresses some of the methodological and analytical issues present in the screen time research.

Therefore, the aim of the current chapter is to review the existing screen time research, to explore the various screen activities and uses now available to young children, and to consider whether there are consistent conclusions that can be drawn from the findings on early screen use and psychological development. In doing so, the related gaps in the field will also be addressed, and a research model for the current research will be proposed. With television being the first form of screen time to be researched, it seems fitting to begin with a review on what is known on the role of screens in children's psychological development from the television era.

Television viewing and early development

Since the 1970s, TV viewing in early childhood has been an area of research interest, with it being noted as a contributor to the rise in obesity and inactivity in children (e.g., Quisenberry & Klasek, 1977; Gioia & Brass, 1986). Despite this interest, the term 'screen time' itself was not created until 1991 and was done so not by a researcher in the field, but rather a journalist (Shapiro, 2019). The original definition was three-fold, defining screen time as the amount of time spent in front of a screen; the amount of time companies had to run their advertisements on TV; and the editing of shots to allow images to run at a quicker speed than real time.

In the following years, there was a sharp incline in how often the term 'screen time' appeared in print, with it later becoming synonymous for time spent watching TV or videos. Researchers began reporting concerns related to children's physical development, such as the rise in sedentary behaviour and cardiovascular health issues due to screen time (e.g., Gortmaker et al., 1996; Anderson et al., 2008; Peck et al., 2015). As a result of this, the term 'screen time' soon became of interest to researchers also concerned with its potential risks to psychological, not just physical, development (Barr & Hayne, 1999; Christakis et al., 2004; Anderson & Pempek, 2005; Zimmerman et al., 2007a), with most suggesting television viewing to also be negatively correlated with healthy psychological development in early childhood.

However, more recent research has suggested the influence of television to be inconclusive when it comes to early psychological development (e.g., Kostyrka-Allchorne et al., 2017). Various factors such as the developmental domain being measured, individual and environmental factors, and programme content, were noted to play a role in the extent to which screen time influences this type of development. To explore this in more depth, it is important to review the research available in this area, and the various limitations and collective issues present in the literature on television viewing's influence onn early psychological development.

The influence of TV viewing on early psychological development

Children's psychological development takes place across two main domains: cognitive and socio-emotional development (National Research Council, 2015). Cognitive development is concerned with the child's ability to learn and utilise new information (Piaget, 1936). Measures of cognitive development include problem-solving and attentional ability, language acquisition, and overall academic achievement (Lerner et al., 2015). Socio-emotional development is related to how well the child is socially and emotionally adjusted. Measures include attachment to a caregiver, how well they can make friends, and level of conflict or difficult behaviour at home or in school (Lamb & Lerner, 2015).

In a review on the available research at the time, Anderson and Pempek (2005) highlighted that many small experimental studies in the 1980s and 1990s showed early television viewing to be related with cognitive delays (e.g., Carew, 1980; Anderson et al., 1986; Troseth & DeLoache, 1998). Larger representative studies conducted in the following decades also showed this to be the case. For example, one of the most cited research papers on TV viewing and early cognitive development was conducted by Christakis et al. (2004). Using the National Longitudinal Survey of Youth (NLSY), the researchers examined the associations between early TV viewing and later attentional disorders at age 7 years with 2,623 American children. Time spent watching TV at age 1 year and 3 years was assessed from parent estimates, and symptoms of attention disorders were assessed at age 7 years from parental report. Christakis et al. (2004) reported a small positive relationship between infant television viewing and later symptoms of attention disorders, suggesting a negative association between TV viewing and this aspect of cognitive development.

Similarly, Zimmerman and Christakis (2005) found 1-hour increments of TV viewing in infancy to be modestly negatively associated with reading ability at age 6 years for the 1,797 participants in the NLSY. In a study with 1,008 parents, Zimmerman et al. (2007a) additionally found early screen time to be negatively related with young children's communication scores, as reported by parents using the Communicative Development Inventory. This was also shown in a study by Chonchaiya and Pruksananonda (2008), where Thai children aged 1 to 4 years who had language delays were found to watch more television and from an earlier age – although their sample size of 166 pre-schoolers was less representative than the above studies. Their odds ratio analyses showed that children who started watching television under 12 months of age and watched more than 2 hours of television daily were approximately 6 times more likely to have language delays identified, after reviewing language milestones and Denver-II scores in a clinical setting.

To add to these findings, Tanimura et al. (2004) found high levels of television viewing (more than 4 hours a day) to again be associated with delayed language in their survey-based study with 1,900 18-month-olds in Japan. However, in a more positive take on early screen time, the researchers noted that this does not necessarily mean screen time is negative for all forms of development. In a follow-up observational study to further explore these associations, the researchers found early television viewing to have some developmental benefits. In this follow-up study, Tanimura et al. (2007) observed the interactions of 14 parent-child dyads in a playroom both when a television was on and off. While parents' utterances of words were significantly lower when the television was on (reducing opportunities for language development), the rate of smiling and singing from parent to child was significantly higher (increasing social and emotional interactions). The researchers concluded that based on the area of development being measured, early television viewing can have benefits to psychological development. In this case, television could be used as an opportunity for emotional communication, which otherwise may have not taken place between parent and child.

These findings added to the research by Mumme and Fernald (2003) who showed that infants can learn emotional responses from television, as the children in this study were found to use social information presented on television to inform emotional reactions. This highlights the importance of measuring the influence of early screen time across various developmental domains to have a better understanding of its role from a holistic perspective, rather than on one developmental measure. A further way to provide a more well-rounded understanding of screen time's role in early development, is to consider the various environmental and individual factors that may also be influencing the developmental outcomes of the children in the TV viewing research studies.

The role of environment and individual factors in the TV viewing research

In contrast to the findings related to TV and cognitive development outlined above, Schmidt et al. (2009) found that early TV viewing has no correlation with cognitive outcomes for 3-year-olds. This longitudinal study more stringently controlled for environmental influences on development by including a wide range of factors available from the Project Viva cohort study, including maternal education, mental health, and income. TV viewing was measured from 6 months to 3 years of age through parental report. While the regression analyses initially showed a significant negative correlation between amount of TV viewing and vocabulary and visual motor scores, this was not the case after the environmental factors were adjusted for. The researchers suggested that when such factors are controlled for, screen time poses little threat to children’s development. Interestingly, this was also illustrated in a study with older children, where Schmidt and Vandewater (2008) found no association between duration of TV viewing and academic achievement when such factors were taken into account.

In addition to this, a previous study that commented on the importance of the inclusion of environmental factors in screen time research noted the issue with interpreting causality from the foundational research in the field. Özmert et al. (2002) conducted a cross-sectional study with over 800 young school-aged Turkish children on television viewing habits and behavioural outcomes. They found high levels of daily TV watching (more than 4 hours) to be associated with poorer social and school achievement, as measured by the Child Behaviour Checklist (CBCL). The children’s age and socio-economic status, however, also showed to be significant predictors of developmental scores and daily screen time, suggesting these factors to be mediators in the analysis. The researchers noted that while causality was not explored, their regression analyses showed attentional and social problems to be associated with higher television viewing.

In a later study on TV viewing and the socio-emotional outcomes of 5- to 17-year-olds from a representative sample using the American National Survey of Children’s Health, Lingineni et al. (2012) found TV watching to be positively correlated with ADHD symptoms in their regression analyses. Their study also indicated that home and environmental factors were significantly correlated with ADHD diagnoses. However, the researchers stated that due to the cross-sectional nature of the study, causality could not be inferred from the findings. These studies highlight the importance of controlling for environmental and individual factors, along with exploring causality using baseline individual factors, before drawing conclusions on the role of early screen time.

In a recent study that looked at both language development and behaviour outcomes in 3-year-olds, Hill et al. (2020) found again that higher levels of daily TV and video viewing were related to poorer language outcomes. However, their analyses showed baseline behavioural issues predicted screen time at age 3 years more than baseline screen time predicted behaviour outcomes. The researchers also reviewed some of the longitudinal studies that have been conducted in the field to date. While some demonstrated that early TV viewing predicted later developmental delays, very few commented on directionality in these studies. Additionally, while there is a considerable amount of research on the environmental factors that contribute to amount of daily screen time (e.g., see Duch et al., 2013a), there is less research controlling for these factors when measuring developmental outcomes in screen time research.

The above studies highlight the need for screen time research that controls for environmental and individual factors when measuring developmental outcomes. Doing so can also allow for the exploration of causality, which has been suggested as an area yet to be fully explored in screen time research concerned with psychological development in early childhood. In addition to exploring these factors, Hill et al. (2020) noted that a limitation to their study was not including the context of screen time, such as the content or activity being engaged in. This is a common limitation in the research on early television viewing and its role in psychological development, despite researchers noting its importance (e.g., Özmert et al., 2002; Schmidt et al., 2009).

Anderson and Pempek (2005) also highlighted the consideration of environmental changes over time as an important area to include in future research. In their review of the literature, Anderson and Pempek (2005) noted an increase in the number of infants exposed to television from 1980s to the 1990s, among the advent of infant-directed TV programmes such as Baby Einstein and Teletubbies. The non-viewing average reported in the research dropped from approximately 83% to 48% in these 10 years. Their review highlights the importance of considering the factors in a child's environment that are ever-changing in future screen time research. With various screen devices now being popular among younger users, this environmental change of the omnipresence of screens may be influencing children's screen time behaviours. Therefore, in line with that suggested by Anderson and Pempek (2005), it is important to understand the changing nature of young children's screen time habits over the past decades and whether these changes are having varying influences on their psychological development in comparison to that reported in the earlier television viewing literature.

The evolution of screen time - from TV to touchscreens

TV and video watching has become increasingly rivalled by contemporary screen devices that utilise child-friendly features (such as screens that respond to simple tactile actions, like tapping or swiping) in gaining children's interest. As an example, in 2011, Australian children under the age of 5 years were spending less than 30 minutes a day on computers or touchscreen devices (Australian Government Department of Health and Ageing, 2011), but by 2015 this had increased to an average of 79 minutes per day on digital devices (Marsh et al., 2015). Touchscreen use by American pre-schoolers also rose from 10% daily usage to 38% between the years of 2011 to 2013 (Rideout, 2011; 2013). Daily TV viewing dropped for these children over the same time span from 79% to 63%. This indicates a possible change in what type of screen activities young children are mostly engaging in, with touchscreens offering the possibility of gameplay and video calls in addition to content viewing.

Kabali et al. (2015) estimated that by 4 years of age, 75% of American children from low socio-economic backgrounds owned a mobile phone, with most of these children using a touchscreen device before 12 months. Similarly, in Britain, children under 5 years of age spent an average of 69 minutes on these devices (Lauricella et al., 2015). Bedford et al. (2017) additionally found that 75% of British children under 3 years of age had daily use of a touchscreen device, and by age 3 years only 10.5% of toddlers had no prior experience with these devices. Early Childhood Ireland (2016) also reported that 85% of Irish children under 24 months were watching over 2 hours of TV daily, and that 38% of the same children had used a mobile device. Drawing on the Growing Up in Ireland data, Egan and Murray (2014) reported that 3-year-olds in Ireland spent an average of 112 minutes per day watching television, with 27% watching more than 2 hours per day. They also reported that 16% of 3-year-olds had a TV, computer, or games console, in their bedroom. By 5 years of age, 42% of these Irish children were engaging in more than 2 hours of screen time per day on average (inclusive of computers and touchscreen devices; Murray et al., 2019). This was also mirrored in studies conducted in Estonia, UK, and the US, which showed on average 83% of 5-year-olds use a digital device at least once a week, with 42% using one every day (OECD, 2020).

These figures highlight how screen time at an early age is transitioning from TV viewing to using digital devices globally, and so, it is important for the research on early screen time use to follow suit. In response to the changing times, there was a motion in the field of early development research to move away from the traditional screen time definition of ‘amount of time spent TV/video watching’ when assessing the role screen time has in early development (Haughton et al., 2015; McClure et al., 2015). This movement in the research was likely related to the development of screen time classifications that provided a more nuanced way to measure the influence of screen time on development. By viewing screen time as an activity with various components, these classifications place importance on moving past measures of screen use that focus solely on the time spent on screens.

Sweetser et al. (2012) were the first to formally create a classification of screen time, by separating screen time into 'Active' and 'Passive' activities. Sweetser et al. (2012) defined active screen time as screen activities that involve cognitive or physical engagement. This could be inclusive of, but not restricted to, completing homework on a screen device or playing educational games on a touchscreen or computer device. While this was the first formal classification of screen time, research previous to this had explored the effects of 'active screen time' during child development.

For example, Shute and Miksad (1997) found that exposure to computer-assisted instruction software over the course of eight weeks resulted in higher verbal and language skills for pre-schoolers due to the availability of scaffolding features. Li and Atkins (2004) also reported greater school readiness among pre-schoolers who had a computer in their home. In their study, children with access to a computer performed better on the Wechsler Preschool and Primary Scales of Intelligence, among other cognitive tests, even after controlling for environmental factors. Drawing on some of the available research on children's computer use, Clements and Sarama (2003, p. 4) stated that "drill-and-practice developmentally appropriate software, educational games, and drawing programs should be addressed separately, because their impact is different".

In a review of the research available on what would have been considered 'active screen time', McCarrick and Li (2004) found the literature on early computer use to report a range of benefits for psychological development in comparison to that found in the literature on early TV viewing. While they noted that very little empirical evidence for computer use in early childhood was available, the studies that had been done showed computer use to improve social interactions (e.g., Heft & Swaminathan, 2002), language development (e.g., Bhargava & Escobedo, 1997), and motivation (e.g., Bergin et al., 1993). Although the above research portrays computer use as more developmentally beneficial than television viewing in early childhood, a limitation that is common to all of these studies is the small sample sizes used. With computers not being as commonplace in the average household in the 1990s and early 2000s, few children had exposure to this form of screen time. Therefore, contemporary studies that include screen activities outside of TV viewing are important for producing meaningful and representative findings in this area. All the while, these studies did provide a positive new narrative on early screen time, which spurred later research in the area.

Drawing on similar research to develop the active and passive screen time classification, Sweetser et al. (2012) suggested that the term 'screen time' was no longer detailed enough to accurately measure the possible health outcomes from time spent on screen-based activities. Instead of viewing it as an overall term, they proposed a 'Hierarchy of Screen Time', where more active and educational forms of screen time were distinct from passive TV watching, and further ranked by their varying positive and negative effects on child development. While the authors have not produced further research to formalise this hierarchy to date, the idea of such a model contributed towards the development of later classifications, such as Blum-Ross and Livingstone's (2016) classification of screen time. Blum-Ross and Livingstone (2016) suggested that instead of solely measuring the time that a child spends in front of a screen, what should be additionally measured is the content, context, and the connections facilitated during their screen time. This refers to what content or activity the child is engaged in during screen time, the context in which screen time is taking place, and whether there is an adult present to facilitate learning and talk time during screen time. These elements of screen time have also been explored in the literature, where developmental outcomes of television viewing were often mediated by the type of content viewed and level of parental engagement during screen time.

For example, some of the foundational research found that children can learn vocabulary from television if the content is of an educational nature (Rice & Woodsmall, 1988; Rice et al., 1990; Naigles & Kako, 1993), and children who watch programmes with educational content receive better grades in school compared to those who mostly watch entertainment programming (Wright et al., 2001). In relation to parental engagement, a study by Barr et al. (2008) found that parents ask questions and provide labels or descriptions when watching child-directed programmes with their children. Children were also found to engage more with the content if a parent was present. Similarly, Lavigne et al. (2015) found that parents who co-view with their child are more likely to introduce new words into their vocabulary than parents who replace that screen time for free play.

While the above classifications hold importance for the direction and quality of screen time research, there is little research to date that has included elements of the classifications when analysing the role of screen time in early psychological development (Li et al., 2020). Recent research has, however, found differences across screen activities in relation to their influence on development in older cohorts. For example, Przybylski and Weinstein’s (2017) research with teenagers illustrated screen time as having varying effects on well-being depending on whether the participants in their study were mostly using their smartphones, games consoles, or watching television. Engaging in a game such as Minecraft, where socialising and creativity is encouraged, did not have the same effect as TV viewing and therefore did not displace activities meaningful for this type of development, such as creative writing. The researchers suggested that social aspects of games like Minecraft may even encourage socio-emotional development more than time spent on solitary reading, an activity that screen time could be displacing.

It is therefore important to review the research that has utilised aspects of these classifications to explore how various screen activities differ from each other, from a developmental perspective. Research using aspects of the screen time classifications with a young cohort will also be reviewed to assess what is known, and what is still yet to be known, about the role of various contemporary screen activities in early childhood development. An important question to also consider is whether the research on newer forms of screen activities remains as inconclusive as that on TV viewing, in relation to their influence on early psychological development. With the term ‘screen time’ being synonymous with TV viewing in much of the past research where only time spent watching a screen was measured, the term ‘screen use’ will be used for the remainder of this chapter to refer to multiple screen related factors, including different types of screen activities as well as the time spent on them.

The importance of considering screen activities to assess their role in development

Lauricella et al. (2016) suggested that with the traditional idea of screen time shifting since the introduction of accessible digital devices, it is important to take into account the new types of engagement these devices afford. For example, in comparison to television viewing, activities on both computers and touchscreen devices require physical interaction. While physical interaction may seem an insignificant affordance of digital devices in relation to cognitive benefits, there is a well-established body of research to show that physically engaging with an environment can promote active learning and cognitive development (e.g., Barsalou, 1999; Niedenthal, 2007). This area of cognitive research, known as embodied cognition, has demonstrated that multi-sensory exploration improves learning in the early years (e.g., Thelen, 2000), which is an idea that has been appearing more and more in recent screen use research.

For example, in a study by Neumann (2018a), it was noted that the best cognitive outcomes during screen use were seen when children used apps that encouraged the child to interact physically with the material. Examples of these child interactions included tracing letters on the screen with their finger, or matching letters together in a similar manner. Russo-Johnson et al. (2017) also found that for the 170 2- to 6-year-olds in their study, content in an on-screen word-learning game that required actions such as dragging, versus non-interactive content, resulted in improved word learning. In addition to the benefits of physical contingency, modern screen activities also allow for social contingency, which has been shown to again differ from passive content viewing in relation to socio-emotional outcomes. Computer and touchscreen devices provide opportunities for children to actively and socially engage with others on a screen, via video calling or interactive dialogue with on-screen characters. From a socio-emotional perspective, there has been research to again show that infants could successfully learn from video calling when an on-screen adult was interacting with them in a socially contingent way (Kirkorian & Pempek, 2013; Roseberry et al., 2014).

The above research would suggest that the key differences between TV viewing and other screen activities, such as screen-based games, lie in the increased opportunities for physical interaction and social engagement. Hirsh-Pasek et al. (2015) stated that when these two types of engagement occur during screen time, a more minds-on screen use experience is created, resulting in higher cognitive engagement and social learning. In their paper, Hirsh-Pasek et al. (2015) noted that if theories in early childhood are used when evaluating the possible benefits of screen activities, it is evident that screen-based games and apps, especially those with educational content, vary significantly from passive content consumption. However, despite pre-schoolers being the target population for educational screen-based games (Shuler, 2012), research on the role of young children’s modern screen use in comparison to passive TV viewing is still scarce (Troseth et al., 2016).

If screen activities are to be viewed differently in their contribution to developmental outcomes, as suggested by the research above, then it is necessary to review what is already known about the influence of contemporary screen use on early psychological development. From this, it can be assessed whether the research findings on newer forms of screen activities remain as contentious as that on TV viewing, or if they provide more conclusive evidence on the influence that screen use has on early psychological development.

What is known about the influence of screen use on early psychological development?

Despite screen time research being a wide-reaching and interdisciplinary field of research, there is relatively little contribution to the literature in the way of high-quality psychological research with young children (Burns & Gottschalk, 2019). A systematic review conducted in 2013 found that only 29 peer-reviewed articles had been published on the topic of screen time correlates for children under the age of 3 years (Duch et al., 2013a). While these studies commented on the environmental factors that correlated with higher levels of screen time in the home, they did not explore the influence this screen time may have had on the children's psychological development. The review highlighted the scarce amount of research available on screen time and young children, identifying a clear gap that exists in the field.

In a similar paper, Carson et al. (2015) reviewed the research available on sedentary behaviour in children aged 5 years and under. Screen time as an example of sedentary behaviour was found to have an inconclusive influence on the cognitive development of the young children in these studies. However, the researchers noted that of the small collection of 37 studies that measured screen time and early cognitive development, 27 were considered to be of weak quality and 10 of moderate quality. They concluded that future screen time research with young children needs to have valid measures of cognitive development, adequate sample sizes, and measure various domains of development to produce more reliable results in the field.

Tamana et al. (2019) stated that there is a dearth of screen use research examining development in the early years, with most only considering television viewing, and few allowing for confounding variables such as environmental factors. Additionally, of the few papers that have considered the influence of early screen use from a psychological perspective, the findings tend to be mixed. For example, in Tamana et al.'s (2019) study with 2,427 Canadian 5-year-olds, those who engaged in any form of screen use for more than 2 hours a day had higher socio-emotional difficulties. While the researchers were extensive in their inclusion of environmental factors, they note their main limitations to be the inability to assess reverse-causal associations and whether there were any differences in behavioural outcomes based on the screen activities that the 5-year-olds mostly engaged in.

Conversely, using the UK Millennium Cohort Study, Griffiths et al. (2010) found no relationship between engaging in more than 2 hours of screen entertainment a day, and behavioural outcomes for 5-year-olds. The researchers used the Strengths and Difficulties Questionnaire to explore the role of screen use in the socio-emotional development of 13,470 5-year-olds, also controlling for contextual variables such as the children's social, demographic, and health factors. Despite reporting opposite findings to Tamana et al. (2019), the same limitations to this study were noted, where screen time was measured for all screen activities, but the analyses did not separate these activities to explore their unique contribution to behavioural outcomes. As the study was cross-sectional in design, the ability to assess direction was again a limitation.

In a smaller cross-sectional study assessing the CBCL scores of 200 Thai pre-schoolers, Tansriratanawong et al. (2017) measured amount of daily screen time across various types of medias and activities. They found that higher screen time, regardless of screen media, did not correlate with higher difficulty scores, instead they reported individual factors to play a larger role in behavioural outcomes than screen use. However, the authors noted that their findings should be explored using larger representative samples and employing a longitudinal design before any concrete conclusions from their results could be drawn. Unfortunately, little research to date has addressed these limitations outlined in this area of research. The majority of the literature has instead focused on exploring whether screen time is dose-dependent, that being whether higher amounts of daily screen time alone correlate with less desirable developmental outcomes (McArthur et al., 2022).

However, one recent meta-analysis on screen use and health indicators did separate screen activities in their study. In this paper, Li et al. (2020) found that across the 23 studies included in their analyses (comprising of nearly 50,000 children under the age of 7 years) there was evidence to suggest excessive screen use is associated with various physical health indicators, but its influence on psychological indicators was less clear. The 23 studies included in their analysis were chosen as they provided high-quality analyses and appropriate designs and methodologies, with each study reporting related effect sizes. While these criteria should be considered a baseline for research to conform to, issues with the quality and robustness of screen time research have been widely reported in the field. These research issues have been outlined by various screen use researchers (e.g., Foster & Watkins, 2010; Elson & Ferguson, 2015; Bell et al., 2015; Przybylski & Weinstein, 2019) and relate to the high rate of correlational designs that do not account for reverse-causal associations. The researchers have also highlighted the issue of significance testing without reporting the related effect sizes, or without reporting effect sizes in comparison to the effect sizes of other influencing factors, such as environmental factors.

In their review of the screen use research conducted with young children, Burns and Gottschalk (2020) noted that these flaws have led to a tendency to conflate the negative influences of screen use in areas such as mental health, cognitive abilities, and well-being. They also noted that due to the research quality issues, it is difficult to discern what developmental outcomes, if any, are associated with early screen time or screen use. These research flaws have therefore resulted in many knowledge gaps within screen use research, especially in the area of development in early childhood (Burns & Gottschalk, 2019).

All the while, Li et al.'s (2020) meta-analyses of these 23 studies showed TV viewing to be the screen media mostly associated with obesity, while smartphone use was more related to lack of sleep than TV viewing. In relation to psychological development, the authors noted there to be significantly less empirical research conducted in this area. However, the findings that were available on psychological health indicators were similar to that noted above. Screen time in the form of TV viewing, especially entertainment or violent content, was often noted to result in lower cognitive abilities and social skills or emotional adjustment, while engaging in screen-based games was noted to improve these skills. However, the studies that indicated positive effects of screen use stated that this may have been due to the increased parent-child interactions that occur during such screen activities. Li et al. (2020) noted that while improved parent–child interactions might be a by-product of early screen use worth exploring in future research, more evidence is needed on the influence of various screen uses on psychological development before assessing the role of mediating factors such as parental engagement. With little research investigating the role of various screen activities in development, this highlights a further gap in the screen time literature.

Given the lack of empirical evidence in this area, it is difficult to know the role that contemporary screen use has in psychological development. Some suggest certain screen activities to have no influence on developmental outcomes (e.g., Griffiths et al., 2010), and others show screen time to have negative developmental influences regardless of the activity engaged in (e.g., Tamana et al., 2019). The variation of results in the little research that has been conducted highlights the further difficulty in interpreting what influence early screen use may have, and so the findings to date may be as inconclusive as those reported in the early TV viewing literature.

The research discussed above highlights the evolution of early screen use from TV to touchscreens and the related importance of considering various screen use factors (e.g., Sweetser et al., 2012; Blum-Ross & Livingstone, 2016) when assessing the role of screen time in early psychological development. As noted by past research, further important factors to consider relate to the children's environmental factors (e.g., Lingineni et al., 2012), individual differences such as their age and psychological predisposition (e.g., Hill et al., 2020), and the developmental domain being measured (e.g., Tanimura et al., 2007). Not controlling for such factors has led to the research quality issues outlined by researchers such as Bell et al. (2015), and Przybylski and Weinstein (2019), whereby the influence of screen use on development is not considered within the context of other ecological factors that also influence developmental outcomes. To encompass these factors into the current research, the use of a theoretical framework that addresses the role of ecology on developmental outcomes is appropriate.

An ecological framework to explore the influence of early screen use on development

In response to the large variation of results in the screen time literature, Kostyrka-Allchorne et al. (2017) stated that the current findings in the field of early screen time research are contentious before even considering the differing influences of various screen activities or ecological factors. Their review of the literature highlighted a need for a more holistic methodology and research design when measuring screen use to gain a deeper, nuanced understanding of its influence on development. The various studies discussed thus far illustrate that while past research has explored important screen use and ecological factors separately, little research in this field to date has considered these factors together in their research design. To do so would mean controlling for environmental/contextual factors in addition to measuring screen time and screen activity, to holistically explore the role of early screen use in development.

To best address this, screen use research should aim to bring together and assess the influence of the screen use and contextual factors noted to be of importance for developmental outcomes. With this more ecological approach to measuring screen use being suggested, particularly for research in the field of psychological development, it seems fitting that this research would be framed by theories available from the field of ecological psychology. As the current research includes an even more specific focus on child development, the models that can frame this research in tandem with the important screen use factors outlined in the research are those proposed by developmental and ecological psychologist, Urie Bronfenbrenner.

In his early work, Bronfenbrenner (1974) argued that the ecological validity of prior developmental experiments was compromised due to the emphasis placed on the influence of a situation on the child, while not accounting for the child's individual differences and prior experiences with the situation outside of the laboratory. Bronfenbrenner therefore thought it necessary to also account for the factors occurring outside of an experiment, which may influence an individual child's development and responses during the experiment. To best synthesise these factors, Bronfenbrenner outlined the various systems in a child's environment that could impact on development in his ecological systems theory (Bronfenbrenner, 1979), which would later become a part of his bioecological model of human development (Bronfenbrenner, 1993). Bronfenbrenner and Morris (2007) described this model as an evolving theoretical system for the study of development over time.

Parallels can be drawn here between Bronfenbrenner's view on measuring early development through laboratory testing and the view on measuring the role of screen use in development by solely measuring time. By focusing on the findings from laboratory testing or measuring screen time alone, the researcher does not get a true sense of what is a result from the experiment or measurement, and what is a result of confounding variables relating to environmental and individual factors. This makes Bronfenbrenner's work worth exploring to see how his theories can be used to support the understanding of screen use's influence on early development. In his own writings, he stated that his theories aim to provide a holistic approach to understanding how various environmental factors may influence individual development (Bronfenbrenner, 1979).

Bronfenbrenner's bioecological model

Bronfenbrenner's bioecological model began with the development of the ecological systems theory (1979), which saw human development as happening in, and impacted by, a complex system of relationships. Each of these relationships are also affected by multiple levels (or systems) in the surrounding environment, ranging from immediate settings such as the family home or school, to the wider culture that the child is raised in (Bronfenbrenner, 1977). Therefore, when it comes to early development, developmental outcomes are not just influenced by the child's immediate environments but also multiple aspects and dynamic interactions within these environments and in the larger environment. To aid the understanding of these influences on early development, Bronfenbrenner devised five nested systems that looked beyond the individual and included wider influencing factors of development. These systems are the microsystem, mesosystem, exosystem, macrosystem, and chronosystem.

The microsystem includes the child’s immediate environments, such as their home, and early educational setting or school, along with the interactions the child has with the people and objects within these settings. The mesosystem relates to the connections between these people in the child’s microsystem, such as the relationship the child’s parents have with the child’s teachers, friends, neighbours, or early years educators. People and environments that the child does not have immediate interactions with but may still have an impact on the child (such as a parent’s workplace) are contained in the exosystem, while the macrosystem refers to the broader environment that the child is raised in and contains factors such as culture, values, and societal structures. The chronosystem is the final system and includes any environmental changes that may happen over the child’s life course, such as socio-historical events like a recession, pandemic, or technological changes. With digital devices evolving over time and being present in most common households, their current and future influence on child development can be seen to be taking place across these systems.

The ecological systems theory provides a holistic approach to understanding early psychological development by considering the individual and environmental factors that may influence child development. Bronfenbrenner further revised these developmental influences by focusing on differentiating between the various factors that make up the child’s environment and their varying influence on development. This resulted in the creation of the bioecological model (Bronfenbrenner, 1993). In this expanded version of the ecological systems theory, Bronfenbrenner placed more emphasis on defining and outlining the influence of proximal processes, which were described as the interactions between a developing child and the people, objects, or symbols in their immediate environment (Bronfenbrenner, 1995).

Bronfenbrenner viewed proximal processes as essential for development to occur, with the properties of a proximal process being outlined by Bronfenbrenner and Morris

(1998, p. 996) as follows: (a) the individual should engage in these activities/interactions/processes “on a *fairly regular basis*, over an extended period of time” to allow for the interactions to becoming “increasingly more *complex*”, (b) the activity is not unidirectional, “there must be influence in *both directions*”, and (c) “given that proximal processes can involve interactions with objects and symbols, these must *invite attention and exploration for reciprocity* to occur”. Based on this definition, it can be seen how the properties of a proximal process neatly fit with those of contemporary screen use, where this activity is often engaged in regularly by young children and provides elements of interactivity that increase in complexity as children age. Therefore, screen use can theoretically be considered a proximal process within Bronfenbrenner’s bioecological model.

Bronfenbrenner further proposed that to understand the influence of proximal processes on development from an ecological perspective, there also needed to be a focus on elements including individual factors such as age and psychological predisposition, contextual factors, and the developmental domain being measured (Bronfenbrenner & Morris, 1998). Therefore, it was argued that to adequately test developmental outcomes using the bioecological model, the use of the Process-Person-Context-Time research model would be necessary (Bronfenbrenner & Evans, 2000).

The Process-Person-Context-Time (PPCT) research model

The PPCT model proposes that when assessing development, it is important to measure the influence of a proximal process (Process) on development, and to control for individual factors (Person) and environmental factors (Context), and how often the process is engaged in with longitudinal observations (Time). Bronfenbrenner and Evans (2000, p. 621) proposed this model would effectively account for the “the nature of proximal processes on development, and how proximal processes interact with person and context to influence particular developmental outcomes”. As mentioned throughout this chapter, the research design and methodologies used in screen time research have resulted in some conflicting claims around the role of screen use in development. In response to this, the current research aims to utilise the PPCT research model to best understand the influences of screen use on children's psychological development by taking a holistic, ecological approach. By doing so, the research will contextualise the screen time research within psychological theory in a way that has not been addressed in the literature to date.

Researchers have noted that although technology use is ubiquitous in children's immediate and broader environments, there is a paucity in the literature utilising the bioecological model in recent research on the topic (Merçon-Vargas et al., 2020; Navarro & Tudge, 2022). Few studies have incorporated screen use as a factor in the PPCT research model, despite it being an omnipresent activity that presents many of the same properties as a proximal process. While the small amount of research using the PPCT model with technology use has looked at its influence from an environmental perspective (e.g., Navarro & Tudge, 2022), none have explored it as a proximal process in and of itself. To that extent, the current research aims to draw upon various elements of Bronfenbrenner's bioecological model as a theoretical framework to aid the understanding of the unique role screen use has in early psychological development. This framework will be used as a lens through which to examine the role of screen use in early cognitive and socio-emotional development, utilising the PPCT research model throughout the following chapters. By using this framework, the current research aims to address some of the limitations highlighted in previous screen time research.

The current research

The literature reviewed in this chapter highlights some of the key limitations and gaps that exists in the currently available screen time research. The foundational research on television viewing shows inconsistent findings, with screen time having either a positive or negative influence on development based on the samples used, the developmental domain being assessed, and whether environmental or individual factors were controlled for. Additionally, the type of screen activity being engaged in has been shown as an important factor to control for in the later screen use research. As noted previously, while past studies have controlled for some of these factors, none to date have explored the collective influence of these factors on screen time outcomes.

While there is a breadth of screen time research on television viewing conducted with young children, the lack of research on other screen activities exposes a further clear gap in the literature. Additionally, the research that does exist for this cohort has been labelled as problematic due to methodological flaws and mixed findings. For example, the main limitations in screen time research relate to the lack of studies testing directionality and reporting effect sizes. Therefore, it is difficult to ascertain from much of the existing empirical evidence to what extent screen use influences development, and whether screen time is the initial causing factor for some of the developmental outcomes measured. To produce such findings, a longitudinal design and ecological approach is necessary.

It is evident from the literature reviewed that more high-quality screen use research needs to be conducted, especially with young children, to provide robust empirical findings on the influence of early screen use on psychological development. The following chapters therefore aim to assess this influence from an ecological perspective by exploring the role of screen use factors within the framework of Bronfenbrenner’s bioecological model. As stated by Bronfenbrenner and Evans (2000), to understand the influence of a proximal process (i.e., screen use) on development there also needs to be a focus on the person, context, and the developmental outcome being measured. The ways in which the current research addresses this statement are threefold.

Firstly, psychological development is broken into two distinct developmental domains in the following chapters – cognitive and socio-emotional development, which are also broken into further measures, such as language, reasoning, attention, prosocial behaviour, and behaviour difficulties. Screen use is broken down by activity and time across the three empirical chapters to assess the differing influence it has on each on the developmental measures. Compared with previous research, the aim is to provide a more fine-grained understanding of the role of screen use in various aspects of psychological development, as opposed to producing and reporting sweeping findings on a single screen activity or developmental outcome.

Secondly, as a part of the Context element of the PPCT research model, environmental/contextual factors are controlled for when measuring the influence of screen use on the various developmental measures. These factors relate to the primary caregiver's educational attainment, closeness with their child, and socio-economic status. The ecological systems theory shows that the inclusion of contextual factors is paramount in developmental research. Ecological systems influence the developing child and often their impact cannot be discerned from the impact of the factor being measured in developmental research, if not controlled for. This, in tandem with past screen use research, highlights the importance of measuring contextual factors to fully understand the unique contribution screen use has on early development.

Thirdly, to include the Person element of the PPCT model and to address one of the main limitations in the existing literature, the first two empirical chapters include a longitudinal design to measure the influence of baseline development scores/psychological predisposition on later screen time. To achieve this, analyses are conducted to assess whether there are any reverse-causal longitudinal associations between screen time and developmental scores. Baseline developmental scores are used to assess their relationship with screen time at a later age, just as screen time's relationship with later developmental scores are assessed. This also speaks to the Time aspect of the PPCT model, as the influence of screen use on development is measured longitudinally as well as cross-sectionally. At a microtime level, screen time itself is measured to assess whether the amount of time spent on a screen device has an influence on concurrent and later developmental scores for the children in the research. At a macrotime level, the chronosystem is addressed through the longitudinal research design in the first two empirical chapters. The inclusion of the various measures of time in the current research also accounts for the influence that time has on development, as commented on by Bronfenbrenner (1989, p. 190): "the process producing developmental change is not instantaneous, but one that takes place over time, and, like the other terms in the equation, can change over time".

The aim of the current research is to therefore provide a more nuanced and robust account on the role of screen use in psychological development by utilising a cross-sectional, longitudinal, and ecological approach that encompasses important screen use and ecological factors in a young representative sample. To first achieve this, data collected as a part of the nationally representative Growing Up in Ireland (GUI) Study is drawn upon to assess the cross-sectional influence of screen time and activity on 5-year-old's cognitive development in the first empirical chapter. The longitudinal influence of screen time on the cognitive measures is also explored. The following chapter similarly uses the GUI data to explore the cross-sectional influence of screen time and activity on the 5-year-olds's socio-emotional development, followed by longitudinal analyses. The final empirical chapter builds on from the findings in the previous chapters by drawing upon primary data to assess the prevalence of engagement with further screen use factors in the home (e.g., screen content and device), and their influence on the developmental scores of children aged 6 months to 6 years. The association between these screen use factors and wider ecological and parental factors such as the children’s developmental stage, parental engagement during screen time, and parental screen beliefs are also explored. The current research therefore aims to bridge the gap between screen time research and psychological research, which addresses some of the methodological issues discussed in the literature, while contributing empirical findings to this under-researched area.

Chapter 3:

Exploring the influence of early screen use in the home on cognitive development

Literature review

Children's psychological development takes place across both cognitive and socio-emotional domains, encompassing the development of necessary skills such as language, reasoning, and emotional regulation (National Research Council, 2015). While these two domains cannot be uniquely categorised, with many areas of development overlapping across both, cognitive development is a field of study in and of itself that addresses children's ability to think, reason, and use language (Haddad et al., 2019). Many developmental theorists have shown interest in this area of child development, with the most notable contributions to the field being provided by theorists Jean Piaget and Lev Vygotsky.

Piaget defined cognitive development as a child's ability to learn and utilise new information (Piaget, 1936). In Piaget's four-stage theory of cognitive development (1936), it is outlined that through the act of problem-solving, or reasoning, children progress through milestones (stages) of cognitive development as they age. These milestones range from achieving object permanence, which was said to occur at 18 months, to achieving scientific reasoning, which develops in adolescence. Vygotsky's work focused more prominently on language development, which was seen as a by-product of social interactions (Vygotsky, 1978). Vygotsky's socio-cultural theory of learning (1978) focuses on cognitive development as a process that is directed and aided by those in the child's immediate environment, such as their caregivers. Language gained and exchanged during these interactions can then be used to drive other elements of cognitive development, such as problem-solving or reasoning.

Given that language and reasoning ability are outlined in these seminal theories as necessary skills to acquire for future cognitive development to occur, it would seem fitting for these to be the main areas of cognition considered in the current research. For that purpose, the following chapter will review the research that has been conducted on these aspects of cognition in the screen use literature. Using the data available from the Growing Up in Ireland (GUI) Study, the influecne of screen use in the home on Irish children's language and reasoning development will then be explored.

The influence of screen use on language development

When it comes to research that has explored the associations between screen time and cognitive outcomes in young children, most of the literature has focused on language development as an aspect of early cognitive development. A possible reason for this area's popularity may be that, as noted above, language is one of the major cognitive skills acquired in the early years (Piaget, 1936; Vygotsky, 1978). However, as discussed in the previous chapter, the majority of this research has been carried out in the television era. Despite this, there is still much than can be learned from the findings produced in these early studies. Therefore, it is important to address what is known on the influence that television viewing has on language development before exploring whether this influence is still found in new research that incorporates various screen use factors.

Television viewing and language development

The research on television and language acquisition reaches back to the 1970s, with studies noting the possible negative influences screen time may have on vocabulary development for infants at the time (e.g., Nelson, 1973). However, later research began to note contrasting findings, with Sachs et al. (1981) showing that watching television provided an opportunity for vocabulary development in their case study with a 3-year-old child with deaf parents. Since then, there have been varying findings on the influence of television viewing on language development. For example, Rice and Woodsmall (1988) investigated if pre-schoolers could learn new words from a television programme. In their study, 61 3- and 5-year-olds were assigned to either an experimental group, who viewed a 15-minute television programme featuring new words, or a control group who had no exposure to the television programme. After testing the children's word comprehension before and after the experiment, the researchers found that the children in the experimental group performed better in the comprehension post-test.

Additionally, Rice et al. (1990) conducted a longitudinal study and found that watching Sesame Street at age 3 years resulted in improved vocabulary scores at age 5 years. However, no associations were found for other programmes, indicating that the majority of TV viewing at 3 years had no role in vocabulary development at age 5. Ruangdaraganon et al. (2009) also found screen time to have no correlation with a language milestone screening measure for the 260 Thai toddlers in their study. They noted that individual differences contributed more to the overall regression model than screen time itself. Similarly, in a study discussed in the previous chapter, Schmidt et al. (2009) found screen time to have no correlation with language development after individual and environmental factors were controlled for. However, further studies have shown TV viewing to have negative effects on language development.

A previously discussed study by Chonchaiya and Pruksananonda (2008), showed that children who watched more than 2 hours of television daily were approximately 6 times more likely to have language delays identified, after reviewing language milestones and Denver-II scores in a clinical setting. Unlike the above studies however, the researchers did not account for environmental factors. However, a later study that did control for such factors continued to find a negative association between TV viewing and language development. Using data from a Korean panel study, Byeon and Hong (2015) tested the relationship between 1,778 pre-schoolers' screen time and their linguistic abilities of using the Ages and Stages Questionnaire. Using regression models, they found a significant negative relationship even after controlling for family income, and mother's education. They noted that previous studies were limited in their ability to draw conclusions on screen time's role in language development due to either small sample sizes, or the lack of consideration of wider contextual variables. While their study addressed these issues, they stated that further representative findings are required in this field of research. They also highlighted the cross-sectional design of their research as a limitation and suggested a longitudinal approach be taken in later research.

A study that addressed this point was conducted by Takeuchi et al. (2015) who carried out fMRI scans with Japanese children aged 5 to 18 years. Their longitudinal analysis investigated the role of TV viewing in verbal intelligence quotient by viewing changes in the related areas of the brain. After correcting for socio-economic status (SES) and individual factors, the regression models showed negative effects of TV viewing on these areas both longitudinally and cross-sectionally. The researchers stated however, while TV viewing may have been the initial causing factors for these neurological changes, the analyses remain speculative and future studies are needed to investigate this issue.

The above studies have singularly controlled for screen time content, children's contextual factors, and considered the influence of screen time longitudinally, respectively. Despite the researchers considering these factors and research approaches more than their predecessors, a notable limitation to the above research is that directionality has not been explored. A further example of this can be seen in a highly cited research paper on the benefits on educational content on language development. In this paper, Linebarger and Walker (2005) looked at vocabulary and expressive language in 30-month-olds after analysing the infants' TV viewing habits as recorded by their parents, starting at 6 months of age. The researchers assessed language development in relation to what screen content children were exposed to, as opposed to screen time alone, while also controlling for environmental factors. Hierarchical multiple regressions were used to examine the relationships between type of television content and the child's vocabulary knowledge and expressive language skills, while also controlling for parents' education, the children's home environment, and their cognitive performance.

The regression models showed that some programmes (e.g., Dora the Explorer) associated with enhanced vocabulary growth, while others (e.g., Teletubbies) had the opposite effect. Additionally, total amount of television viewing, including adult programming, was associated with reduced vocabulary but slightly increased expressed language. These findings show how screen content, or the activity engaged in during screen time, has a varying influence on language development and so should be measured in addition to children's total amount of screen time. However, what can be inferred from the findings of this study are limited by its correlational design. By not accounting for the possibility of reverse-causality, the associations may be due to slower language learners being drawn to different programmes than faster language learners, as opposed to certain programmes resulting in poorer language development (Anderson & Pempek, 2005).

Screen time research that has examined reverse-causal associations with developmental outcomes does exist, however, it is not specific to language development as a measure of cognitive development. Wright et al. (2001) were one of the first to put forward a convincing argument for children's screen time, using a bi-directional model. In their study, they examined screen time content and future educational skills. Children who were mostly exposed to educational screen content between ages 2 and 3 years had high subsequent performance on four measures of academic skills: reading, maths, receptive vocabulary, and school readiness. However, a notable strength of the study is their finding of children's prior cognitive skills also predicting later viewing, supporting a bi-directional association.

Their analyses found children with high cognitive skills viewed more educational programmes and fewer cartoons, while children with lower skills at age 3 years shifted to viewing more general audience programmes by ages 4 and 5 years. These findings also remained after controlling for home environment quality. The results affirm that the relationship between television viewing and early academic skills may depend on screen activity and content, among other environmental variables. The findings also illustrate the importance of exploring reverse-causal associations in developmental studies when interpreting correlational findings, as screen time was not found to be the initial causing factor for cognitive development in Wright et al.'s (2001) study.

However, a recent study exploring directionality by Madigan et al. (2019) found that the amount of time spent on screens at age 2 and 3 years was associated with poorer developmental scores on the Ages and Stages Questionnaire at age 5 years. Their study was conducted on three Waves of data from the All Our Families study, which contained 2,441 children at ages 2, 3, and 5 years. After testing for reverse-causal associations, the authors inferred that screen time is a likely initial causing factor for cognitive developmental delays, after controlling for environmental and individual difference. This is in contrast to the previously mentioned finding reported by Wright et al. (2001). While these studies include many strengths such as the inclusion of contextual factors and directionality testing, a limitation is that TV watching was the only screen activity measured, and so the findings may not extend to other screen activities. It would therefore be beneficial to consider the findings related to other forms of screen use and language development.

Research on other screen activities and language development

Karani et al. (2022) conducted a scoping review in 2020 on the topic of screen time and language development. While their initial search produced over 500 papers on the topic, of these studies only 13 focused on young children aged 5 years and under, used reliable language development measures, and were peer-reviewed academic papers published in the last two decades. This was also found by Kuta (2017) who noted the lack of research available in the field, with most screen time intervention strategies being spurred by the findings on physical risks, rather than cognitive risks. These reviews highlight the limited existing evidence base on the role of various screen activities on early language development.

Of the few studies available for this age group, most have focused on the pedagogical benefits of touchscreen devices. In a study on language development and digital games, Neumann (2018a) found that school children could enhance their emergent literacy skills when engaging in educational games on an iPad. This was thought to be attributed to the interactive and engaging nature of the digital games provided. E-books have also been shown to promote vocabulary acquisition and reading comprehension due to their integrated animations, graphic effects, and synced audio sounds, creating an immersive and interactive learning experience (Radesky et al., 2015). In their review on these additional affordances, Bus et al. (2015) noted that while screen activities provide a source of literacy development for children of all ages, they speculated that the numerous distractors in on-screen books or games may detract from learning outcomes. That being said, no research to date has empirically tested whether screen-based educational games differ significantly from other screen activities in their contribution to language development in early childhood.

In a recent study, Operto et al. (2020) conducted cross-sectional analyses on digital device use and language abilities with 260 children aged under 3 years. Using the Communicative Development Inventory, the researchers found a statistically significant negative relationship between the total daily time of engagement with digital devices and language ability in children between 18 and 36 months. However, the researchers reported the effect sizes in their analyses to be small. Interestingly, in contrast to most of the previously discussed research, including control factors such as parents' level of education or SES did not significantly affect the result of the regression analysis. While this study included various digital activities and controlled for environmental factors, the type of screen activity was not separated in the regression analyses. Therefore, it would be useful for future research to examine the role different activities may have in language development.

This was also noted by Madigan et al. (2020) in their meta-analysis that explored the role screen time may have in older children's language skills. The 42 studies analysed in this research included 18,905 children aged under 12 years, but only 10 of these studies included screen activities outside of TV viewing. When combined effect sizes for the studies were produced, the researchers found screen time to be associated with lower language skills. Screen content was measured in 13 of the studies, and the combined effect size showed educational content to have a positive association with language skills. The authors stated however that larger effect sizes were noted in studies with small samples, and so, large-scale studies were suggested to further explore these effects.

Based on their findings, Madigan et al. (2020) suggested a number of limitations are still present in the research in this area. They noted that the results from their analysis were correlational, as opposed to causal, as the studies included did not test reverse-causal associations. A further limitation was that over half of the studies did not report adjusted effect sizes, resulting in a major issue in interpreting the results or influence that screen use has in childhood. Other researchers in the field have also highlighted the lack of effect size reporting in screen time research to be problematic (e.g., Elson & Ferguson, 2015; Bell et al., 2015; Przybylski & Weinstein, 2019). Furthermore, the effect sizes reported were small to moderate in the meta-analytic findings. Madigan et al. (2020) called for the findings reported in the screen use literature to be placed in the context of other known predictors of language development, such as SES and parental factors. Screen use represents one of many potential predictors in the child's developmental ecology, and therefore other factors should be controlled for where possible, so that screen use effect sizes can be understood in context.

While there is a scarcity of research on language development and screen time outside of TV viewing, these studies highlight how various screen activities seem to relate to beneficial developmental outcomes, especially if the content is educational. However, when it comes to other measures of cognition, the research separating these activities is equally as scarce, despite how ubiquitous various screen activities now are in the early home environment. In their systematic review of the literature on sedentary behaviour and cognitive outcomes in children under 5 years, Carson et al. (2015) found that few screen time studies have focused on cognitive outcomes outside of the domain of language development. Given the already limited amount of research on language development, this illustrates the paucity of research that has been conducted on other cognitive measures, such as reasoning ability.

The influence of screen use on reasoning ability

In early childhood, reasoning ability is a prerequisite for the development of logical thinking and problem-solving in novel situations (Horn & Cattell, 1967). The ability to reason enables people to draw inferences and reach conclusions (Johnson-Laird, 2006), and is supported by many cognitive skills, such as attention, processing speed, and working memory (Fry & Hale, 1996; Kail, 2007). For young children, reasoning ability is also a good indicator of future academic success, and the development of higher order cognitive skills (Cattell, 1987; Floyd et al., 2003; Ferrer & McArdle, 2004), with research suggesting that reasoning ability between the ages 5 and 10 years is a stronger predictor of scholastic achievement than reasoning ability at any other age (Ferrer et al., 2007). This, in addition to that proposed by developmental theorists Piaget and Vygotsky, highlights the period relating to early childhood as particularly important for the development of reasoning ability. Despite this, little research has examined screen use and early reasoning development together. The existing research, however, again provides mixed findings on the role of early television viewing in reasoning development.

For example, Anderson et al. (2000) conducted a longitudinal quasi-experiential study with 120 children comparing the cognitive outcomes of 5-year-olds who watched Blue's Clues at age 2 years to those who had no exposure to this programme. Using the Kaufman Assessment Battery for Children, the researchers found that children who had access to the programme at an early age showed a significant increase in problem-solving and flexible thinking over the 3 years of the study in comparison to those who did not. It is important to note though that the effect sizes between the groups were not reported. In their studies with school-aged children, Tamir (1990) and Gerber et al. (2001) also showed television viewing to be an activity within children's informal learning environment that can contribute to informal scientific reasoning and learning. However, the effect sizes for television viewing were small in comparison to other informal learning activities such as visiting museums, zoos, or libraries, and engaging in creative activities such as art and music.

In a review on young children's ability to learn from television, Wartella and Richert (2009) noted that screen time may not benefit the development of analogical reasoning. One of the studies included in their review was conducted by Crawley et al. (1999). These researchers conducted an observational study with 108 3- to 5-year-olds and tested learning outcomes such as comprehension and transferable problem-solving skills after children were exposed to an educational television programme. Their findings suggested that children performed better on the other learning tasks than analogical reasoning. However, the more episodes of the programme they watched the more likely they were to transfer problem-solving skills from a similar problem shown on the programme to a real-life situation. Richert and Abrego (2007) also tested children's ability to apply reasoning skills from a problem presented to them in either a storybook or a video to a similar real-life problem. Their study found that that children were better at transferring solution-based reasoning knowledge when the problem was presented in a story than a video.

However, opposite findings to these have been produced for other forms of screen activities. Using an experimental design, Huber et al. (2016) explored whether 4- to 6-year-olds could transfer problem-solving skills from a puzzle presented on a screen to a real-life physical version of the same puzzle. There was no significant difference in children's ability to solve the puzzle based on whether their initial experience with the puzzle was physical or digital. This was replicated by Tarasuik et al. (2017) who reported the same findings for the 49 3- to 6-year-olds in their study. These papers would suggest that screen activities that allow for physical interaction such as digital games can provide informal learning opportunities for children where they can learn and transfer reasoning skills. Similarly, other research has found that children can improve their math skills using digital games. Aladé et al. (2016) found that preschool children can learn basic maths concepts from child-directed, educational content presented on a digital device. Fessakis et al. (2013) also found that the mathematical, problem-solving, and social skills of 5- and 6-year-old children improved after a classroom intervention involving a series of computer programming-based learning activities.

Studies with older children also suggest that computer games may play a role in reasoning development. Yang (2012) found that playing digital games in school was effective in improving 14- and 15-year-olds' problem-solving skills in comparison to a control group using traditional classroom methods. Fisch et al. (2011; 2014) reported that third and fourth graders who used digital games demonstrated better mathematical reasoning and problem-solving in offline problem-solving tasks. Blumberg and Randall (2013) also found that 11-year-olds made greater references to problem-solving strategies during their think-aloud comments about the game after just 20 minutes of gameplay.

However, an important study to note is that conducted by Fiorini (2010) who reported that young children can also improve their reasoning skills through computer usage. Fiorini (2010) stated that studies concerned with the effects of computer use were mainly conducted with teenagers, with most not exploring this effect in context. To address this, the author used the large-scale Longitudinal Study of Australian Children, where data relating to the lives and screen use habits of nearly 10,000 5- and 7-year-olds were accessed. The study assessed the children's cognitive skills, including reasoning and vocabulary ability, and their rate of screen usage, including TV viewing, computer usage, and console usage. SES and parental factors were also controlled for in the analyses. The results of the study indicated that computer use at age 5 years had a positive influence on vocabulary and reasoning ability, both cross-sectionally and longitudinally. However, computer use at age 7 years did not have any significant influence on developmental outcomes. The effect was not shared by other screen activities, such as TV viewing, which instead showed a negative relationship with cognitive development.

While the inclusion of environmental factors in the models did not mediate the results, Fiorini (2010) noted that there was a correlation between home computer ownership and parental education and income, whereby children were more likely to use a computer if they were of high socio-economic status. The researcher stated that this is an area that should continue to be explored in future research given the growing prevalence of computer and screen device ownership by families of all socio-economic backgrounds. Fiorini's (2010) study provided findings on an area that has been poorly researched and did so in a comprehensive manner, where not only various screen activities were considered but further ecological factors were also controlled for. A longitudinal aspect of the study also allowed for the long-term influence of screen time on cognitive development to be assessed. However, directionality was not explored, which is an unfortunate limitation to the study.

In their review, Herodotou (2018) continued to find that few studies have explored the influence of screen activities outside of TV viewing. Those that have, however, tend to focus on comparing the learning opportunities provided by digital devices to traditional learning methods, rather than comparing the developmental differences seen across screen activities themselves, with the exception of the above study by Fiorini (2010). This has been seen throughout this chapter, where research inclusive to more contemporary screen activities has compared screen-based games with other early learning practices. It is important to note that such studies have examined the role of specific, targeted screen use in supporting aspects of cognitive development rather than measuring the influence of natural incidental screen use in the early home environment on development.

Herodotou (2018) also noted this, where the limited research papers in their systematic review that discussed digital devices often compared the screen activities to similar paper-based activities (such as writing or finger painting) when assessing the learning possibilities (e.g., Crescenzi et al., 2014; Neumann & Neumann, 2014). When discussing the current limitations and challenges in the screen use research, the author noted that there is a lack in the comparison of findings to the more well-established research on TV viewing, and in the inclusion of environmental and ecological factors as mediators. In addition to this gap in the research, Herodotou's (2018) review noted that the existing research has mainly focused on older children and adolescents. The author's extensive search of the literature revealed only 19 studies to have examined the cognitive effects of early digital device use with children aged 5 years or younger. The studies included in the review showed mostly positive, but small, effects for maths and science understanding. While reasoning was not directly measured, these subjects are areas where reasoning skills are often applied. However, drawing concrete conclusions from a limited pool of findings shows a current challenge in this area of the literature.

The author also noted issues with the research approaches in the studies reviewed, stating that research should move towards studies that are: (a) longitudinal and recruit large samples to best identify long-term effects of screen use and overcome effects that might occur in small-scale studies, and (b) "theory-driven investigations that draw from established theories of children's development" (Herodotou, 2018, p. 6). In line with these recommendations, it seems appropriate to expand on the study conducted by Fiorini (2010) by continuing to use longitudinal approaches with a further large sample to explore the question of whether the influence of screen time on early cognitive development is equal, or whether it differs based on the activity engaged in. To best achieve this, the research will be framed by developmental theory, as suggested by Herodotou (2018), namely Bronfenbrenner's bioecological model.

Using the bioecological model to explore the influence of early screen use on cognitive development

As mentioned at the beginning of this chapter, developmental theorists Piaget and Vygotsky have made some of the more notable contributions to the field of early cognitive development. While Piaget's (1936) theory of cognitive development was substantial in providing a framework for understanding how children think and view the world, little consideration was given to the influence that social settings or culture may have on the development of cognition. In addition to Piaget's work, development theorist Vygotsky highlighted the importance of the child's environment on their learning, especially for language development, which was seen as a by-product of social interactions (Vygotsky, 1978).

Vygotsky's contributions highlight how a child's home, interaction with their caregivers, and the society in which they grow up in, all influence their cognitive development. As discussed in the previous chapter, this idea was further developed by Bronfenbrenner, whose ecological systems theory categorised the child's environment into five different systems that all have varying impacts on the child's early development (Bronfenbrenner, 1979). Additionally, his contribution of proximal processes as engines of development (Bronfenbrenner & Morris, 1998) can be seen as an extension of Vygotsky's work on the importance of interactions within the socio-cultural theory of learning.

Bronfenbrenner's work looks to be influenced by Vygotsky's approach to measuring early cognitive development as both theorists' work criticised the laboratory-based research approaches used by Piaget. However, Piaget's theory of cognitive development laid the necessary foundations for future theories of cognition and early development to follow. As such, while all theories are unique in what they contribute to the field of developmental studies, Bronfenbrenner's bioecological model can be seen as the culmination of theory testing and development in the 1900s. From this bioecological model, the Process-Person-Context-Time (PPCT; Bronfenbrenner & Evans, 2000) research model was created as a means to improve the quality of research exploring the role of a process, such as screen use, in development from an ecological perspective. Bronfenbrenner's bioecological model can therefore be seen as an appropriate theoretical framework for understanding the holistic factors that affect early cognitive development, inclusive to factors within the child's immediate and external environments.

The use of such a model also allows for the limitations and research issues within the screen use literature to be addressed. Past research has shown to support the use of such an ecological approach. For example, Madigan et al. (2019) suggested that screen time may not have as much of a negative influence on development as outlined in previous research, as often the findings were not contextualised within the child's ecological systems. Their study showed screen time to be negatively associated with early development, but they suggested this to be an indirect effect of various environmental factors that result in extended amounts of daily screen time to take place in the first place. This indicates screen use to be a part of the multiple influences on development in the child's ecological system, rather than the driving factor, illustrating the necessity for controlling for mediating factors such as those included in the PPCT research model.

The research discussed throughout this chapter collectively calls for future research to adopt a wider lens when assessing the role of screen use in cognitive development. There is an encouragement to move away from measuring the influence of singular screen activities and measuring the effects of screen time in isolation to the wider context of factors that influence development. To add to this, a scoping review conducted by Karani et al. (2022) reported that the relationship between screen time and cognitive development was hard to decipher due to the mixed findings present in the papers reviewed in their analysis. However, in line with the earlier research (e.g., Ruangdaraganon et al., 2009), their review highlighted individual and environmental factors as important variables to control for. Additionally, Hudon et al. (2013) stated that the quality of screen time may affect language development more than the quantity as they found early TV viewing to have no association with developmental outcomes. This is also in line with the foundational research conducted by

Rice and Woodsmall (1988) and Rice et al. (1990). Despite research over the decades continuously suggesting external variables and screen activity to be controlled for, these still tend to be discussed in the literature as issues needing further consideration and investigation. This highlights the benefits of utilising an ecological framework and the PPCT model to address the limitations and gaps that still exist in this field of research.

The final element of the PPCT model is Time, which the literature also suggests more researchers should consider in the design of their studies. The previously discussed study by Byeon and Hong (2015) highlighted the need for more longitudinal research in the literature, as opposed to solely using cross-sectional methods. Despite this, the use of cross-sectional design remains common in developmental research. While cross-sectional findings provide valuable information on the current screen use habits within the sample, measuring screen time levels in earlier childhood and mapping this onto later developmental scores would prove beneficial in providing a more robust understanding on the influence of early screen time. As noted by Wang and Cheng (2020), despite the merits of cross-sectional data, linking outcome to a predictor variable from this data alone can be problematic, as the child's past amount of screen time may differ to when developmental issues were measured. Therefore, there are clear benefits to considering longitudinal approaches when discussing developmental outcomes and screen time.

Longitudinal research also allows for causality to be tested, as seen in the previously discussed studies by Wright et al. (2001) and Madigan et al. (2019). Their studies allowed for baseline developmental scores/psychological predisposition to be factored into the analysis, contextualising the results. Despite neither study noting this as taking an ecological approach to explore the influence of early screen use, their research designs and approaches are in line with that proposed in the bioecological model. By utilising a longitudinal design, these studies accounted for the role of time, context, and baseline developmental differences when assessing the role of early screen time in cognitive development.

Additionally, as shown by past researchers, there are a number of factors in a child's environment that can influence the development of cognitive abilities. The most common factors controlled for in screen time research relate to parental and SES factors. This is likely due to the large amount of research that has shown maternal education levels (e.g., Veena et al., 2010; Carr & Pike, 2012), the socio-economic status of the family (e.g., Neitzel & Dopkins-Stright, 2004; Mackey et al., 2011), and the parent-child relationship (e.g., Glaser, 2000; Bernier et al., 2012) to all play a significant role in early development. This would suggest that it is important to account for these environmental factors in addition to implementing a longitudinal design to produce more robust and holistic screen use findings. The research reviewed thus far therefore highlights the appropriateness of using an ecological framework in the current studies to explore the role of screen use in early development within the context of wider influencing factors.

The current studies

The literature discussed in this chapter highlights the complexity of interpreting screen time research as screen use has been shown to potentially play a role in child development, but to varying degrees. Screen use research has been critiqued by researchers due to the conflicting results found on the influence of screen time on cognitive development. For example, while the research on television watching has suggested it has a negative influence on cognitive development, these findings have not been replicated in all samples (Obel et al., 2004). Additionally, many studies do not account for other factors that have been shown to influence early cognitive development, such as household income or maternal factors (Foster & Watkins, 2010). With some studies noting inconsistent findings and others with small effects sizes (e.g., Madigan et al., 2020), there is debate about what influence, if any, screen use has on development. This is particularly the case when considering the influence of screen use on early childhood development. (Burns & Gottschalk, 2020).

The research available on early television viewing focuses strongly on language development as a form of cognitive development (Carson et al., 2015). The findings in this area suggest that instead of measuring screen time alone, screen activity is also an important factor to consider when assessing developmental outcomes. Yet, little research on screen use and language development has been conducted beyond TV watching (Karani et al., 2022). Given the research available on the more positive role that screen activities such as computer games have on reasoning ability in later childhood, it seems necessary to assess whether these findings also apply to early language development, and early reasoning ability.

Similar to the findings on TV watching, studies on the role of various screen activities have been shown to have flaws in their research design or methodology. As highlighted in the early TV watching research, determining the causal links between screen use and development can be challenging. Therefore, not only should these studies be interpreted with caution, but further research should be conducted to assess such causal inferences by conducting analyses that test reverse-causal associations (Madigan et al., 2019). This would require a longitudinal approach with a representative sample for such inferences to be claimed (Herodotou, 2018). With the majority of previous research focusing on later childhood or adolescence, and implementing a cross-sectional design, little is known on the role of screen use in early childhood and its possible longitudinal influence on cognitive development. As various screen activities, such as digital games, are being engaged in at a younger age than in previous decades, understanding the influence that this early screen use is having is more important than ever. To fully assess this, younger cohorts need to be researched to explore whether screen use is influencing reasoning ability at an earlier age, and if this influence has longitudinal effects.

As noted previously, Bronfenbrenner's bioecological model provides a strong framework in which the role of screen use in early cognitive development can be assessed. The use of the PPCT model as a research design approach also addresses the main limitations noted in the screen use research to date. For example, longitudinal analyses that allow for reverse-causal associations to be observed, while accounting for baseline developmental scores, are addressed in the Person and Time elements of the model. Additionally, controlling for environmental factors and interpreting ecological influences in the analyses is addressed in the Context element. Some of the studies discussed thus far also suggest that engaging in screen-based games should not be classified as the same activity as TV watching. This gives rise to the question of what influence various screen activities and contexts (not just time spent on screens) have on early cognitive development, and whether the findings are similar for each activity or if they are more nuanced as seen in the research on television viewing. In doing so, such research would also contribute to the literature available on the influence of screen use in the home on young children's development. Therefore, the two main aims of the current studies are to:

1. Examine the cross-sectional influence of screen use (both time and activity) on 5-year-olds' language and reasoning ability, after controlling for environmental factors.
2. Assess the longitudinal influence of screen time at age 3 years on 5-year-olds' concurrent developmental scores, and observe whether reverse-causal associations are present after controlling for baseline differences.

To address these aims, the current research is carried out across two studies. A cross-sectional design is utilised in Study 1 to report the prevalence of screen use and the associations between screen use and cognitive development scores, after environmental factors are controlled for. This is followed by Study 2, which implements a longitudinal research design to assess the influence of screen time engaged in at 3 years of age on 5-year-olds' cognitive development. Directionality is then explored, which allows for inferences to be made on whether the amount of screen time at age 3 years is associated with later cognitive development at age 5 years (after controlling for screen time and environmental factors at age 3 years), or if developmental scores at age 3 years is associated with later higher screen time at age 5 years (after controlling for cognitive development scores and environmental factors at age 3 years).

Study 1: Exploring the cross-sectional influence of screen use on cognitive development

The data used in this research were from the Growing Up in Ireland (GUI) Infant Cohort '08, Anonymised Microdata File, which was obtained from the Irish Social Science Data Archive. The GUI Study is a national longitudinal study of children and young people in Ireland that is managed by the Department of Children and Youth Affairs and the Central Statistics Office. The study initially followed two cohorts of children in 2006, when the children were 9 months of age, and 9 years of age (Infant Cohort '08 and Child Cohort '98, respectively).

Researchers from the Economic and Social Research Institute and Trinity College Dublin collected data from the primary caregivers of the 11,134 9-month-olds between September 2008 and April 2009, which represented the first Wave of the Infant Cohort. A simple systematic selection procedure based on a random start and constant sampling fraction was used to select these families from the Child Benefits Register. As just over 70,000 births were recorded in Ireland at this time, the study sample represents approximately 1 in 7 Irish children in this cohort, sampling from all socio-economic backgrounds and family types living in Ireland (see Murray et al., 2019).

Interviews were conducted during visits to the household by a trained interviewer from the GUI research team who administered the 'Main questionnaire' to the child's primary caregiver. The questions within the questionnaire related to the child's home environment, parental factors, as well as the activities that the child participates in. In Wave 2 and 3 (when the children were 3 and 5 years old, respectively), the interviewers also administered the British Abilities Scale II (Elliott et al., 1997) with the children, in their home, as a measure of their cognitive development. Ethical approval was granted by the Research Ethics Committee established by the Department of Health and Children. Full ethical considerations, including child welfare, data protection, and interviewer training are reported by Williams et al. (2019). The GUI Study was harmonised with other international longitudinal cohort studies by synchronising measures and approaches used in the Millennium Cohort Study in Britain, the Growing Up in Australia Study, the Early Childhood Longitudinal Study in the United States, the Avon Longitudinal Study of Parents and Children based in the Bristol area of Britain, and the Canadian National Longitudinal Study of Children and Youth (Williams et al., 2019).

As a main aim of the GUI Study is to provide information on the lives and development of young people in Ireland, their families, and the various factors within their ecological systems, the data collected offered insight to the variables of interest for this research. In the current study, analyses were carried out on the data collected when the children were aged 5 years (Wave 3), as this was the first time point in the study in which screen time and screen activity were measured separately. Using this data from Wave 3 of the

GUI Study, the current study aimed to examine the cross-sectional influence of screen use (both time and activity) on the 5-year-olds' language and reasoning ability, after controlling for environmental factors. Aspects of this study have been published in Beatty and Egan (2018; 2020a; 2020b).

Method

Participants

9,001 of the children from the original 11,134 families in the Infant Cohort '08 participated in Wave 3 of the study when the children were 5 years old, which represents an 81% retention rate from when the children were 9 months old. Of these 9,001 5-year-olds, 50.7% were males and 49.3% female. The demographic data of the children's primary caregivers can be seen in Table 1.

Table 1. Percentages for the participants' demographic variables in Wave 3 of the GUI data.

Demographic Variables		**Percentage**
Parents' Education	Education up to third level	60.8%
	Third level degree	22%
	Postgraduate degree	17.2%
Parents' Employment	Full-time	54.3%
	Part-time/student	2.1%
	Looking after family/on leave	39.2%
	Unemployed	4.4%

Measures

Screen Use Variables. The child's primary caregiver was administered the 'Main questionnaire', which included detailed information on the study child as well as information on the primary caregiver. The study child questions of interest relate to the child's daily screen time and the screen activity they mostly engaged in. At Wave 3, the caregivers were asked: “How many hours does [study child] spend on screen time on an average weekday?”. The data were collapsed into four groups by the Growing Up in Ireland research team: No screen time; Less than 2 hours; 2 to less than 3 hours; and 3 or more hours. For screen activity, the question asked of caregivers was: “What does [study child] mostly engage in during screen time? Is s/he usually engaged in: Educational games; Other games; Watching TV/Videos; or a Mix of all activities?”.

Cognitive Development Scales. To obtain a direct assessment of the study child’s cognitive abilities, two of the core scales from the British Ability Scales II (BAS II; Elliott et al., 1997) were administered in the home by the trained interviewer: the Naming Vocabulary test, and the Picture Similarities task. The BAS II is a battery of twelve core sub-tests of cognitive ability and educational achievement (Elliott et al., 1997), and was chosen by the GUI research team as it facilitates direct participation by the Study Child, while also having high test-retest reliability and validity as a measure of cognitive ability (Elliott et al., 1997), with an internal reliability of .79, and a test-retest reliability score of .64. The Naming Vocabulary and Picture Similarities subtests of the BAS II correlate (0.68 and 0.47, respectively) with the verbal and performance IQ components of the WPPSI-R (Elliot et al., 1997).

The Naming Vocabulary test serves as a measure of children’s expressive English language vocabulary. It consists of 36 items ordered in terms of increasing difficulty and children are required to name the item displayed from a picture book (e.g., ‘shoe’, or ‘scissors’). The Pictures Similarities task is a 33-item test that measures non-verbal reasoning ability and problem-solving skills, by showing a row of four pictures and asking the child to identify and place down a further congruent picture that best matches the set. For example, a child might place a picture of an aeroplane by a set of four pictures of birds or kites. It allows the child to solve non-verbal problems by identifying key features in pictures and attaching meaning to pictures. The reported Cronbach alphas for these tests at age 5 years is .81 for the Picture Similarities task, and .65 for the Naming Vocabulary test (Elliot et al., 1997).

Environmental Factors. The Primary Caregiver questions from the 'Main' questionnaire that are of interest to this study related to the primary caregivers' highest educational achievement, their level of closeness to the study child, and family income. These variables were chosen for this research as they have been shown to influence early cognitive development, as detailed below, and are noted as important factors within children's ecological systems, as outlined by Bronfenbrenner. Controlling for these variables also allows for the Context element of the PPCT model to be explored in this study. In addition to this, these factors were the environmental and parental factors most often noted in the screen use literature reviewed in the current chapter as important to control for.

The possible answers relating to education attainment ranged from 'No formal education/Primary education' to 'Doctorate Ph.D.', and the data for equivalised household annual income used in the study were collapsed into deciles, with 1 being the lowest income category and 10 being the highest. These variables were chosen to be included in this study as higher levels of parental education and economic status have been shown to be positively associated with overall cognitive ability such as school readiness (Seefeldt et al., 1999) and academic attainment (Haveman & Wolf, 1995; Sirin, 2005). SES disparities have also been shown to have a large role in vocabulary development, with children from lower income families reported to be exposed to fewer words by the age of 3 years than those in upper class families (Rowe & Zuckerman, 2016). Parental education, as a measure of SES, has also been seen to influence differences in reasoning ability (Demir-Lira et al., 2021).

The Child-Parent Relationship Scale – Short Form (Pianta, 1992) was used to collect data on the level of attachment between the primary caregiver and the study child. The subscale 'Level of closeness' within this 15-item scale, received alpha coefficients of 0.58 (Pianta, 1992). Example of questions from this subscale are "I share an affectionate, warm relationship with my child" and "My child openly shares his/her feelings and experiences with me", where the parent rates their answer from 1: "Definitely does not apply to me" to 5: "Definitely applies to me".

The parent-child relationship has been highlighted to be among the most important factors in early child development, with a healthy relationship being shown to support cognitive attainment, such as school grades (O'Connor et al., 1997). Parent-child interactions have also been illustrated as important for developing and improving language abilities (Hirsh-Pasek et al., 2015; Christakis et al., 2019). Additionally, children with strained parent-child relationships are more likely to have lower communication and problem-solving abilities (Ghanizadeh & Shams, 2007), while strong parent-child relations have been linked with higher instances of scaffolding behaviour and therefore stronger problem-solving, or reasoning, abilities (Edwards et al., 2010).

Data analyses

After applying for, and receiving, the GUI Infant Cohort Anonymised Microdata Files from the Irish Social Science Data Archive, the relevant variables of interest were extracted from the original datafiles. All data were cleaned by identifying missing data and deleting irrelevant variables, then organised by recoding variables to fit the current research questions. The data were then weighted to improve the accuracy of the survey estimates by using the Weighting Factor variable provided in the original datasets. This variable was constructed by the GUI study researchers based on the most recent Census and the Child Benefit Register.

Statistical analyses were conducted using IBM Statistical Package for the Social Sciences (IBM SPSS) version 24.0. The influence that the screen use variables had on the cognitive scores was tested using one-way Analysis of Variance (ANOVA) and chi-square tests. While assumption testing found the variables in the study to not be normally distributed, ANOVA tests were still conducted as they are considered robust enough to withstand violations to the assumptions if there is a large sample (Cone & Foster, 2006; Ghasemi & Zahediasl, 2012). This also aligns with contemporary discussions that note normality testing to be overly sensitive in large samples, and the Central Limit Theorem (Mordkoff, 2016; Kwak & Kim, 2017) which assumes data to take on a normal distribution once the sample is large enough. Hierarchical multiple regressions were conducted to assess whether any significant findings remained after controlling for the environmental factors. The assumption of collinearity was tested before applying weighting to the scores, and the data were shown to meet this assumption with the test statistic indicating multicollinearity was not a concern (all *VIF* values < 10, and *Tolerance* values > 0.1). Scatterplots indicated the relationship between the independent and dependent variables were linear, and P-P plots suggested the assumption of homoscedasticity and normality were met (Appendix A).

Results

Descriptive findings

Of the 9,001 5-year-olds who were included in the GUI Study (Wave 3), 8,862 completed both the Pictures Similarities task and Naming Vocabulary test, and also had their corresponding screen time and screen activity data available. The children's scores on the Pictures Similarities task ranged from 10 to 199, with the average score being 86.66, *SD* = 11.75, and their Naming Vocabulary test scores ranged from 26 to 170 (*M* = 111.44, *SD* = 17.17). The primary caregivers of these children indicated that 238 (2.7%) of them had no screen time in the home, with 40.6% of the children in the current study engaging in 2 or more hours of screen time a day (see Table 2).

Watching TV was the single screen activity mostly engaged in by the 5-year-olds (36.3%), however, the majority of the children (56.6%) were reported to mostly engage in a mix of all activities. Playing educational games was the activity least engaged in, with only 1.6% of the 5-year-olds reported to mostly play these games during their screen time. Looking to the means, children who had no screen time had the highest scores on the Picture Similarities task, followed by those who mostly engaged in a mix of all screen activities. For the Naming Vocabulary test, the children scored highest if they were in the 'Less than 2 hours' screen time bracket, and mostly engaged in either watching TV or a mix of all screen activities (see Table 2).

Table 2. Mean cognitive task scores based on the 5-year-olds' screen use categories.

Screen Use Categories	**Picture Similarities Score**		**Naming Vocabulary Score**		**Overall Participants**	
	M	**SD**	**M**	**SD**	**N**	**%**
Screen Time						
No screen time	87.91	12.39	110.35	17.74	238	2.69
Less than 2 hours	87.11	11.45	111.88	16.60	5019	56.65
2 to less than 3 hours	86.49	11.81	111.45	17.27	2463	27.79
3 or more hours	84.96	12.60	109.91	19.06	1142	12.87
Main Screen Activity						
Educational games	84.08	12.85	109.40	18.41	145	1.64
Other games (video games)	85.91	11.99	104.32	17.83	245	2.76
TV/Video watching	85.91	11.50	111.74	16.94	3217	36.31
Mix of All	87.20	11.80	111.74	17.14	5017	56.60

Chi-square tests showed that there was a significant association between the amount of screen time per day and the type of activity children mainly engaged in, χ^2 (12, N = 8862) = 9025.69, p < .001, *Cramer's V* = .583. Approximately two-thirds of children who mainly played educational games (66.2%) or watch TV/videos (65.8%) had less than 2 hours of screen time per day (see Table 3). In contrast, a smaller percentage of children who engaged in less than 2 hours of screen time per day mainly engaged in video games (60.4%), or a mix of activities (53%). Of those who engaged in a mix of screen activities, 1 in 6 children did so for 3 or more hours per day (16.2%). This rate was higher than for children who mainly engaged in a single type of screen activity (e.g., playing educational games: 1 in 10 children, or 10%, did this for over 3 hours per day; see Table 3).

Table 3. Percentage (n) of screen activity engagement based on screen time brackets.

Main screen activity	Less than 2 hours	2 to less than 3 hours	3 or more hours	Total
Educational Games	66.2% (96)	23.4% (34)	10.3% (15)	100% (145)
Video Games	60.4% (148)	29.0% (71)	10.6% (26)	100% (245)
Watching TV	65.8% (2116)	25.3% (813)	9.0% (288)	100% (3217)
Mix of Activities	53.0% (2659)	30.8% (1545)	16.2% (813)	100% (5017)

The chi-square test findings provide evidence of the variety of screen activities young children engage in, and how their preferred screen activities may influence their amount of daily screen time, demonstrating the need for this factor to be considered in screen time analyses. These findings show that screen use variables are significantly related to each other and may create a variance in the scores on the Pictures Similarities and Naming Vocabulary tasks. To assess whether this variance between the levels in the screen time and screen activity variables were statistically significant, ANOVA tests were conducted.

The cross-sectional influence of screen time and activity on reasoning scores

The first ANOVA test showed that the 5-year-olds' screen time did have an influence on their reasoning scores, $F(3,8858) = 12.075$, $p < .001$, $\eta_p^2 = .004$, with those engaging in 3 or more hours of daily screen time scoring significantly lower than all other time brackets (all p's <

.004). The other time brackets did not significantly differ from one another (all *p*'s > .05). Figure 1 shows the means plot for the children's scores along with the error bars (95% CI) for each time bracket.

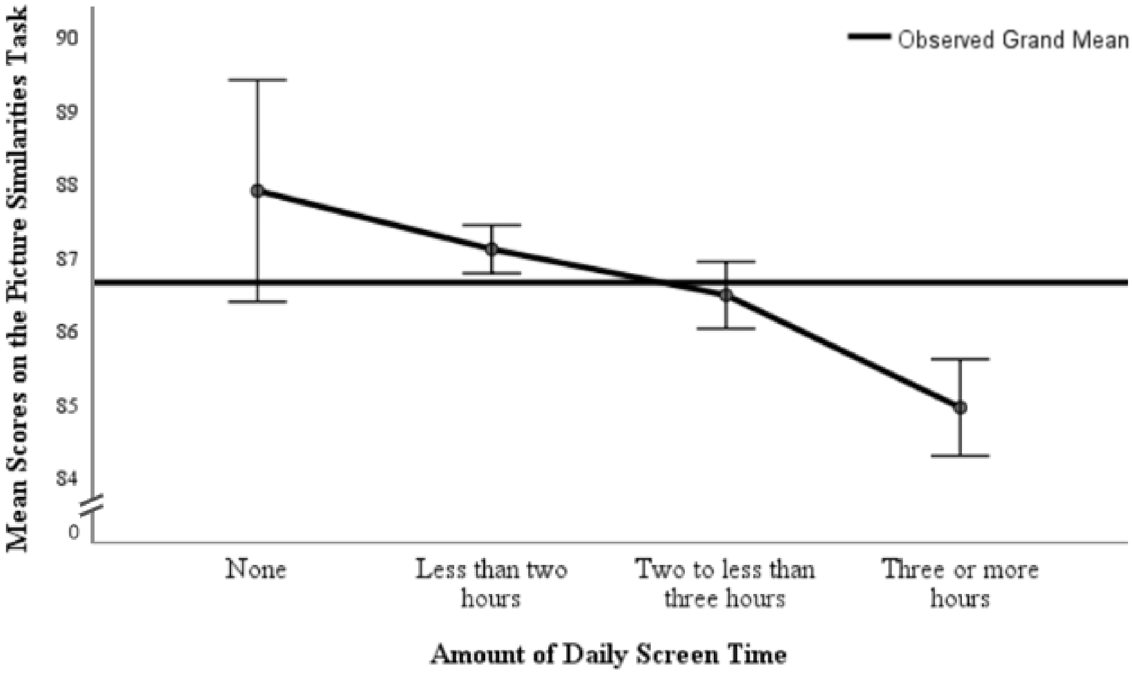


Figure 1. Mean reasoning scores based on screen time brackets.

The second ANOVA test showed that the screen activities mostly engaged in by the 5-year-olds also had an influence on their reasoning scores, $F(3,8620) = 10.631$, $p < .001$, $\eta_p^2 = .004$, with those who mostly engaged in a mix of all activities scoring significantly higher than those who mostly played educational games ($p = .009$) or watched TV/videos ($p < .001$). There were no significant differences between playing video games or engaging in a mix of all screen activities, nor were there any significant differences between the single screen activities (all *p*'s > .25). This is thought to be due to the large error bars seen for those who mostly engaged in either educational or video games. Figure 2 shows the means plot for the children's scores along with the error bars (95% CI) for each screen activity.

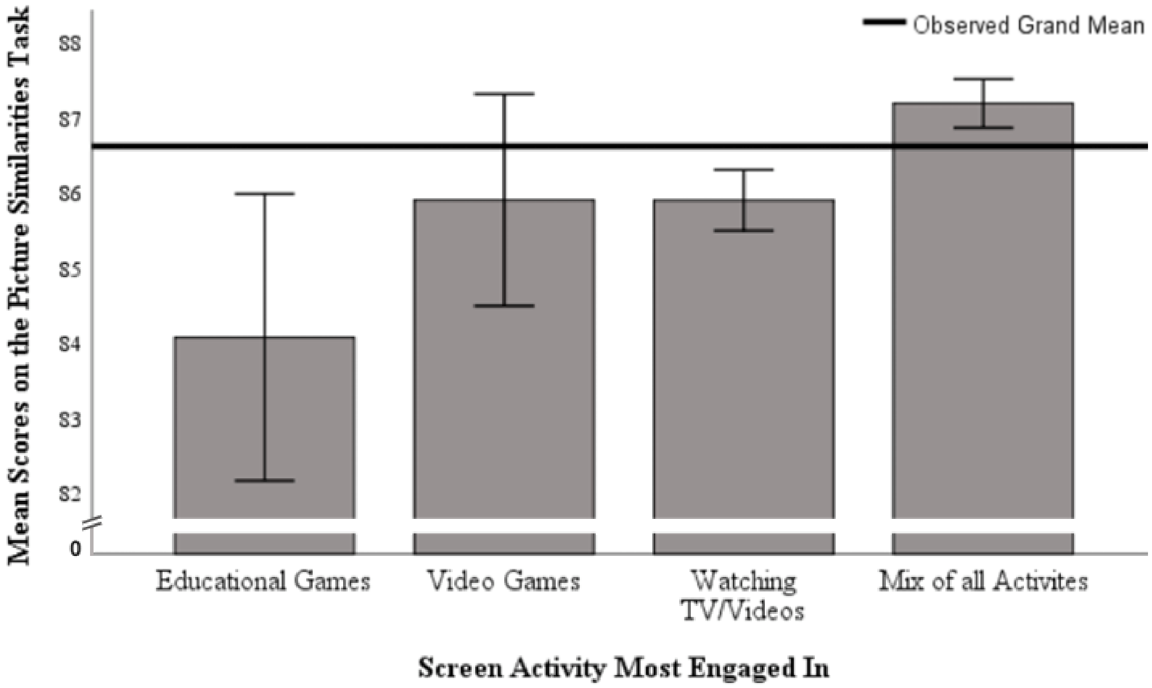


Figure 2. Mean reasoning scores based on screen activity.

These ANOVA tests suggest that the 5-year-olds' screen use does have varying influence on their reasoning ability. However, as noted by Bronfenbrenner's bioecological model, and many previous screen use researchers, it is also important to control for the various environmental factors that are known to influence development. For this reason, hierarchical multiple regressions were also conducted to explore whether the screen use variables still had a significant influence on the children's cognitive scores after these variables were controlled for.

Prior to running the regression models, the two screen use variables (time and activity) were dummy coded so as each level within the variables could be entered into the regression independently. The screen activities (Educational games; Video games; and Watching TV/Videos) were entered into the regression in Step 1, with 'Mix of all activities' used as a reference category. Similarly, the screen time categories (No screen time; 2 to less than 3 hours; and 3 or more hours) were entered into the regression at Step 2 with ‘Less than 2 hours’ used as a reference category. These variables were used as reference categories as over half of the study sample were contained in these categories. The control environmental factors (the primary caregivers’ education level, household income, and the level of parent-child closeness) were then entered as variables into the regression in the final step. The variables were entered in this order to assess whether screen use variables remained significant in their contribution to the children’s reasoning scores, even after the environmental factors were included.

The regression model indicated that at Step 1, screen activity accounted for 0.4% of the variation in the children’s reasoning scores, $R^2 = .004$, $F(3,8429) = 12.347$, $p < .001$. In contrast to the ANOVA findings, video games also significantly differed from the mix of all reference category in the regression model ($p = .021$). However, the standardised beta (β) coefficients confirmed the findings of the ANOVA tests, by showing the negative influence of playing educational games ($\beta = -.033$) and watching TV ($\beta = -.059$) to be larger than that seen for playing video games ($\beta = .025$; see Table 4, Model 1). The amount of screen time the child engaged in was added in Step 2 of the model and explained an additional 0.5% of variation in reasoning scores, $R^2 = .005$, $F(6,8426) = 13.628$, $p < .001$. As per the ANOVA tests, children who engaged in 3 or more hours of screen time per day had the lowest β coefficient value (Table 4, Step 2).

The environmental factors were then added to the regression model in the final step and explained an additional 1.8% of the variation. The final model with all variables entered accounted for 2.7% of the variance in reasoning scores, $\Delta R^2 = .027$, $F(9,8423) = 26.859$, $p < .001$. The same pattern of results relating to screen use remained in the final model when the control variables were added to the model (Table 4, Model 3), with the exception that the ‘2 to less than 3 hours’ screen time bracket and playing video games no longer made a significant unique contribution to the model when the family factors were controlled for. As expected, each of the control variables added in Step 3 also made significant unique contributions to the model predicting reasoning scores.

Table 4. Regression model of screen use variables and reasoning scores.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1: Screen Activity ('Mix of all activities' as reference category)									
Educational games	-3.00	-.033	.003	-3.22	-.035	.001	-2.92	-.032	.003
Video games	-1.74	-.025	.021	-1.87	-.027	.013	-1.52	-.022	n.s
Watching TV	-1.44	-.059	<.001	-1.63	-.067	<.001	-1.49	-.061	<.001
Step 2: Screen Time ('Less than 2 hours' as reference category)									
No screen time				.302	.004	n.s	.321	.004	n.s
2 to less than 3 hours				-.713	-.027	.016	-.326	-.013	n.s
3 or more hours				-2.53	-.074	<.001	-1.68	-.049	<.001
Step 3: Environmental Factors									
Education level							.259	.059	<.001
Household income							.335	.082	<.001
Closeness with child							.395	.065	<.001
R^2	.004, p <.001			.005, p <.001			.018, p <.001		
Total ΔR^2							.027		

Note. n.s = non-significant.

The cross-sectional influence of screen time and activity on language scores

The ANOVA tests run with the Naming Vocabulary test scores showed that screen time also had a significant influence on language development for the 5-year-olds in this study, $F(3,8858) = 4.597$, $p = .003$, $\eta_p^2 = .002$. Children who engaged in 3 or more hours of daily screen time scored significantly lower on the task than those who had less than 2 hours (p = .002), but no other significant differences were present across the time brackets (all p's > .05; Figure 3).

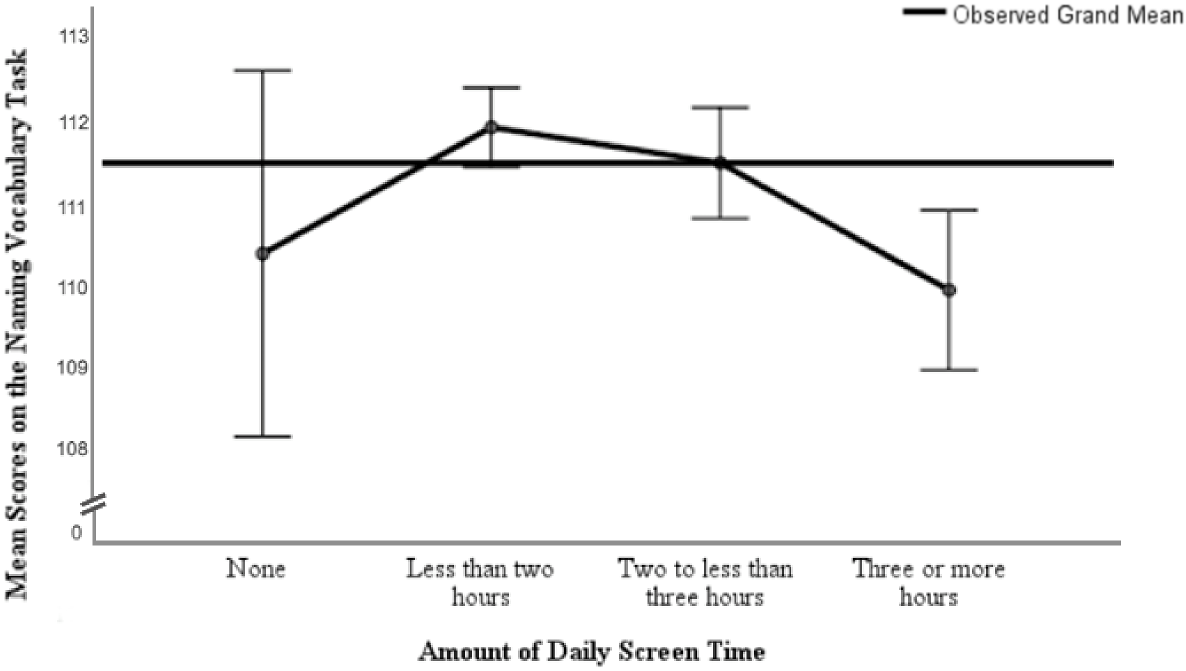


Figure 3. Mean language scores based on screen time brackets.

The screen activity that the children mostly engaged in also had a significant effect on language development, $F(3,8620) = 16.800$, $p < .001$, $\eta_p^2 = .006$, with those who engaged mostly in video games scoring lower on the vocabulary task than any other screen activity (all *p*'s < .03). No differences were seen across the other activities (all *p*'s > .36). Figure 4 shows the mean score differences across the screen activities that the children mostly engaged in and their Naming Vocabulary test scores.

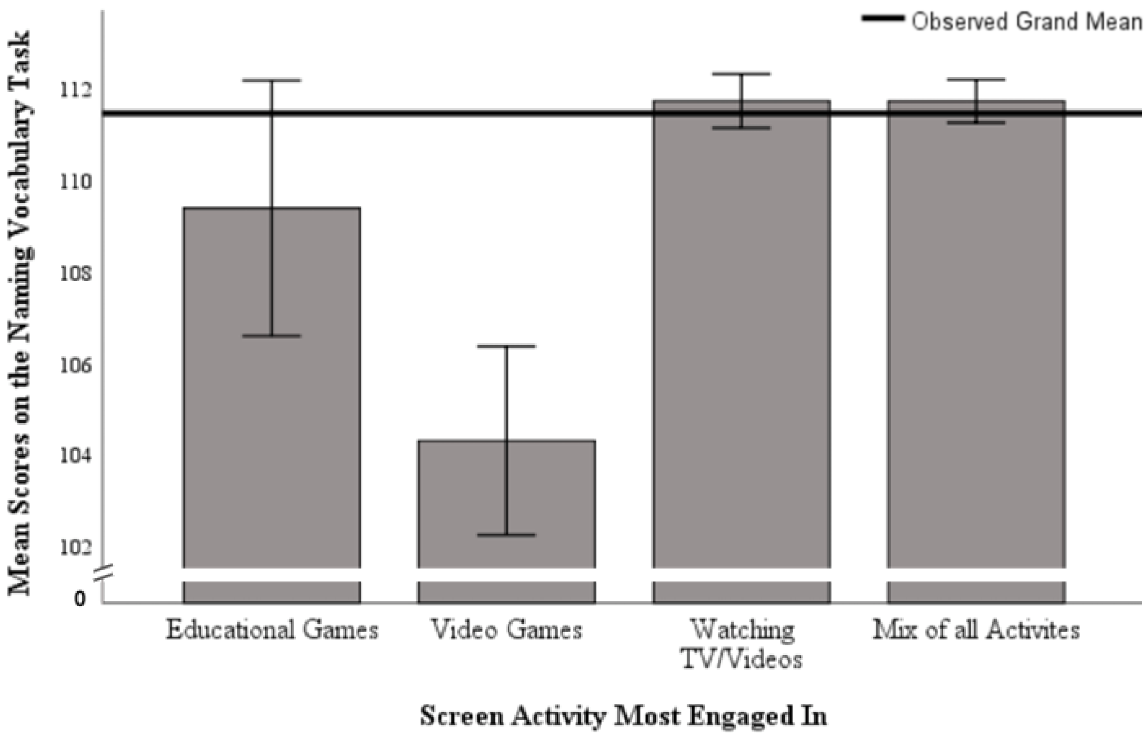


Figure 4. Mean language scores based on screen activity.

As noted in the inferential analyses on reasoning ability, the above ANOVA tests suggest that the 5-year-olds' screen use does have varying influences on their language development, and so it is necessary to further explore this using hierarchical multiple regressions to assess whether these findings remain significant after the children's environmental factors are controlled for. The variables used were dummy coded and entered into the model in a similar manner to the reasoning ability model. The language development regression model indicated that at Step 1, screen activity accounted again for 0.5% of the variation in the children's language scores, $R^2 = .005$, $F(3,8429) = 15.631$, $p < .001$. Only video games significantly differed from the reference category, as also seen in the ANOVA tests (Table 5, Step 1). Screen time explained an additional 0.2% of variation in Step 2, $R^2 = .002$, $F(6,8426) = 11.309$, $p < .001$. Again, children who engaged in 3 or more hours of screen time per day had the lowest language scores ($\beta = -.045$; see Table 5, Model 2). The final step explained an additional 3.3% of the variation. The final model with all variables entered accounted for 4.0% of the variance in the Naming Vocabulary test scores, $\Delta R^2 = .040$, $F(9,8423) = 39.950$, $p < .001$. With the additional factors included, screen time no longer had a significant influence on language scores, however video games remained statistically significant (Table 5, Model 3).

Table 5. Regression model of screen use variables and language scores.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1: Screen Activity (‘Mix of all activities’ as reference category)									
Educational games	-1.80	-.013	n.s	-2.08	-.015	n.s	-1.80	-.013	n.s
Video games	-6.77	-.067	<.001	-6.97	-.069	<.001	-6.21	-.062	<.001
Watching TV	.042	.001	n.s	-.218	-.006	n.s	.018	.001	n.s
Step 2: Screen Time (‘Less than 2 hours’ as reference category)									
No screen time				-2.00	-.019	n.s	-1.87	-.017	n.s
2 to less than 3 hours				-.629	-.017	n.s	.208	.006	n.s
3 or more hours				-2.20	-.045	<.001	-.497	-.010	n.s
Step 3: Environmental Factors									
Education level							.434	.060	<.001
Household income							.790	.134	<.001
Closeness with child							.376	.042	<.001
R^2	.005, p < 001			.002, p < 001			.033, p < 001		
Total ΔR^2							.040		

Note. n.s = non-significant.

Summary of findings

The initial descriptive findings showed that the majority of 5-year-olds in the GUI dataset engaged in screen use on a regular basis, indicating the prevalence of screens in the home was high. The chi-square tests also demonstrated the variety of screen activities engaged in by the children in this national sample, and the association between screen activity and time.

This identifies screen activity as an important measure of screen use in early childhood, which was also shown in the ANOVA tests and regression models.

The inferential findings indicated that the children's cognitive development scores were influenced by their amount of daily screen time at the time of testing. The ANOVA tests showed that those who had 3 or more hours of screen time scored significantly lower than those in the other screen time brackets on the reasoning task, and significantly lower than the 'less than 2 hours' bracket on the language task. The screen activities that the 5-year-olds mostly engaged in were shown to also play a role in the children's cognitive scores. Those who mostly engaged in a mix of all screen activities scored significantly higher on the reasoning task than those who mostly engaged in educational games or watching TV. For the language scores, children who mostly played video games during their screen time scored significantly lower than those who mostly engaged in the other screen activities.

However, the regression findings showed that screen time had no significant influence on language development after the children's environmental factors were controlled for, while screen activity did. This suggests that early language development may be predicted more by the child's environmental factors and the screen activities they engage in than screen time itself. For reasoning ability, both screen time and activity contributed uniquely to the reasoning scores for the 5-year-olds in this study, even after other factors were controlled for. However, the β coefficients for screen time and screen activity in the final reasoning regression model show screen time to be mediated more by the environmental factors than screen activity. This shows activity to perhaps have more of an influence on reasoning scores than screen time.

Although screen use still predicted variance in the children's reasoning scores after accounting for environmental factors, it is also important to note that the R^2 values in the regression models show that environmental factors account for more of the variance in both the reasoning and language scores than the screen variables themselves. This would suggest that while screen use did significantly influence the cognitive scores for the children in this study, factors such as parents' educational attainment and parent-child closeness have greater influence on overall cognitive development. Similarly, the β coefficients showed screen use to have less of a negative effect on developmental scores in the final models. This suggests that the environmental factors in this study may had a mediating effect on screen use.

All the while, as noted by developmental researchers, it is difficult to tell at a cross-sectional level if the cognitive scores are linked to the children's current screen use behaviour, as this may have differed prior to these tests (Wang & Cheng, 2020). Due to the possibility of the 5-year-olds' screen time being higher or lower in previous years, and therefore longitudinally influencing their concurrent cognitive scores, it is important to measure the children's screen time at a younger age to account for this. To do so, the GUI Wave 2 dataset was used to attain the 5-year-olds' screen time at age 3 years as well as their cognitive development scores.

Study 2: Exploring the longitudinal influence of screen time on cognitive development

Using the data from Wave 2 and 3 of the GUI Study, this study aimed to examine the longitudinal influence that screen time at age 3 years had on the 5-year-olds' concurrent developmental scores, and to observe whether reverse-causal effects are present after controlling for baseline developmental scores and environmental factors. At age 3, less information about children's screen use was collected by the Growing Up in Ireland Study than at age 5. Therefore, the analyses in the current study focus on the longitudinal role of screen time, as screen activity data were not recorded at age 3 years.

Method

Participants

9,793 families in the GUI Study participated in the second Wave of data collection when the children were 3 years of age (50.7% males and 49.3% females). Of the 9,793 3-year-olds who were included in Wave 2, 9,149 completed both the Pictures Similarities task and Naming Vocabulary test, and also had their corresponding screen time data available. Longitudinal data for screen time were available for 8,579 of the 3-year-olds at age 5 years. For reasoning scores, longitudinal data were available for 8,430 of the children, and data on language scores were available for 8,167 of the children.

Measures

As in the previous study, the child's primary caregiver completed the 'Main questionnaire' at Wave 2, which included detailed information on the study child as well as information on the primary caregiver. At Wave 2, the question relating to screen time asked caregivers to note the: "Time per day spent watching TV in minutes". No other data on screen time or screen activity were recorded at age 3 years. The Picture Similarities task and the Naming Vocabulary test from the BAS II (as described in Study 1) were also used with the 3-year-olds, and so were chosen for this study to ensure longitudinal consistency. The reported Cronbach alpha values for these tests at age 3 years were .82 for the Picture Similarities task, and .86 for the Naming Vocabulary test (Elliott et al., 1997). The same environmental factors were also measured in Wave 2 as in Wave 3.

Data analyses

Statistical analyses were conducted using IBM SPSS version 24.0. The relevant variables of interest were extracted from the original data files and input to a merged file that combined

Wave 2 and Wave 3 dataset based on the Household ID code. This allowed for longitudinal analyses to be conducted. To ensure consistency of variables across ages, the screen time variable at age 3 years was recoded to conform with the levels within the screen time variable at age 5 years (None; Less than 2 hours; 2 to less than 3 hours; 3 or more hours). Descriptive statistics could then be run with this recoded screen time variable to explore whether amount of daily screen time changed for the children over the two Waves of the study.

For the longitudinal analyses, the screen time and cognitive measure variables were recoded again for the purpose of conducting odds ratio tests. The variables were collapsed into two levels so that exploratory analyses could be run (as an odds ratio statistical test provides the ratio of two odds; Tenny & Hoffman, 2020). The two levels that screen time was collapsed into were 'Under 2 hours', and '2 or more hours', which could be categorised as lower screen time and higher screen time. The scores on the Picture Similarities and the Naming Vocabulary tasks were also recoded into two levels (Low and High) by conducting median splits. With the new two-level variables, odds ratio tests could provide an exploratory analysis of the odds and relative risk the children had of scoring either low or high on the cognitive tasks at age 5 years, based on their screen time at 3 years.

As noted previously, causality is difficult to capture using cross-sectional analyses, and while odds ratios can provide an insight to causal and reverse-causal relations, it is important to use a statistical model that can also control for baseline differences, such as developmental scores or environmental factors. To further investigate any longitudinal associations between the ages of 3 and 5 years, hierarchical multiple regressions were used to assess causation, utilising the two Waves of data. For this study, assessing the differences in the cross-sectional associations, causal longitudinal associations, and reverse-causal longitudinal associations is therefore paramount.

The regression models included the predictor scale variables of screen time and the developmental scale scores; and the control scale variables of parental education, income, and parent-child closeness, all at age 3 years. The dependent variables of screen time and developmental scores at age 5 years were used in the models to explore the causal and reverse-causal longitudinal associations between screen time and cognitive development. The assumption of collinearity was tested before applying weighting to the scores, and the data were shown to meet this assumption with the test statistic indicating multicollinearity was not a concern (all *VIF* values < 10, and *Tolerance* values > 0.1). Scatterplots indicated the relationship between the independent and dependent variables were linear, and P-P plots suggested the assumption of homoscedasticity and normality were met (Appendix B).

Results

Descriptive findings

The children's scores at age 3 years on the Pictures Similarities task ranged from 10 to 119, with the average score being 60.40, *SD* = 14.36, and their Naming Vocabulary test scores ranged from 10 to 170 (*M* = 74.69, *SD* = 19.79). The primary caregivers of these children indicated that 219 (2.39%) of them had no screen time in the home, with 48.1% of the children in the current study engaging in 2 or more hours of screen time a day (see Table 6). This is a higher rate than that seen at age 5 years, indicating the children engaged in higher amounts of screen time at 3 years of age. In contrast to the data at age 5 years, the children seemed to perform better on the cognitive tasks if they were exposed to at least some daily screen time, according to the means. The mean scores shown in Table 6 indicate that children who had up to 2 hours of daily screen time had the highest reasoning and language scores.

Table 6. Mean cognitive task scores based on screen time at age 3 years.

Screen time at age 3 years	Picture Similarities Score		Naming Vocabulary Score		Overall Participants	
	M	SD	M	SD	N	%
No screen time	54.07	18.00	69.38	19.24	219	2.39
Less than 2 hours	61.03	13.71	75.79	18.74	4530	49.51
2 to less than 3 hours	60.40	14.76	75.06	19.91	2622	28.67
3 or more hours	59.72	14.66	72.32	21.87	1778	19.43

A bivariate correlation found screen time at age 3 and age 5 years to be positively associated ($r = .338$, $p < .001$). This suggests that the children's amount of daily screen time remained similar across ages. A chi-square test was also conducted to see whether screen time at age 3 years was associated with the screen activity the children mostly engaged in at age 5 years. The results indicated that early screen time does have a significant association with the screen activity most engaged in at age 5 years, $\chi 2$ (9, N = 8474) = 65.48, $p < .001$, *Cramer's V* = .051. Table 7 shows that children who had no screen time at age 3 years were mostly likely to engage in TV watching at 5 years (55.6%).

In comparison, less than a third (31.6%) of children who had over 3 hours of screen time mostly watched TV at age 5 years, with the majority engaging in a mix of screen activities (63.2%). There was no difference in the likelihood of mostly engaging in educational or videos games based on prior screen time but the highest engagement in video games (3.4%) was seen for the children who had 3 or more hours of screen time at age 3 years. Although screen activity was not measured at age 3 in the GUI Study, this analysis provides empirical evidence that amount of early screen time may influence the type of screen activities children mostly engage in during later childhood. To further explore whether screen time at age 3 years had a longitudinal influence on later developmental scores at age 5 years, odds ratio tests and regression models were employed.

Table 7. Screen time at age 3 and later preferred screen activity at age 5, as shown by percentage (n).

Screen time at age 3 years	**Screen activity most engaged in at age 5 years**				Total *n* for screen time
	Educational games	Video games	Watching TV	Mix of activities	
None	1.7% (3)	2.8% (5)	55.6% (99)	39.9% (71)	178
Less than 2 hours	1.8% (74)	2.7% (114)	39.6% (1653)	55.9% (2335)	4176
2 to less than 3 hours	1.3% (33)	2.4% (58)	36.3% (888)	60.0% (1470)	2449
3 or more hours	1.8% (30)	3.4% (57)	31.6% (528)	63.2% (1056)	1671

The longitudinal influence of screen time on reasoning scores at age 5 years

Reasoning scores and screen time data for the 3- and 5-year-olds were coded for the purpose of running odds ratio tests, as described in the method section of this chapter. The initial chi-square test showed that screen time at age 3 years did not have a significant association with reasoning scores at age 5 years, $\chi 2$ (1, *N* = 8579) = 3.72, *p* = .054, *Cramer's V* = .021, (although the *p* value was approaching significance) and so no relative risk between screen time and later reasoning scores were found (*OR* = .920, *RR* = .960), resulting in a non-significant causal longitudinal association.

As confirmed in the previous study, the cross-sectional odds ratio test for the 5-year-olds' screen time and reasoning scores were significant (*OR* = .878, *RR* = .938, *p* = .003), where 5-year-olds in the high screen time group were 1.14 times more likely to be in the low reasoning score group than those in the low screen time group at age 5 years. As the Picture Similarities task was also carried out with the children when they were 3 years old, it was possible to assess if reasoning ability at age 3 years was associated with screen time at age 5 years, as opposed to screen time being the initial causing factor for reasoning ability scores.

A final odds ratio test suggested a reverse-causal longitudinal association, $\chi 2$ (1, *N* = 8430) = 6.46, *p* = .011, *Cramer's V* = .028, where 3-year-olds who were in the high reasoning score group were 1.11 times more likely to be in the low screen time group at age 5 years (*OR* = .893, *RR* = .955), in comparison to 3-year-olds in the low reasoning group. The odds ratio and significance values for each of the tests are presented in Table 8. These longitudinal and cross-sectional odds ratio values indicate screen time to have no causal longitudinal association with reasoning scores, but a significant reverse-causal longitudinal association is present.

Table 8. Odds ratio and significance values for the reasoning ability odds ratio tests.

	Screen time at age 5 years	Reasoning scores at age 5 years
Screen time at age 5 years		*OR* = .878, p = .003
Reasoning scores at age 3 years	*OR* = .893, p = .011	
Screen time at age 3 years		*OR* = .920, p = .054

To further explore the longitudinal associations, hierarchical multiple regressions were conducted. For the first model exploring the association of early screen time on later reasoning scores, the variable of screen time at age 3 years was entered into the regression in Step 1, and reasoning scores at age 3 years in Step 2. The environmental factors were then entered into the regression in the final step. The regression model confirmed the findings of the odds ratio tests, whereby screen time at age 3 years did not have a significant association with reasoning scores at age 5 years, R^2 = .000, F(1,7750) = 3.564, p = .059. Previous reasoning scores predicted scores at age 5 years (R^2 = .097, F(2,7749) = 416.422, p < .001) and accounted for 9.7% of the variation in the 5-year-olds' reasoning scores. Environmental factors at age 3 years also significantly contributed to the model, R^2 = .006, F(5,7746) = 178.700, p < .001. The final model with all variables entered accounted for 10.3% of the variance in reasoning scores at age 5 years (see Table 9).

Table 9. Regression model exploring the longitudinal influence of screen time on reasoning scores.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Screen time at 3 years	-.004	-.021	n.s	-.003	-.017	n.s	.001	.004	n.s
Step 2:									
Reasoning scores at 3 years				.251	.311	<.001	.241	.298	<.001
Step 3: Environmental Factors									
Education level							.214	.054	<.001
Household income							.324	.040	.001
Closeness with child							.151	.024	.028
R^2	.000, p = .059			.097, p <.001			.006, p <.001		
Total ΔR^2							.103		

Note. n.s = non-significant.

The second regression model, exploring the association between early reasoning scores and later screen time, included the reasoning scores of the 3-year-olds in Step 1, and screen time at 3 years in Step 2. The environmental factors were again entered in the final step. By entering the variables in this way, it could be explored whether the reverse-causal association reported in the odds ratio tests remained significant after controlling for screen time at age 3 and the wider contextual variables. The regression model confirmed the findings of the odds ratio tests, where reasoning scores at age 3 years did have a significant association with screen time at 5 years, $R^2 = .001$, $F(1,7788) = 5.500$, $p = .019$.

Screen time at 3 years, however, was the highest predictor in this model, $R^2 = .117$, $F(2,7787) = 519.864$, $p < .001$. In this step of the regression, the association between reasoning at age 3 years and screen time at age 5 years was no longer significant (see Table 10, Step 1), meaning reasoning scores do not predict later screen time when baseline screen time is accounted for. Environmental factors contributed 0.4% of the variance to the model in the final step, R^2 = .004, F(5,7784) = 216.248, p < .001, although only parental education level significantly contributed to the model. The final model with all variables entered accounted for 12.2% of the variance in screen time at age 5 years (see Table 10).

Table 10. Regression model exploring the longitudinal influence of reasoning scores on screen time.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Reasoning at 3 years	-.001	-.027	.019	-.001	-.020	n.s	-.001	-.010	n.s
Step 2:									
Screen time at age 3 years				.004	.342	<.001	.004	.326	<.001
Step 3: Environmental Factors									
Education level							-.015	-.056	<.001
Household income							-.008	-.015	n.s
Closeness with child							-.008	-.020	n.s
R^2	.001, p = .019			.117, p <.001			.004, p <.001		
Total ΔR^2							.122		

Note. n.s = non-significant.

The longitudinal influence of screen time on language scores at age 5 years

Similar to the analyses on reasoning ability, the cross-sectional and longitudinal associations of screen time and language scores were first explored through the use of odds ratio tests. The first chi-square test showed screen time at age 3 years to have a significant association with language scores at 5 years, $\chi 2$ (1, N = 8579) = 21.08, p < .001, *Cramer's V* = .050, with the children who had high screen time at age 3 years being 1.22 times more likely to score low in the Naming Vocabulary task at age 5 year (*OR* = .818, *RR* = .918) than those with low screen time.

The cross-sectional odds ratio for the 5-year-olds showed high screen time at the time of testing to have an equal significant amount of risk for the children in relation to their scores on the task (*OR* = .820, *RR* = .920, $p < .001$). A significant reverse-causal association was also found in the final chi-square test, $\chi 2$ (1, *N* = 8167) = 16.45, $p < .001$, *Cramer's V* = .045, where the odds ratio showed that those who scored high in the Naming Vocabulary task at 3 years were 1.20 times more likely to have under 2 hours of screen time at age 5 years (*OR* = .833, *RR* = .929) compared to those who had low language scores at age 3 years. The odds ratio and significance values for each of the tests are presented in Table 11.

Table 11. Odds ratio and significance values for the language development odds ratio tests.

	Screen time at age 5 years	Language scores at age 5 years
Screen time at age 3 years		*OR* = .818, $p < .001$
Screen time at age 5 years		*OR* = .820, $p < .001$
Language scores at age 3 years	*OR* = .833, $p < .001$	

To assess if the longitudinal associations still remained after controlling for baseline development and environmental variables, regression models were conducted. The first regression exploring the longitudinal association between screen time at age 3 years and language at age 5 years had the variables entered in the same manner as the reasoning regression models, with the reasoning score variable being replaced with language scores. The model indicated that early screen time did significantly contribute to later language scores at age 5 years, $R^2 = .002$, $F(1,7480) = 13.891$, $p < .001$, although this association became non-significant in the next model with baseline language scores at age 3 years controlled for (Table 12, Model 2). Language scores at 3 years was the highest predictor in the model ($R^2 = .243$, $F(2,7479) = 1215.237$, $p < .001$), accounting for 24.3% of the variation in later language scores. Environmental factors contributed 0.6% of the variance to the model, R^2 = .006, F(5,7476) = 500.719, p < .001. The final model with all variables entered accounted for 25% of the variance in language scores at age 5 years.

Table 12. Regression model exploring the longitudinal influence of screen time on language scores.

	Models								
	Model 1			Model 2			Model 3		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Screen time at 3 years	-.010	-.043	<.001	-.004	-.016	n.s	.001	.002	n.s
Step 2:									
Language scores at 3 years				.413	.494	<.001	.399	.477	<.001
Step 3: Environmental Factors									
Education level							.120	.022	n.s
Household income							.706	.062	<.001
Closeness with child							.242	.027	.007
R^2	.002, p <,001			.243, p <.001			.006, p <.001		
Total ΔR^2							.250		

Note. n.s = non-significant.

The final regression model explored if earlier language scores at age 3 years predicted later screen time at age 5 years, with variables entered into the model in the same manner as that seen for the reverse-causal reasoning ability regression model. The results confirmed the findings of the odds ratio tests, where language scores at age 3 years did have a significant association with screen time at 5 years, R^2 = .004, F(1,7515) = 33.537, p < .001. Screen time at 3 years made a similar contribution as that reported in the reasoning ability model, R^2 = .116, F(2,7514) = 514.728, p < .001. However, in this case, the language scores remained significant (see Table 13, Step 1), meaning language scores do predict later screen time even when baseline screen time is accounted for. Environmental factors contributed 0.3% of the variance to the model in the final step, R^2 = .003, $F(5,7511) = 211.618$, $p < .001$, although again only parental education level significantly contributed to the model. The final model with all variables entered accounted for 12.3% of the variance in screen time at age 5 years.

Table 13. Regression model exploring the longitudinal influence of language scores on screen time.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Language at 3 years	-.003	-.067	<.001	-.002	-.047	<.001	-.001	-.037	.001
Step 2:									
Screen time at 3 years				.004	.341	<.001	.004	.328	<.001
Step 3: Environmental Factors									
Education level							-.013	-.049	<.001
Household income							-.006	-.012	n.s
Closeness with child							-.006	-.014	n.s
R^2	.004, p <.001			.116, p <.001			.003, p <.001		
Total ΔR^2							.123		

Note. n.s = non-significant.

Summary of findings

The initial descriptive findings showed that screen time at age 3 years did have a significant association with the screen activity the children mostly engaged in at age 5 years, however, as screen activity was not measured when the children were 3 years old, no further exploration of screen activities could be conducted. All the while, this shows early screen time to be a correlate of the type of screen activity children engage in during later childhood, which is a novel finding in the early screen use literature.

The inferential findings explored the longitudinal associations of screen time and cognitive scores between the ages of 3 and 5 years. The odds ratio tests also compared the strength of these associations cross-sectionally for both reasoning and language scores. These tests showed the cross-sectional associations to have the highest risk values for reasoning scores, indicating concurrent screen time age 5 years to pose more of a risk to reasoning scores at age 5 than screen time at age 3 years. For language development however, the cross-sectional and longitudinal associations were approximately the same. Interestingly, screen time at age 3 years had no longitudinal association with the 5-year-olds' reasoning scores, which was also indicated by the hierarchical multiple regressions. While reasoning scores at age 3 initially predicted screen time at age 5, ultimately previous reasoning scores had no significant association with the 5-year-olds' screen time levels when screen time at age 3 was controlled for.

The regressions on language development again confirmed the odds ratio tests whereby both longitudinal associations were initially significant. However, similar to the regression findings from the previous study, screen time at age 3 years had no significant influence on the 5-year-olds' language scores once control factors (baseline language scores and environmental variables) were accounted for. The reverse-causal regression model however showed that language scores at age 3 years were negatively related with screen time at age 5, even when baseline screen time and environmental factors are considered. This highlights that, unlike reasoning development, screen time and language have a longitudinal reverse-causal association.

In the causal longitudinal regressions for both reasoning and language, the environmental factors at age 3 years had a significant positive relationship with the 5-year-olds' cognitive development scores at age 5 years. In the reverse-causal longitudinal regressions, only the primary caregivers' educational attainment had a significant negative correlation with later screen time. Even though screen time was not significant in the final causal models, the β coefficients indicate that screen time would have had less of an influence on later developmental scores when the environmental factors were considered, outlining the possible mediating effect of contextual factors. This provides further evidence on the importance of considering contextual factors when measuring the influence of early screen time on cognitive development.

Discussion

The aim of this chapter was to explore the cross-sectional and longitudinal influence that screen use in the home has on reasoning and language development, as measured by the Picture Similarities and Naming Vocabulary tasks, for the 5-year-olds in the GUI Study. The following section will discuss these findings in relation to the existing literature, while also drawing on the findings to assess what evidence-based claims can be made regarding early screen use after considering it from an ecological perspective.

The role of screen time

The descriptive findings across both studies indicate the high prevalence of screen devices, and screen time, in the early home environment in this nationally representative sample of young children in Ireland. The findings show that children engaged in a variety of screen activities at age 5 years, although TV/video viewing remained the most popular single screen activity. The children's amount of daily screen time at both 3 and 5 years of age was associated with the screen activity that they mostly engaged in when 5 years old. A bivariate correlation showed the children's screen time to be significantly correlated across the two time-points, meaning that while the children engaged in higher levels of screen time at age 3, for most of the children their amount of daily screen time remained similar across the two years. Therefore, changes in screen time could be noted as unlikely in having a significant influence on changes in developmental scores seen in the longitudinal inferential statistical analyses.

The initial cross-sectional findings on screen time in Study 1 indicated that the 5-year-olds' cognitive development was influenced by their concurrent amount of daily screen time, especially for those who engaged in 3 or more hours of screen time a day. This compares to the previous screen time research, where more time spent on screens was seen to have a negative influence on cognitive development scores (e.g., Christakis et al., 2004; Duch et al., 2013b). Zimmerman et al. (2007a) also found screen time to have a dose-dependent effect on early language development. Using the Communicative Development Inventory with 1,008 infants, they found a decrement in language scores for each hour of TV viewing per day. These findings are, however, in contrast to research and reviews, such as those produced by Przybylski (2019) and Bavelier et al. (2011), which suggest screen time to only have an influence on developmental outcomes if children are engaged in an excessive amount (more than half of the waking day). While over 2 hours of daily screen time for this age bracket is discouraged by many child protection organisations (e.g., the American Academy of Paediatrics), and was shown to have a negative influence on cognitive scores in the current research, whether this can be considered an excessive amount is an area for debate (e.g., Przybylski & Weinstein, 2019).

The initial longitudinal findings in Study 2 contributed to the above finding by showing that the same language scores were also influenced by the children's amount of daily screen time at age 3 years, although this longitudinal influence was not found for the reasoning scores. This is in line with research by Duch et al. (2013b), who found that more than 2 hours of daily screen time in early childhood resulted in increased odds of low communications scores in later childhood, both cross-sectionally and longitudinally. Interestingly, however, a significant reverse-causal association was found in Study 2 for reasoning ability in the odds ratio tests. This was also found for the language scores, where a bi-directional effect for language and screen time was reported. These findings were then confirmed by the regression models, although the only association that remained significant after baseline individual differences at age 3 years were accounted for, was the reverse-causal association for language scores. The reverse-causal findings in this study are in contrast with a recent study by Madigan et al. (2019) who found screen time to be the initial causing factor for later development when exploring bi-directional effect. However, the findings do support the earlier research conducted by Wright et al. (2001) who also found a bi-directional effect between screen use and early cognitive development. Given the limited research on directionality, it is still difficult to draw conclusions on whether screen time is an initial causing factors of later development, although the current research would not suggest this to be so.

These studies therefore provide empirical findings on the role of early screen time in early cognitive development by exploring this role in under-researched age bracket. This adds to the gap in knowledge within the literature. One of the main limitations noted in the screen time literature relates to the lack of research exploring reverse-causal associations, which is also an area that the current findings can contribute to. However, as noted in past screen time research, screen time alone is not an extensive or inclusive measure of modern screen use. Therefore, in line with this, and the bioecological framework, further notable variables were considered to provide more nuanced and holistic findings to this field of research.

The role of screen activity

As noted above, the descriptive findings showed screen time and activity to be significantly associated and so it was important to explore the role that various screen activities might have in the children's cognitive development scores. The ANOVA test exploring screen activity and reasoning ability revealed that those who mostly engaged in a mix of all screen activities scored significantly higher on the reasoning task than those who mostly engaged in educational games or watching TV. This finding is in contrast to previous research that has suggested digital games to benefit cognitive development, such as reasoning and problem-solving ability (e.g., Yang, 2012; Fisch et al., 2011; 2014; Fessakis et al., 2013). However, most of the previous research on this topic was conducted with older children, and the differences seen between the current study and existing research may be due to the differences in age and developmental stage of the children. Additionally, these researchers did not compare digital games to other screen activities in their analyses, and so it could not be concluded from these past papers whether the benefits of playing digital games were as high as the benefits of regularly engaging in a mix of screen activities or watching TV.

For language scores, the findings showed that children who mostly played video games during their screen time scored significantly lower than those who mostly engaged in the other screen activities. This is perhaps more in line with previous research that shows educational screen-based games and TV content instead to be beneficial for language development in young children (e.g., Linebarger & Walker, 2005; Neumann, 2018a). In contrast to this, research with older children has reported video games to play a positive role in cognition (e.g., Spence & Feng, 2010). Green and Seitz (2015) also found teenagers who played action games showed a widespread enhancement in cognitive function in comparison to those who did not play these games. This again emphasises the importance of replicating such studies with younger cohorts to assess whether these findings are applicable at all developmental stages.

Interestingly, the cross-sectional regression models showed that screen activity did have a significant influence on language development after the children's environmental factors were controlled for, even though screen time did not. For reasoning scores, both time and activity were significant contributors in the final models, although the β coefficient values for activity were less influenced by the environmental factors than those for screen time. This suggests that when it comes to screen use, early language development is predicted more by the screen activities concurrently engaged in than screen time itself. This highlights the importance of considering screen activity when measuring the influence of early screen use on development.

The findings from the language regression model are also in line with the research in the field of developmental psychology that suggests language development to be highly reliant on factors such as educational content (e.g., Linebarger & Walker, 2005) and parental education and presence (Veena et al., 2010; Murray & Egan, 2014). Based on this, measuring parental engagement during these activities may have shed light on why certain activities influence language development more favourably than others, and is therefore a factor that future research should consider. The findings of screen use reported above also provide cause for further screen use factors, and wider ecological factors that may be associated with it such as parental engagement and screen beliefs, to also be considered in later research.

Despite this, few studies to date have measured screen activities and cognition in a young cohort and have compared the developmental benefits of digital games to other screen activities such TV watching in early childhood. This is a clear strength of the current studies. Research that has done so, however, has produced varying findings to the current study. For example, Fiorini (2010) found computer use to have a positive influence on language and reasoning development, both cross-sectionally and longitudinally, while TV watching had a negative influence. However, given the lack of research comparing screen activities in relation to their influence on development, the findings reported in this chapter can be noted as relatively novel in the literature.

The consideration of screen activities resulted in a more holistic measure of screen use in the current studies, and produced more nuanced findings on the role of screen use in early development. Unfortunately, however, as screen activity was not measured at 3 years of age, the influence of screen activities on the 5-year-olds' cognitive development could not be explored longitudinally. This is a regrettable limitation within the current studies as there is a gap in knowledge about the types of activities preschool children are engaging in within the early home environment, and the influences this may have on development. Similarly, further research is needed to assess whether certain screen activities are related to higher amounts of screen time. While the current research suggests this to be the case for the 5-year-olds, there is little prior research in this area to further support this claim for children under the age of 5 years.

The current research shows that screen activity is an important element of screen time that should be measured when exploring the influence of early screen use on cognitive development. As research on the role of screen activities at this age is scarce, the current findings provide an insight to an area in which little is still known. However, the existing literature, and above findings, indicate screen use to not exist in a vacuum and so its influence should be viewed in the light of the child's environmental factors, which is a further area that was explored in the current research.

The role of ecological factors

A further strength of the studies in this chapter is the use of a bioecological model to frame the research. By integrating aspects of the bioecological model into the studies' methodologies, the influence of early screen time on cognitive development could be assessed from an ecological perspective. As mentioned in the literature review of this chapter, this is an approach that past research collectively calls for more holistic findings on early screen use and development.

The first example of how the bioecological model was drawn upon in these studies was the measurement of various areas of cognitive development as opposed to summating screen use's influence on overall cognitive development based on a single measure. This was an important consideration as the results demonstrated that screen use had varying influences based on whether it was reasoning, or language development being measured. The varied findings seen between the two measures of cognitive development provide further empirical evidence on how complex the role of screen use in early development is. A strength of the current studies therefore is that different aspects of cognitive development were measured in the same nationally representative sample, where previous studies often only included one measure of cognition or have compared findings across samples rather than within the same sample (e.g., Christakis et al., 2004; Zimmerman et al., 2007a).

Based on the findings in the current chapter, it cannot be said that one single screen activity can ultimately be more beneficial to early cognition in comparison to others, as differences are seen even within this main development domain. Educational games may serve as a more beneficial activity for language development than video games, but they are possibly less beneficial for reasoning ability. Additionally, video games may have no influence of reasoning ability but may have a negative influence on language scores. These findings are congruent with the mixed findings reported in the screen time literature. While some studies have found more than an hour of daily screen time, in comparison to under an hour, to have a negative influence on vocabulary development (e.g., Zimmerman & Christakis, 2005), others have suggested that television viewing can enhance vocabulary development when contextual factors are considered (e.g., Linebarger & Walker, 2005; Lavigne et al., 2015), or if the child does not have prolonged screen exposure (e.g., Parkes et al., 2013; Przybylski & Weinstein, 2019). Similarly, Kostyrka-Allchorne et al. (2017) found that contextual and environmental factors matter in their systematic review on television watching and its influence on development. They found that associations between screen time and cognitive development were mostly found in high-risk children, or children from disadvantaged backgrounds, and for children under the age of 2 years.

In relation to other screen activities, Bavelier et al. (2011) also found that the influence video games have on development is highly reliant on the developmental stage of the cohort and individual baseline psychological predisposition. In line with this past research, the current studies showed that depending on the aspect of development being examined, and individual and contextual differences, screen use may have positive or negative influences, and in some instances no influence. This point is further emphasised by the inclusion of individual and environmental factors as control variables in the analysis, which is a further example of the use of the bioecological model and a strength of the studies.

In their study, Barr et al. (2010) made a case for the future focus of screen time studies to not be placed on screen time, but rather the elements of screen use, such as media content or activity, and the context in which screen use is engaged in, in addition to the amount of time itself. As previously discussed, the screen use findings in both Study 1 and 2 altered significantly once contextual factors were controlled for. Exploration of the causal longitudinal associations of screen time in Study 2 showed that screen time has no significant longitudinal influence on cognitive development when baseline cognitive scores and environmental factors at age 3 years are considered. Similarly, screen time had no cross-sectional influence on language development in Study 1 after contextual factors were accounted for in the regression models.

This is in line with the replication studies conducted on previous screen time research that suggest early cognitive development to only be impacted by high levels of screen time, with these negative effects no longer remaining significant when controlling for external factors (e.g., Foster & Watkins, 2010). These findings also align with the bioecological model, where the child's environmental and individual factors are highlighted as important factors to consider when measuring the impact of proximal processes on development. These findings are also consistent with previous research, which showed the influence of screen use to diminish after contextual factors are controlled for (e.g., Ruangdaraganon et al., 2009).

Conversely, in Fiorini's (2010) study, the influence of screen time did not change after the inclusion of environmental factors. However, it was noted that parental education and income were correlates for computer ownership. The longitudinal regressions in Study 2 similarly found that parental education at age 3 had a negative correlation with amount of daily screen time at age 5 years. This finding provides evidence that family factors can have a mediating effect on screen time but can also be correlates of later screen time. Foster and Watkins (2010) noted that while there is an established body of research available on screen time correlates, such as parental education, little research has been conducted on the influence that this resulting screen time might have on cognitive development. The current research therefore addresses this gap by reporting on the longitudinal influence of screen time on developmental outcomes after controlling for such factors.

Although screen use still predicted variance in the children's reasoning scores after accounting for environmental factors, the cross-sectional regression models would suggest that the 5-year-olds' environmental factors relating to parents' educational attainment, income, and parent-child closeness have greater influence on overall cognitive development. This shows that factors within the child's ecological systems hold greater weighting on the children's cognitive development than their screen use behaviour. Similarly, while screen activity did have a significant influence on the 5-year-olds' concurrent language development, the interpretation of the results show that the effect size is quite small when contextualised within the child's ecological systems.

Additionally, the findings from Study 2 showed early screen time to have no significant longitudinal influence on development after baseline individual differences were considered. The only association that remained significant in the final regression model was the reverse-causal longitudinal association of language scores on later screen time. This indicates that, when considered in tandem with wider contextual factors, screen time as a factor in the early home environment has no longitudinal influence on these aspects of cognitive development. This contextualisation of screen use among other driving factors of development in the children's ecological systems, allowed for the above evidence-based claims on the influence of early screen use from an ecological perspective to be made, which is a further strength of these research findings.

Conclusion

The current studies provide novel findings on the influence of early screen use in the home on cognitive development, and the various screen activities being regularly engaged in within the early home environment, using a nationally representative sample. The findings suggest that, when viewed from an ecological perspective, screen use has no longitudinal influence on the cognitive measures used, although the 5-year-olds' concurrent screen use did influence reasoning ability, and video games did have a negative cross-sectional association with language scores in comparison to other screen activities. Language scores at age 3 year were also significantly associated with amount of screen time at 5 years, supporting a reverse-causal association. Using a bioecological approach also showed to be beneficial for providing holistic and more robust empirical findings on the influence of early screen use on cognitive development.

For example, the influence that screen time had on cognitive development varied based on time of measurement (i.e., previous screen time had no influence on development in comparison to concurrent screen time), and individual and environmental differences (i.e., the effect sizes and statistical significance of the influence of screen use variables changed when these differences were considered). Similarly, the influence of screen use varied based on the aspect of cognition being measured, further outlining the importance of considering various domains of development in screen time research. Based on this, it is therefore of interest to assess what influence early screen use may have in the other major domain of psychological development, socio-emotional development, and whether more clear-cut conclusions can be drawn from the findings in the following chapter.

Chapter 4:

Exploring the influence of early screen use in the home on socio-emotional development

Literature review

As mentioned in the previous chapter, cognitive and socio-emotional skills acquired in early childhood do not develop in isolation, with both domains being closely related and often supporting each other. For example, socio-emotional competence helps children approach learning in a more confident and positive manner, and the development of certain cognitive skills is necessary to exercise emotional self-regulation (National Research Council, 2015). The overlap of these domains has been also noted in the work of developmental theorist Vygotsky (1978), where important social interactions in early childhood were described as necessary for the development of not only socio-emotional skills, but also the development of language and problem-solving abilities.

While these domains are closely related, a child's socio-emotional development is suggested to be influenced by their immediate environment more so than cognitive development (Benson, 2020). This is supported by the vast amount of research that has found factors in the home environment, such as play and other proximal processes, to have an important role in the psychological development and well-being in early childhood (e.g., Whitebread et al., 2012). It is also supported in the screen time research that has highlighted the necessity of controlling for these factors when assessing the influence of screen use on socio-emotional development in later childhood (e.g., Stevens & Mulsow, 2006; Valkenburg & Peter, 2013; Nikkelen et al., 2014).

As the previous chapter showed that children are spending a considerable amount of time per day on screens, and are engaging in a variety of screen activities, it is worth exploring whether the presence of these screen activities in the early home environment is having a significant influence on children's socio-emotional development. Research has found that children can resolve socio-emotional difficulties, and practice and extend socio-emotional skills, through social exchanges that occur during play (Whitebread et al., 2012). Similarly, Vygotsky (1967) believed that through play, children can regulate emotional processes. It is therefore of interest to explore whether screen use as a type of play or proximal process in the early home environment also provides opportunity to improve socio-emotional skills, or whether it adversely contributes to socio-emotional difficulties.

For that purpose, the following chapter will review the screen use literature to examine if the presence of screens in the home has been shown to contribute to early socio-emotional development, and whether different screen activities are associated with varying developmental outcomes. As with the previous chapter, the influence of screen use on Irish children's socio-emotional skills will then be explored using the data available from the Growing Up in Ireland (GUI) Study.

The influence of television viewing on socio-emotional development

The literature that has explored early screen use and socio-emotional development is slightly more plentiful than that available for early cognitive development, which has been discussed in the previous chapter. However, the screen time research that has been conducted on this developmental domain is still far from extensive (Domingues-Montanari, 2017). The topic that has gained the most attention in this area of research, however, is the role of screen use in externalised behaviour. Externalised behaviour encompasses hyperactivity and attentional disorders (Sevincok et al., 2020), along with conduct problems such as aggression or defiance (Oliver, 2015). Other measures of socio-emotional development such as emotional and peer problems, known as internalised behaviour (Liu et al., 2011), and prosocial behaviour, have been less explored in the research. This highlights a clear gap in the current knowledge on the associations between screen use and overall socio-emotional development.

In addition to this, most of the research that has been conducted used TV viewing as a sole measure of screen time. As with the literature on cognitive development, there is a level of discrepancy in the empirical findings on the extent of TV's influence on socio-emotional outcomes. Therefore, it is necessary to review what is known on the role that television viewing has in socio-emotional development to ascertain if any conclusive findings have been reported. Limitations of the research relating to whether covariates were controlled for, or if directionality was tested, will be considered before exploring whether associations are also found in the few studies that have incorporated various screen uses and devices in their analyses.

Television viewing and externalised behaviour

Much of the evidence on television and socio-emotional development that has accumulated over the decades has focused on ADHD symptoms or attentional problems/hyperactivity as a measure of externalised behaviour specifically. However, the research to date is noted to not be well understood given the level of mixed findings in the past literature (Wilkinson et al., 2021). Cheng et al. (2010) noted these conflicting findings in their review on early TV viewing's influence on children's behaviours and social skills. These researchers reported that a study using a representative American sample found television watching in infancy to not predict hyperactivity by age 3 years if the content was educational (Zimmerman &

Christakis, 2007). This did not compare to findings from a study using a representative Japanese sample, where an association between TV viewing in infancy and ADHD symptoms at age 4 years was found (Kano et al., 2007). However, a further Japanese study by Sugawara (2010) reported no significant influence of TV viewing at age 2 years on socio-emotional development at 5 years.

To compare the findings of Zimmerman and Christakis (2007) to other American studies, Miller et al. (2007) assessed the cross-sectional association between television viewing and ADHD symptoms for 170 American preschool children. They found that amount of daily TV viewing did predict parental-reported ADHD symptoms, as indicated by parents on an ADHD checklist, in their regression models. Although, unlike Zimmerman and Christakis (2007), Miller et al. (2007) did not use a representative sample and their study was not a longitudinal design, which could have resulted in the differing findings. Still, these findings were similar to Christakis et al. (2004) who used the hyperactivity subscale of the Behavioural Problems Index to assess the longitudinal influence of screen time at ages 1 and 3 years on scores at age 7 years, in a representative sample from the National Longitudinal Survey of Youth (NLSY). Their analyses showed the amount hours of television viewed per day to be associated with attentional problems in later childhood.

However, a reanalysis of the same NLSY data by Stevens and Mulsow (2006) found no meaningful relation between the children's TV viewing and later ADHD symptoms. Their analyses showed the effect sizes from the original Christakis et al. (2004) study to be extremely small. It was suggested that the variance in hyperactivity scores was predicted by the infants in the study who were spending over 10 hours a day viewing television. Therefore, under 10 hours of screen time a day was noted to have no meaningful impact when the effect sizes were taken into consideration. Obel et al. (2004) also noted that the original study's results were not generalisable to all samples as the findings were not replicated in a Dutch sample of pre-schoolers. Furthermore, Foster and Watkins (2010) again reanalysed the data from Christakis et al.'s (2004) study and found that the reported statistically significant association between early screen time and later attentional problems was eliminated when additional covariates relating to socio-economic status (SES) and maternal education were added to the analysis. In line with Stevens and Mulsow (2006), Foster and Watkins (2010) concluded that television viewing has no meaningful influence on hyperactivity or attentional problems using the NSLY data, at least for the average child watching typical amounts of television.

Based on the above debates in the literature, Barr et al. (2010) summarised that the research on early TV viewing and externalised behaviour is largely incomparable and inconclusive. However, Foster and Watkins' (2010) findings highlight the importance of considering ecological factors before interpreting screen time findings. Further studies have also reported that children's socio-emotional outcomes from media exposure is highly dependent on social factors (e.g., family relations and environment; Valkenburg & Peter, 2013), and the child's individual psychological predisposition (e.g., aggressive children are more susceptible to the effects of video games; Kronenberger et al., 2005). Therefore, it is important to review what research has measured the influence of screen time on externalised behaviour while accounting for important environmental factors.

The role of environmental factors. Following Foster and Watkins' (2010) paper, screen time researchers continued to show that when ecological factors (such as environmental, family, and individual differences) are considered, meaningful relationships between screen time and socio-emotional outcomes are often reduced. Schmiedeler et al. (2014) used the Conners scale of ADHD symptoms with a German sample of 924 kindergarteners to test the influence of factors in the early home learning environment on children's attention difficulties and hyperactivity symptoms. They found a significant cross-sectional correlation between early television viewing and ADHD symptoms, however longitudinally the children's ADHD scores at age 7 years were far more dependent on other early home environment factors and the children's SES, than television watching. Their study highlights the importance of measuring other factors external to screen time when assessing externalised behaviour to provide more robust findings, while also showing the differences in these associations over time. While TV viewing did influence the children's scores cross-sectionally, it had no significant association with ADHD symptoms longitudinally.

These findings were somewhat in line with a study by van Egmond-Fröhlich et al. (2012) who measured ADHD symptoms using the externalised behaviour subscale in the Strengths and Difficulties Questionnaire (SDQ) with a representative German sample of children aged 6 to 17 years. The researchers found while there was a small significant relationship observed between TV viewing and ADHD outcomes, the outcome scores were explained more by the children's SES and maternal factors. This was also observed by Nikkelen et al. (2014) in their meta-analysis of 45 studies exploring the relationship between screen time and externalised behaviour. While a small significant positive correlation was found between these variables in most studies, the interpretation and reporting of the studies were not contextualised, with few of the studies accounting for potential influencing family and environmental factors. In this meta-analysis, it was found that the average correlation for the relationship between media use and ADHD-related behaviours was small. Additionally, of the 45 studies included, only 18 of them explored this relation with children under the age of 7 years. This is similar to the meta-analyses conducted on early screen use and cognitive development outlined in the previous chapter (Li et al., 2020; Madigan et al., 2020) where few studies were noted to explore the role of screen use in children's development under the age of 6 years, and the combined meta-analytic effect sizes were also reported to be small to moderate.

Nikkelen et al.'s (2014) meta-analysis included studies exploring the influence of TV viewing and video games on externalising measures, although only 3 studies with young children in their sample included video games in their analysis. The authors noted that while some of the studies did include covariates in their research, the type and number of covariates included varied substantially across the included studies. Therefore, analyses exploring effect sizes after covariates were controlled for could not be conducted. They did note, however, that there were mixed reports across these studies on whether environmental factors did or did not meditate the influence of screen time on externalised behaviours. The authors therefore noted the importance of considering screen activity along with children's environmental differences and psychological predispositions in future screen use research.

In contrast to the findings from the above studies, a study exploring the influence of early television viewing on socio-emotional outcomes by Mistry et al. (2007) found TV viewing to be an independent predictor of behavioural outcomes after environmental factors were considered. In their study with 3,165 American pre-schoolers, it was found that heavy early and concurrent TV viewing (more than 2 hours daily) at ages 3 and 5 years was associated with higher externalised behaviour, as measured by the Child Behaviour Checklist (CBCL). However, the results showed that only heavy sustained exposure from age 3 years to 5 years predicted socio-emotional difficulties after adjusting for maternal education, income, ethnicity, and involvement.

In a later study, Chonchaiya et al. (2015) explored the associations between TV watching at 6 months of age and externalised behaviour at 18 months, again using the CBCL. After adjusting for family income, parental education, and children's baseline temperament scores, total duration of TV watching at 18 months of age was significantly associated with externalising scores. Although, the authors did state that the variance explained by TV watching in the regression models was relatively low to be considered a predictor of behavioural concerns. Therefore, the authors suggest that their findings, along with others in the screen time literature, be interpretated with caution as significance testing may not provide the best understanding on the role that screen time has in early development, and effect sizes should also be considered. Their final suggestion was that screen time variables in addition to TV watching and time itself should be taken into account as they may shed light on how screen use, not just time, contributes to child behaviours.

Similarly, Cheng et al. (2010) measured 302 18-month-old Japanese infants' TV watching and their later socio-emotional scores at age 30 months. Using the SDQ, the researchers found that amount of early TV watching was positively associated with later hyperactivity levels. TV viewing at 18 months remained significant after adjusting for maternal education and income level, although concurrent TV viewing at 30 months no longer had a significant association with hyperactivity scores. This is in contrast with Mistry et al. (2007), where only concurrent TV viewing remained significant in their sample, although the samples were markedly different in size and age, which may contribute to these differing findings. Cheng et al.'s (2010) findings are also similar to the aforementioned study by van Egmond-Fröhlich et al. (2012) who also used the SDQ and found TV viewing to have a small significant association with hyperactivity in older children, although the variance was explained more by the children's environmental factors. As with all of the above studies, Cheng et al. (2010) noted that the direction of the relation was not explored in their study, and so this was a main limitation to the interpretation of their findings and the findings in the literature before them.

This was also noted by Nikkelen et al. (2014) who stated that only 3 of the 45 studies in their meta-analysis attempted to investigate reverse-causal associations. Although past research would indicate that in some cases early TV viewing might cause attentional problems or hyperactivity, Acevedo-Polakovich (2005) noted that children with baseline risk-factors for ADHD may be more drawn to screen time than typically developing children. Children with high externalised behaviour are also more likely to engage in solitary activities due to related peer difficulties (Hoza, 2007). Additionally, children with externalised behaviour may be given greater access to screen media as a way for parents to try to manage challenging behaviour (Hill et al., 2016). The highlights the need for screen time researchers to also consider causality in their research design.

The importance of testing causality. Ebenegger et al. (2012) highlighted the importance of considering the reverse-causal associations between television viewing in pre-school years and later externalised behaviour. In their analysis with 450 Swiss children, the pre-schoolers in this study who already exhibited ADHD symptoms were shown to favour television viewing more than the children who did not exhibit these symptoms. The researchers suggested that past findings in the field be reconsidered with causality in mind, especially given that TV viewing may also be supported by the parents (Milich et al., 2005). Miller et al. (2007) also highlighted that any inferences from past studies regarding causation, especially those implementing a cross-sectional design, should be made with caution.

Later studies by Thompson et al. (2013) and Radesky et al. (2014) also revealed that children with difficult behaviours were exposed to more television in infancy compared to those who did not exhibit difficult behaviours or temperaments. These studies used prospective cohort studies to assess reverse-causal associations with 7,450 American infants (Radesky et al., 2014), and 217 African American mother-child dyads (Thompson et al., 2013). However, these authors did not measure whether there was an associated negative influence on later behaviour based on this higher level of screen time in infancy.

To fill this gap, Ansari and Crosnoe (2016) conducted a study on the potential effects of ADHD-behaviour on later television viewing. Using the same prospective study data as Radesky et al. (2014) but at a later age, their findings showed that hyperactive behaviour at age 4 years was associated with increased television viewing at age 5 years. Importantly, Ansari and Crosnoe (2016) also included ecological factors in their analyses and found these factors to have a mediating effect on this reverse-causal association, whereby increases in television watching was more strongly predicted for those in lower SES families. The researchers highlighted the value of understanding the influence that early socio-emotional difficulties may have on later home activities, and that more remains to be known on different measures of socio-emotional development outside of externalised behaviour.

The studies discussed above highlight the importance of considering elements of the bioecological model in screen time research, such as the influence of wider ecological factors on both screen time and early development. The importance of controlling for individual baseline developmental scores, and the influence of time on developmental changes, when measuring the role of screen use was also noted. The above studies consider some of the ecological factors that may influence externalised behaviour, in addition to screen time, but as noted by Ansari and Crosnoe (2016) more research is needed on the other measures of socio-emotional development, such as internalised behaviour and prosocial behaviour.

Television viewing and internalised and prosocial behaviours

To date, very little research has examined the role of early television in internalised or prosocial behaviour. Research on older children would suggest that more time spent on screens leads to more internalised behaviour, especially relating to mental health, at a later age (e.g., Twenge & Campbell, 2018). However, other research has found no significant association between adolescents' computer use and socio-emotional well-being (Huang, 2010). In contrast to this again, Przybylski (2014) found screen time to have benefits for internalised and prosocial behaviour in 10- to 14-year-olds.

To further test these findings with a younger cohort, Przybylski and Weinstein (2019) used the National Survey of Children's Health, which includes data on nearly 20,000 American 2- to 5-year-olds, to assess early screen time's influence on socio-emotional scores. Using the Social Competence Scale, they found increased screen time to have no negative influence on the children's socio-emotional scores, cross-sectionally. Higher levels of screen time were modestly positively associated with positive affect, however, in the adjusted models with the children's background factors included, this very small effect was no longer statistically significant. Their findings suggested that there is little or no harmful link between screen use and young children's socio-emotional development, once external factors and effect sizes were considered.

Pagani et al. (2013) assessed the influence of TV viewing at 29 months on kindergarteners internalised and prosocial behaviours. Using the data for 1,997 children from a Canadian prospective study and the Social Behaviour Questionnaire, they found that each one-hour increase in TV watching in infancy was modestly related to an increase in teacher-reported internalised behaviour, but not prosocial behaviour. These findings were independent of key covariates, including maternal education and the child's baseline temperament. Cheng et al. (2010) also investigated the associations between infants' TV watching and later socio-emotional development. As they used the SDQ, internalised and prosocial behaviour could be measured in addition to externalised behaviour. Interestingly, similar to Pagani et al. (2013), positive associations were found for externalising scores, and negative associations were found for prosocial scores, but no significant association was present for internalised scores. These findings remained after the adjustment for maternal education and income levels. However, there were no significant differences in the SDQ subscales scores based on daily hours of TV viewing at age 30 months, and unfortunately reverse-causal associations were not assessed. This study highlights the importance of measuring various aspects of socio-emotional development with prospective cohorts where these domains can be measured within the same large-scale sample.

There has also been past evidence to suggest that viewing violent TV content leads to more aggressive behaviour in young children (e.g., Paik & Comstock, 1994; Bickham & Rich, 2006; Christakis & Zimmerman, 2007). However, this is contested in the screen time literature. In a nationally representative study, Rideout et al. (2003) reported that preschool children are more likely to mimic prosocial behaviours viewed on TV than violent behaviours. In this study, 87% of parents noted that their child had imitated positive behaviours, while only 47% reported that their child mimicked aggressive behaviour. Research by van Evra (2004) also suggests that TV viewing is associated with increased sympathy, nurturing behaviour, tolerance, and can be a positive role model for children. This is largely based on the findings of Friedrich and Stein's (1973) study that followed the prosocial benefits of viewing prosocial television shows in early childhood. Children in this study showed greater cooperative play and verbalisation of emotions. While later studies also showed this to be the case (e.g., De Leeuw et al., 2015; Mares & Woodard, 2012; Coyne et al., 2018), these studies have been mostly conducted on children aged 6 years and above.

In more recent studies, screen time in infancy has been reported to be a risk factor for internalised behaviour at 4 years of age for the 2,492 Chinese children in a birth cohort study (Liu et al., 2021). Cross-sectionally, screen time at age 4 years was also associated with externalised, internalised, and prosocial behaviours. The measure used in this study was the SDQ, and maternal education, income, and the child's birth information was also adjusted for in the analysis. While parents were asked about the amount of time their children spent on various screen activities, these times were totalled and summed up under the one measure of screen time, and so screen differences across screen activities could not be compared. The authors also noted that few longitudinal studies have investigated the association between screen time and socio-emotional problems outside of externalised behaviour. This highlights a further gap in knowledge in the early screen time research.

Additionally, as noted in the introduction of this chapter, play has an important role in the development of socio-emotional skills in early childhood (Vygotsky, 1967; Whitebread et al., 2012). Screen-based games as an example of this have been shown to be associated with positive behaviour towards peers and activity involvement (Durkin & Barber, 2002). Some researchers have also found that such games do not displace activities such as reading or outdoor play for older children (Vandewater, 2006; Hinkley et al., 2018). These studies have shown that children engage in just as much reading, active play, and screen time under the age of 8 years, which therefore puts digital games in a favourable position for the development of social skills through video game play. In relation to younger children, Lieberman et al. (2009) also commented that well-designed games, both educational and entertaining, cannot be compared to other screen types such as TV when assessing developmental impact.

Accounting for some of the more complex measures of screen time, such as the type of activity being engaged in, would make it possible to assess the varying influences different screen activities have on early socio-emotional development. By reviewing the literature that has accounted for this more holistic measure of screen time, it can be discerned whether there is an evidence base showing video games to empirically differ from TV viewing, in addition to theoretically differing. Furthermore, findings on other screen activities and their influence on socio-emotional development can be reviewed to assess whether any clear conclusion can be drawn from this area of the literature.

Research on the influence of other screen activities on socio-emotional development

One of the most researched areas in the literature on screen activities outside of TV viewing is the effect of video games on externalised behaviour. Congruent with the research reviewed in this chapter thus far, meta-analyses on video game use also reveal a lack of consensus on whether video games have any meaningful influence on developmental outcomes. For example, a meta-analysis examining the influence of video games on socio-emotional development in adolescence suggested that teenagers who play video games, in comparison to other past times, had increased levels of aggression and displayed lower prosocial behaviour (Anderson & Bushman, 2001). Yet, another meta-analysis, also examining the effect of video games in adolescence, found that video games contributed to cognitive enhancements in the areas of visual and spatial processing and hand-eye coordination (Powers et al., 2013).

In a meta-analysis of studies including younger children, Ferguson (2015) reviewed 101 studies in this area of the literature and found that while there were reported associations between playing video games and socio-emotional difficulties, the effect sizes were quite weak across the studies, with R^2 values ranging from .00 to .06. Ferguson noted that the studies in which better methodologies were used (i.e., those with the use of standardised outcome measures and control factors), tended to be less likely to produce evidence for negative effect, although the effect sizes seen across all studies were small to begin with. Interestingly, the larger effect sizes were seen for externalised behaviour, which was followed by internalised, and then prosocial, behaviour. It is important to note, however, that the age range of the children in these reviewed studies was from 5.5 years of age to 17 years. While the meta-analysis showed video games to have little meaningful influence on socio-emotional development for the children in these studies, Ferguson (2015) noted there still remains a gap in knowledge on whether this influence is also seen for even younger children. Ferguson suggested the need for research on screen use to be theory-driven to produce more reliable and interpretable results.

Similarly, Kardefelt-Winther (2017) carried out a systematic literature review on time spent on digital technology and its role in children's socio-emotional well-being. Of the 55 papers included in their review, only 4 explored screen use in very young children, which was highlighted as an area that required more attention. The review suggested that moderate screen use, irrespective of activity, tends to be more beneficial than no use or excessive use. Although, as with past research, the negative influences found for the 'no screen use group' had small effect sizes and were shown to be not as relevant in their contributing to children's well-being as other individual and environmental factors. However, this was mainly found in the research with older children, with not enough research available on early screen use to draw a concise conclusion.

The lack of research available on very young children was also evident in a meta-analysis by Coyne et al. (2018) on prosocial media and its influence on prosocial behaviour. Their analysis showed that no studies measuring screen use and prosocial behaviour compared the individual effects of different screen activities. Furthermore, there was little research available on young cohorts. Only 6 of the 72 studies in their analysis were concerned with children and had been published since the turn of the millennium. This was echoed in Saleme et al.'s (2020) systematic review on video games and prosocial behaviour, where the 11 studies that had been published on the topic had all been conducted with children aged 7 years and older. The overarching findings of these studies were somewhat mixed but encouraging towards the use of video games to support prosocial behaviour.

Further studies that have examined the role of various screen activities in young children's socio-emotional development continue to show a discrepancy in their findings. For example, Tamana et al. (2019) found that early engagement with screen activities, including using computers, tablets, mobile phones, and watching TV, was associated with externalising problems. Their cross-sectional study drew on the data from a Canadian cohort study with 2,427 5-year-olds and showed that those engaging in screen activities for over 2 hours a day had a 2.2-point increase in total externalising scores, as measured by the CBCL. In contrast, Levelink et al. (2021) did not find a dose dependant effect of computer use and TV watching on externalised behaviour, specifically ADHD symptoms, in their longitudinal study with 2,768 children from a Dutch prospective study. Using the CBCL as well, the authors found screen use at age 2, 4, and 5 years to only have a significant longitudinal influence on symptoms at age 8 years in the unadjusted regression models. Although, in their cross-sectional analysis there was a significant association in the final regression models between amount of daily screen use and CBCL externalising scores at age 2 years. However, the effect of screen use was noted to be much smaller than that reported by Tamana et al. (2019), with each hour of screen time resulting in only a .03-point increase in the externalising scale.

A limitation within the above two studies is that reverse-causal associations were not explored, with Levelink et al. (2021) stating the necessity for further longitudinal studies in the field. A further limitation is not separating screen activities, which Tamana et al. (2019) noted as necessary for understanding the varying influence different activities may have. Both studies summed the screen activities together to create a screen time measure, despite past research outlining the pedagogical and theoretical differences across the screen activities available to young children in recent times. A study that addressed the latter limitation found TV to be associated with worse socio-emotional outcomes than other interactive digital activities for 4,013 10-year-olds (Sanders et al., 2019). The regressions conducted showed that screen time had a small effect on children's outcomes and was further moderated by the type of screen activity engaged in. Similarly, Swing et al. (2010) found prolonged amounts of TV viewing in middle childhood to be more strongly related to later externalised behaviour than playing video games at this age. This remained the case when baseline externalising scores were controlled for. Lingineni et al. (2012) also found higher TV viewing to be more significantly associated with ADHD diagnoses than computer use for 5–17-year-olds in a large-scale cross-sectional study, after adjusting for control factors. However, as seen in the meta-analysis by Ferguson (2015), whether this effect would be also observed in a younger sample is an area that still needs more contribution in the research.

Hinkley et al. (2018) explored the effect different screen activities had on the social skills of 575 2- to 5-year-olds. Using results from the Adaptive Social Behaviour Inventory, the researchers found that poorer compliance scores were only associated with high levels of TV watching, while digital games had no significant influence on any of the social skills scales. While maternal factors were adjusted for, the cross-sectional design of the study precludes identification of causality. The generalisability of the findings was also low as 75% of the mothers in the sample were highly educated. Therefore, the authors encouraged further longitudinal research with large-scale studies. Similarly, Poulain et al.'s (2018) study with 527 German children from the LIFE Child study explored the relationship between device usage and socio-emotional development as measured by the SDQ. The analysis revealed that computer use predicted later internalising and externalising scores. While the analysis did account for SES and age, no parental factors were controlled for in the regression models. Similarly, the authors noted that their data was not as representative as a large-scale study with most of the families in the study being of a middle or higher socio-economic status.

In a similar sized study, Kostyrka-Allchorne et al. (2020) again examined the causal relationship between 520 young children's screen use and socio-emotional scores on the SDQ. Their analyses also found a positive association between media use and externalised behaviour. In contrast to Poulain et al. (2018), the authors did not compare the individual effects of screen activities but rather compared media use overall to non-digital activities.

They found that children with higher externalised behaviour were less likely to participate in non-digital activities and more likely to use screen media. The limitations to these findings however relate to the cross-sectional design, and the large age range of the children (3 to 11 years), making interpretation of the findings for specific age cohorts difficult. In saying this, the findings add to the debate that pre-existing socio-emotional difficulties may influence children's screen use, rather than screen use being an initial causal factor. Their findings suggested the need for more research to examine the direction of these relationships to further understand what influence, if any, early screen use has on children's socio-emotional development.

Based on the research available, it is not clear whether screen use has a differing influence on early socio-emotional development depending on the screen activity mostly engaged in. While TV viewing has been linked with socio-emotional difficulties in children, findings have not all been consistent. Few studies have examined screen activities separately but those that have showed TV viewing to be more strongly associated with socio-emotional difficulties than digital games. Furthermore, even fewer studies have explored the influence of various early screen activities on internalised and prosocial behaviour.

Some of the foundational research has considered screen-based games as a type of play for young children (e.g., Durkin & Barber, 2002; Vandewater, 2006; Lieberman et al., 2009). As noted previously, play is an important activity in the home that can benefit socio-emotional development (Whitebread et al., 2012). While some of the more contemporary research has also shown the influence of these games to have less of a negative influence on socio-emotional development than TV watching, whether they can be considered an activity or proximal process that supports development in the early home environment has not been thoroughly explored. As cited by Wilkinson et al. (2021), the influence of screen use on behavioural development remains complex and not well understood, but more harmful associations appear strongest for TV viewing, despite these associations being generally mild.

Despite the strengths of prior research, a more comprehensive study is warranted, especially using a large cohort study where data on socio-emotional development and children's screen time has been measured across time points within the same sample of children. With inconclusive findings in the literature, and little research examining causality between socio-emotional measures and screen use, it is also important to consider further explanations for the correlations reported. As mentioned previously, Ferguson (2015) recommended that future screen use research be driven by theory to improve the empirical rigour in the field. As a recommendation for psychological science, Ferguson suggested that screen time research be framed by established theories in psychology to provide more robust and interpretable findings on the influence of screen use on socio-emotional development by moving beyond the concept of screen time itself. To do this, and to better isolate the influence of early screen use on various measures of socio-emotional development, ecological factors should also be controlled for by adopting an ecological perspective.

Using the bioecological model to explore the influence of early screen use on socio-emotional development

Many developmental theorists have explored the associations between children's socio-emotional well-being and home factors, such as SES and parent-child closeness. One of the more prominent of these socio-emotional development theories was introduced by John Bowlby, now known as Bowlby's attachment theory (1958). Bowlby's theory suggests that the establishment of healthy relations between infant and caregiver have lifelong influences on socio-emotional health and psychological well-being. For healthy socio-emotional development to take place, the caregiver should provide a comforting and safe environment where the infant feels safe enough to explore their immediate environment and be soothed if they feel fearful (Bowlby, 1958). Therefore, creating a reassuring and responsive relationship and environment in infancy is critical for forming healthy relationships in later life.

A further theory of interest for assessing children's environmental factors on socio-emotional development is Vygotsky's socio-cultural theory (1978). Aspects of Bowlby's theory can be seen in Vygotsky's work, as the foundations for healthy socio-emotional development proposed by Bowlby were outlined in Vygotsky's socio-cultural theory as critical for healthy cognitive development. Here, the caregiver's interactions and guidance are paramount for the development that takes place in both cognitive and socio-emotional domains. These theories suggest the importance of including parent-child closeness along with environmental factors when measuring the influence of home factors on development. While these theories encourage the measurement of such ecological factors, Bronfenbrenner's bioecological model provides a more structured framework for approaching the current research.

Elements of Bronfenbrenner's (1979) work on the ecological systems in which a child develops, incorporates parent-child relationships and closeness as an important aspect of child development in the microsystem. Parent-child relationships are also considered in the Process-Person-Context-Time (PPCT) research model of the bioecological framework, where Bronfenbrenner and Evans (2000) outlined the importance of considering the child's contextual factors when assessing the impact of a proximal process on development. Similarly, further environmental factors such as SES or parental education can be considered as elements of the macrosystem that are also important to control for. The inclusion of these factors in the bioecological model shows how elements of Bowlby's theory can be seen in Bronfenbrenner's ecological systems where interactions in the micro and macrosystem shape development. While Bowlby did consider the influence of early interactions on socio-emotional development, there was little consideration for individual psychological predisposition and further ecological factors, and how such factors could influence these early interactions. Addressing these limitations, Vygotsky’s and Bronfenbrenner’s developmental theories account for both ecology and meaningful interactions or processes in their theories, which highlights them as appropriate theories for holistically assessing and understanding socio-emotional development.

As also seen in the previous chapter, comparisons between Vygotsky’s and Bronfenbrenner’s work can be easily made, with both theorists showing interest in how development happens from an ecological perspective. However, Bronfenbrenner’s work also provides a useful research design model (the PPCT model) that summarises these important factors, making the bioecological model a strong theoretical framework for understanding and testing the influence of early childhood interactions, including screen use, on socio-emotional development. The use of this model addresses the limitations and gaps in knowledge present in the current screen use and socio-emotional development research.

For example, Foster and Watkins (2010) highlighted the importance of considering the mediating effect of environmental factors when assessing the influence of early television viewing on externalised behaviour. They called for more research to adopt this research approach to challenge the foundational findings in the field that reported the large effect of TV on later behavioural outcomes. This study emphasised the need to move away from measuring screen time solely to better contextualise the results of past studies within children’s ecological systems. Additionally, Parkes et al. (2013) stated the need for more longitudinal research that explores directionality. By accounting for baseline developmental scores, the direction of the association between screen use and socio-emotional development can be more accurately assessed.

The above studies highlight screen use as one of many influences on development in the microsystem, rather than a driving factor of socio-emotional development. However, little research has explored these factors together. Despite research continually suggesting more longitudinal research be conducted on younger children and various screen activities, these are still areas that are under-researched in the literature to date. This highlights the importance of using a developmental and ecological approach to understanding the influence of early screen use, as an activity in the home, on later socio-emotional development.

The literature would therefore suggest that it is important to conduct more theory-driven research in this field, where factors known to influence socio-emotional outcomes, as outlined by developmental theories, are controlled for. Furthermore, longitudinal studies are needed to assess the accuracy of the claims outlined in cross-sectional research, as development is known to not happen instantaneously (Bronfenbrenner, 1989), making the long-lasting effects of early screen use, if any, of particular interest. As noted in the previous chapter, the inclusion of multiple measures of socio-emotional development also needs to be considered. Wilkinson et al. (2021) specifically noted the need for more research on socio-emotional domains outside of externalised behaviour. Investigating the influence that screen use has on early socio-emotional development in a holistic way therefore warrants the use of the bioecological model to support the research approach. This may provide a better understanding on the unique role that early screen use has in socio-emotional development.

The current studies

Similar to the previous chapter, the reviewed literature highlights the criticisms that screen time research has received to date, and also the complexity of interpreting screen time research due to the various influencing factors at play. Again, the research on television watching has suggested it to have a negative association with socio-emotional development, but these findings have not been replicated in all samples (e.g., Obel et al., 2004; Stevens & Mulsow, 2006). Additionally, some of the foundational studies do not account for the environmental factors that have been shown to influence children's socio-emotional development (Foster & Watkins, 2010; Nikkelen et al., 2014), and inconsistent findings and effects sizes are still present in the current literature (e.g., Ferguson, 2015). Due to this, there is debate about what role, if any, screen use alone has in socio-emotional development. Furthermore, there is a significant gap in knowledge on the influence that screen use has on socio-emotional domains outside of externalised behaviour, which has been noted in both systematic reviews and meta-analytic studies (e.g., Saleme et al., 2020; Wilkinson et al., 2021).

More recent research in this area has suggested that instead of just measuring the influence that screen time has on later developmental outcomes, baseline socio-emotional scores should be measured to assess the directionality of these findings (e.g., Poulain et al., 2018; Kostyrka-Allchorne et al., 2020). As highlighted by Ebenegger et al. (2012), determining causality in the early TV watching research can be challenging. Therefore, not only should past studies be interpreted with caution, but further research should be conducted to assess such causal inferences by exploring reverse-causal associations. Although there is a range of longitudinal studies concerned with screen use and socio-emotional development, little research has collectively controlled for the influencing factors on this type of development, such as environmental factors and baseline developmental scores. The use of the PPCT research model, as a framework for exploring the influence of early screen use from an ecological perspective, aims to address this limitation. As in the previous chapter, screen use will be considered a proximal process as a part of this research model to assess whether engaging in screen time and various screen activities at a young age significantly contributes to socio-emotional developmental outcomes.

While the above factors remain important, the gap in the research largely lies in the lack of knowledge on what role early screen use has on internalised or prosocial behaviour. The research that has assessed these measures of socio-emotional development, have not also controlled for screen activity or ecological factors (e.g., Poulain et al., 2018; Kostyrka-Allchorne et al., 2020). Therefore, the current research will include three measures of socio-emotional development, available in the GUI Infant Cohort '08 dataset: externalised, internalised, and prosocial behaviour. While there is more research on early screen use and socio-emotional development, in comparison to that available on cognitive development, there remains insufficient empirical evidence to determine what role early screen use has in various behavioural outcomes in early childhood. Additionally, much of the research that is available has not been conducted through an ecological lens, nor has it separated screen activities when measuring the influence of early screen use. To date, no research has collectively examined the cross-sectional and longitudinal influence of both screen time and screen activity on various socio-emotional domains, while also controlling for individual and ecological differences, in a young representative cohort. For that reason, the two main aims of the current studies are to:

1. Examine the cross-sectional influence of screen use (both time and activity) on 5-year-olds' socio-emotional scores, after controlling for environmental factors.
2. Assess the longitudinal influence of screen time at age 3 years on 5-year-olds' concurrent developmental scores, and observe whether reverse-causal associations are present after controlling for baseline differences.

To address these aims, the current research is broken into two studies. The first study of this chapter (Study 3 of this thesis) utilises a cross-sectional design to examine the associations between 5-year-olds' concurrent screen use and developmental scores, after environmental factors are controlled for. Study 4 then implements a longitudinal design to explore any developmental differences at age 5 years, associated with the amount of screen time engaged in at 3 years of age. Causal and reverse-causal longitudinal associations will be explored, allowing for inferences to be made on whether amount of screen time at age 3 years is a driving factor of socio-emotional developmental at age 5 years (after controlling for baseline factors), or if a reverse-causal association is found. These two studies are similar in design to those reported in the previous chapter, with the exploration of socio-emotional development scores rather than cognitive development scores.

Study 3: Exploring the cross-sectional influence of screen use on socio-emotional development

The data used in the following studies were drawn from the Growing Up in Ireland (GUI) Infant Cohort '08, Anonymised Microdata File, which was obtained from the Irish Social Science Data Archive. The studies in this chapter utilise data from the 'Main questionnaire' provided to primary caregivers at Wave 3 (when the children were 5 years old), which provides data on the child's home environment, parental factors, as well as the activities the child participates in, such as screen time. Primary caregivers were also asked to complete the Strengths and Difficulties Questionnaire (Goodman, 1997), as a measure of the children's socio-emotional development. Full ethical considerations, including child welfare, data protection, and interviewer training are reported by Williams et al. (2019). Using this data, this study aimed to examine the cross-sectional influence that screen use (both time and activity) had on the 5-year-olds' socio-emotional scores, after controlling for environmental factors.

Method

Participants

The 9,001 5-year-olds (50.7% male, 49.3% female) from Wave 3 of the GUI Study were used in this chapter, as in the previous chapter.

Measures

Screen Use Variable. As described in the previous chapter, the primary caregivers were asked: “How many hours does [study child] spend on screen time on an average weekday”, with the response options being: No screen time; Less than 2 hours; 2 to less than 3 hours; and 3 or more hours. For screen activity, the question asked of caregivers was: “What does [study child] mostly engage in during screen time? Is s/he usually engaged in: Educational games; Other games; Watching TV/Videos; or a Mix of all activities?”.

Socio-emotional Development Scale. The socio-emotional development of the children was measured using the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). The SDQ is a 25-item behavioural screening questionnaire designed to assess emotional health and problem behaviours in children. The questionnaire comprises of 5 subscales (‘Emotional Problems’, ‘Conduct Problems’, ‘Hyperactivity’, ‘Peer Problems’, and ‘Prosocial’) each containing 5 items, and each having a minimum score of 0 and a maximum score of 10. Parents answer on a scale of 0-2 for each statement, where 0 = Not true, 1 = Somewhat true, and 2 = Certainly true. Examples of statements in each subscale are: “Nervous or clingy in new situations” (Emotional problems), “Often lies or cheats” (Conduct problems), “Easily distracted, concentration wanders” (Hyperactivity), “Rather solitary, tends to play alone” (Peer problems), and “Considerate of other people’s feelings” (Prosocial Scale).

The SDQ was chosen by the GUI researchers as it is substantially shorter than comparable instruments such as the CBCL and the Rutter Scales, while also correlating highly with these other measures (see Williams et al., 2019). It is a widely used questionnaire in assessing the socio-emotional development of children aged 3-18, and with an overall Cronbach alpha of .77 for the parent-report version of the scale it is considered a valid and reliable instrument to use for this study (Mieloo, et al., 2012). Hawes and Dadds (2004), who examined the stability of SDQ scores over a 12-month period, also found test-retest reliabilities to be strong: hyperactivity, r = 0.77; conduct problems, r = 0.65; emotional symptoms r = 0.71; peer problems, r = 0.61; prosocial, r = 0.64; total difficulties, r = 0.77.

Environmental Factors. The same environmental control variables from the previous chapter were also used in the current study (e.g., education, income, parent-child closeness). The reason for controlling for the primary caregiver's educational attainment relates to the research associating parental education with enriched home learning environment, known to affect socio-emotional development (Christian et al., 1998), and parental expectations of how far the child will go in school, influencing the child's own self-efficacy and self-belief (Williams et al., 2009). Parental income was also controlled for as it has been highlighted as a factor that can influence socio-emotional development, as deprivation has adverse effects on this developmental domain (Watson et al., 2014).

The parent-child relationship has been previously highlighted by developmental theorists such as Bowlby (1980) and Vygotsky (1978) as an important factor to control for when measuring socio-emotional development. Such relationships have continued to be shown as vital for development in contemporary developmental research (e.g., Bornstein et al., 2012; McFadden & Tamis-LeMonda, 2013). Parent-child closeness has also shown to support parental level of engagement in play with the child (Ginsburg, 2007). This provides theoretical and empirical reason for the inclusion of the primary caregiver's closeness with child to also be measured. As in the previous chapter, these variables are also noted as important factors within children's ecological systems as outlined by Bronfenbrenner. Therefore, controlling for these variables also allows for the Context element of the PPCT model to be explored in this study. In addition to this, these factors were the environmental and parental factors most often controlled for in the screen use and socio-emotional development literature reviewed in this chapter.

Data analyses

The relevant variables of interest were extracted from the original datafile, and all data were cleaned, organised, and then weighted using the Weighting Factor variable provided in the original datasets. The five SDQ subscales were collapsed into three subscales: Internalised Behaviour (combining the Emotion and Peer Problems subscales), Externalised Behaviour (combining the Hyperactivity and Conduct Problems subscales), and Prosocial Behaviour (remained the same). The rationale for collapsing the subscales in this way derived from findings by Hawes and Dadds (2004), who found the hyperactivity and conduct subscales to by heavily related, with the prosocial scales showing inverse effects to the other four subscales. Goodman et al. (2010) also stated that when using the SDQ outside of a clinical setting, where populations are deemed low-risk, utilising internalising and externalising subscales may be more appropriate.

Statistical analyses were conducted using IBM Statistical Package for the Social Science (IBM SPSS) version 24.0. The influence of the screen use variables on the socio-emotional scores was tested using one-way Analysis of Variance (ANOVA) tests. As in Study 1, the assumption testing found the variables in the study to not be normally distributed, but the ANOVA tests were still conducted under the recommendations of Cone and Foster (2006), Ghasemi and Zahediasl (2012), Mordkoff (2016), and Kwak and Kim (2017). Hierarchical multiple regressions were conducted to assess whether any significant findings from these tests remained after controlling for the environmental factors. The assumption of collinearity was met (all *VIF* values < 10, and *Tolerance* values > 0.1). Scatterplots indicated the relationship between the independent and dependent variables were linear, and P-P plots suggested the assumption of homoscedasticity and normality were met (Appendix C).

Results

Descriptive findings

Of the 9,001 5-year-olds in the third Wave of the GUI Study, 8,985 had data available for their screen time and activity, and the three SDQ subscales. The children's scores on the internalised (*M* = 2.56, *SD* = 2.47) and externalised (*M* = 4.88, *SD* = 3.42) behaviour scales ranged from 0 to 14, and 0 to 20, respectively. The average score on the prosocial behaviour scale was 8.43 (*SD* = 1.65), with scores ranging from 0 to 10. Looking to the means, the children who had the highest internalised and externalised behaviour scores overall were those who had 3 or more hours of daily screen time, followed by those who mostly played video games (see Table 14). Those who had the highest prosocial scores were those who had less than 2 hours of daily screen time, followed by those who mostly engaged in educational games. These descriptive findings suggest that screen use may create variance in the socio-emotional scores. To assess whether this variance between the levels of the variables was statistically significant, ANOVA tests were conducted.

Table 14. Mean SDQ subscale scores based on the 5-year-olds' screen use categories.

Screen Use Categories	Internalised Behaviour		Externalised Behaviour		Prosocial Behaviour			
	M	SD	M	SD	M	SD	N	%
Screen Time								
No screen time	2.27	1.88	4.50	3.74	8.52	1.67	241	2.68
Less than 2 hours	2.35	2.34	4.58	3.27	8.52	1.55	5074	56.47
2 to less than 3 hours	2.71	2.54	5.04	3.46	8.36	1.71	2499	27.81
3 or more hours	3.15	2.82	5.79	3.70	8.19	1.89	1171	13.03
Main Screen Activity								
Educational games	2.94	2.75	4.80	3.26	8.49	1.54	147	1.64
Video games	3.06	2.90	5.70	4.12	8.26	1.93	248	2.76
TV/Video watching	2.59	2.49	4.85	3.35	8.44	1.61	3268	36.37
Mix of All	2.52	2.45	4.87	3.41	8.42	1.67	5081	56.55

The cross-sectional influence of screen time and activity on socio-emotional scores

Analysis of Variance Tests. The first set of ANOVA tests showed that the 5-year-olds' screen time did have an influence on their internalising scores, $F(3,8981) = 39.884$, $p < .001$, $\eta p2 = .013$; externalising scores, $F(3,8981) = 45.251$, $p < .001$, $\eta p2 = .015$; and prosocial scores, $F(3,8981) = 15.735$, $p < .001$, $\eta p2 = .005$. Looking to the post hoc analyses, those with 3 or more hours of screen use per day, had significantly higher mean internalising and externalising scores than those in any other time bracket (all *p*'s < .05; see Figure 5 and 6). The pattern was similar for those with 2 to less than 3 hours screen use per day for internalising scores. These findings also held in relation to prosocial scores, with those with higher daily screen time having significantly lower mean scores than those with lower screen time (all *p*'s < .029; see Figure 7).

Of note, there was no significant difference in the scores between those who did not use screens at all (no screen time) and those who engaged in less than 2 hours per day for internalised ($p = .952$) and externalised ($p = .984$) behaviour. This was also the case for the 2 to less than 3 hours bracket for externalised scores (p = .088). Similarly, there was no significant difference in prosocial scores for those who engaged in no screen time and those who engaged in less than 2 hours (p = 1.00), or 2 to less than 3 hours a day (p = .483). Figures 5-7 shows the means plot for the children's scores on each subscale, along with the error bars (95% CI) for each time bracket.

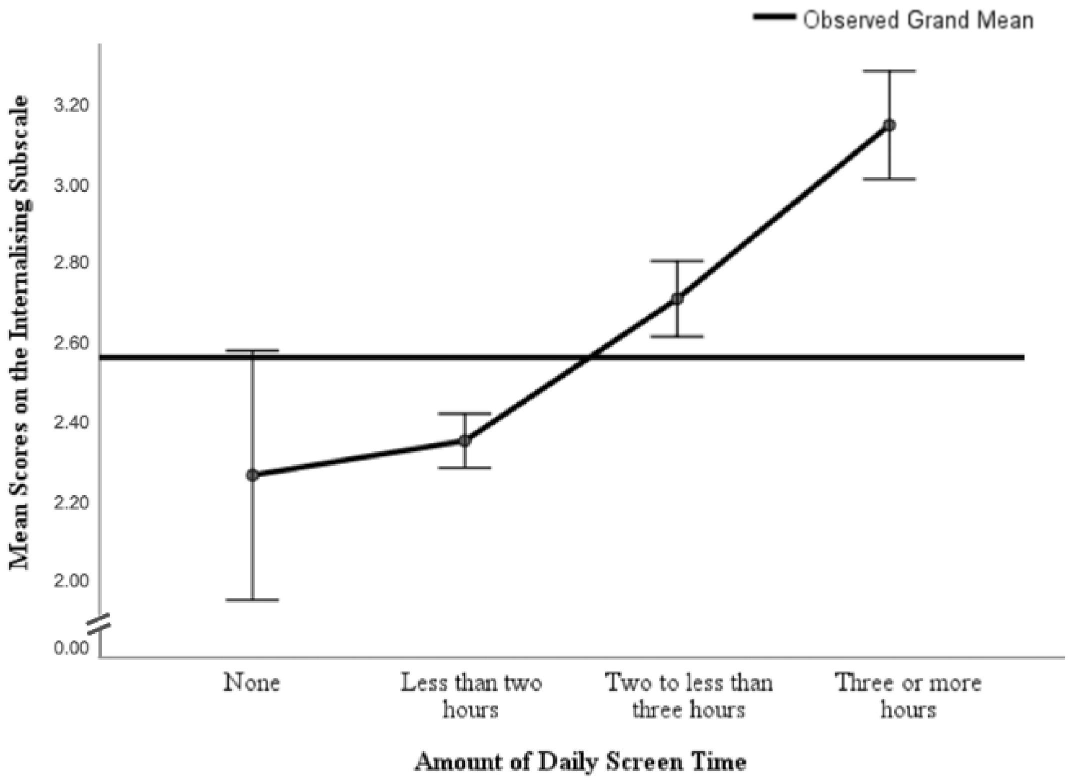


Figure 5. Mean internalising scores based on screen time brackets.

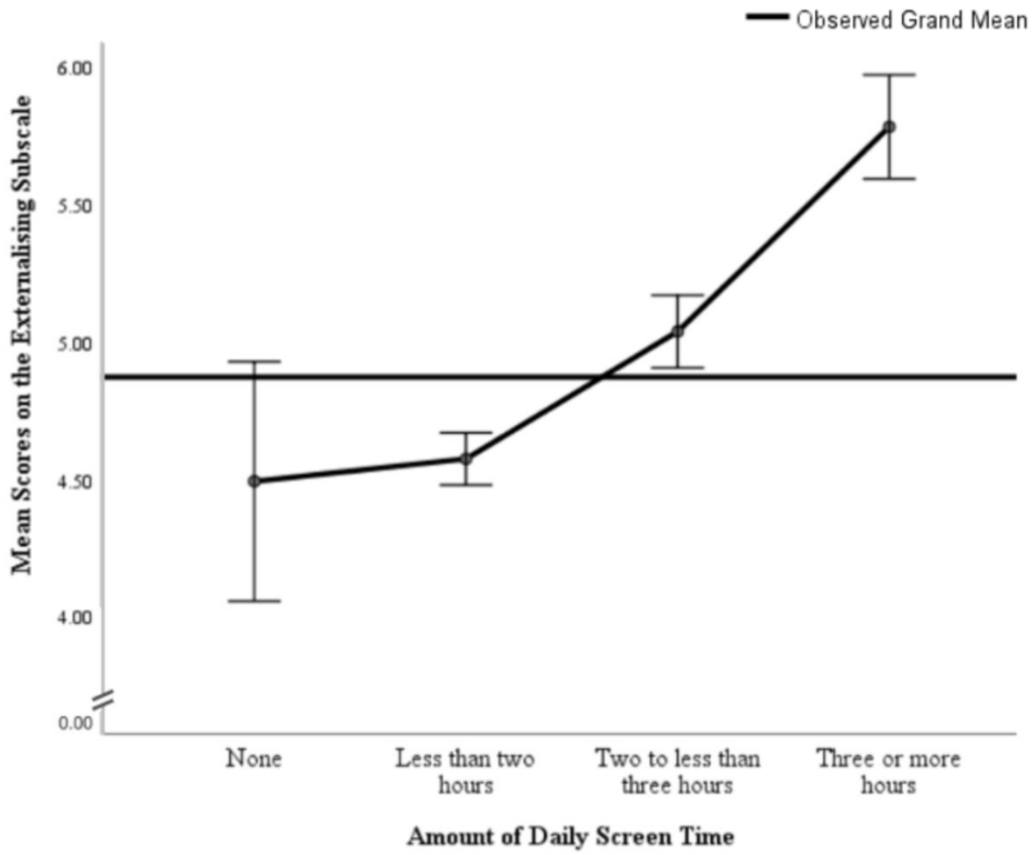


Figure 6. Mean externalising scores based on screen time brackets.

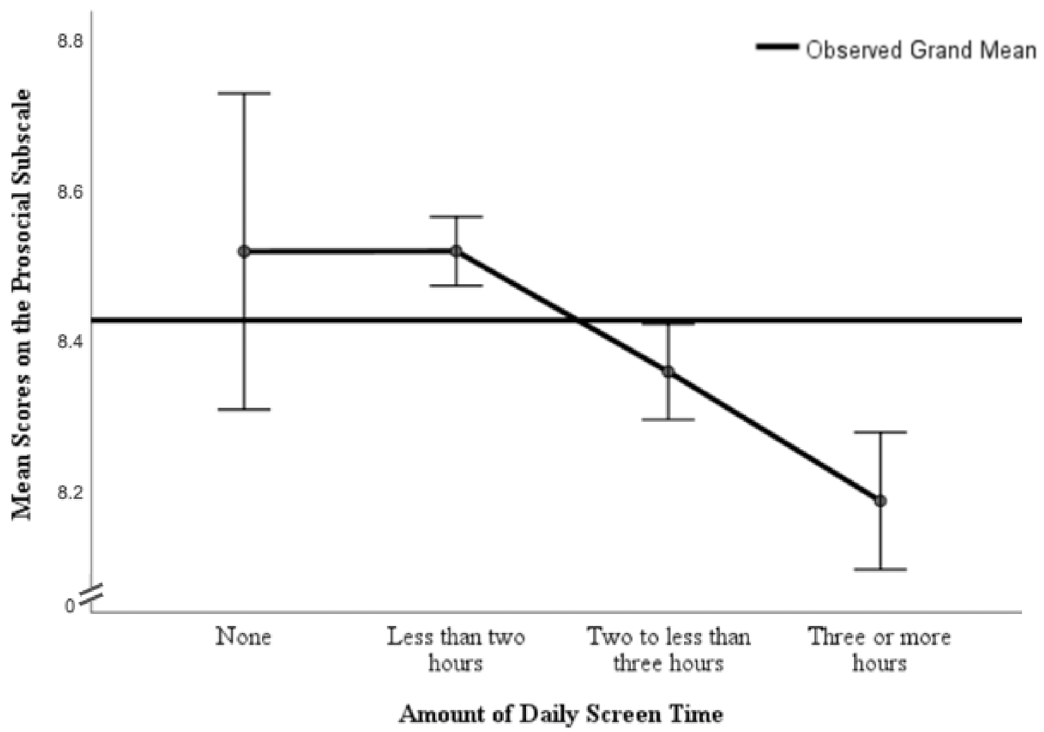


Figure 7. Mean prosocial scores based on screen time brackets.

The second set of ANOVA tests showed that the screen activities mostly engaged in by the 5-year-olds also had an statistically significant influence on their internalised behaviour (F(3,8740) = 5.286, p = .001, η_p^2 = .002) and externalised behaviour (F(3,8740) = 5.280, p = .001, η_p^2 = .002). Post hoc analyses showed those who mostly engaged in video games scored significantly higher on both scales than those who mostly watched TV/videos or engaged in a mix of screen activities (all p's < .017). Scores for those who mainly engaged in educational games did not significantly differ to any other screen activity (all p's > .05; see Figures 8 and 9). There were no statistically significant differences in scores based on screen activity for prosocial scores, F(3,8740) = 1.086, p = .354, η_p^2 = .000.

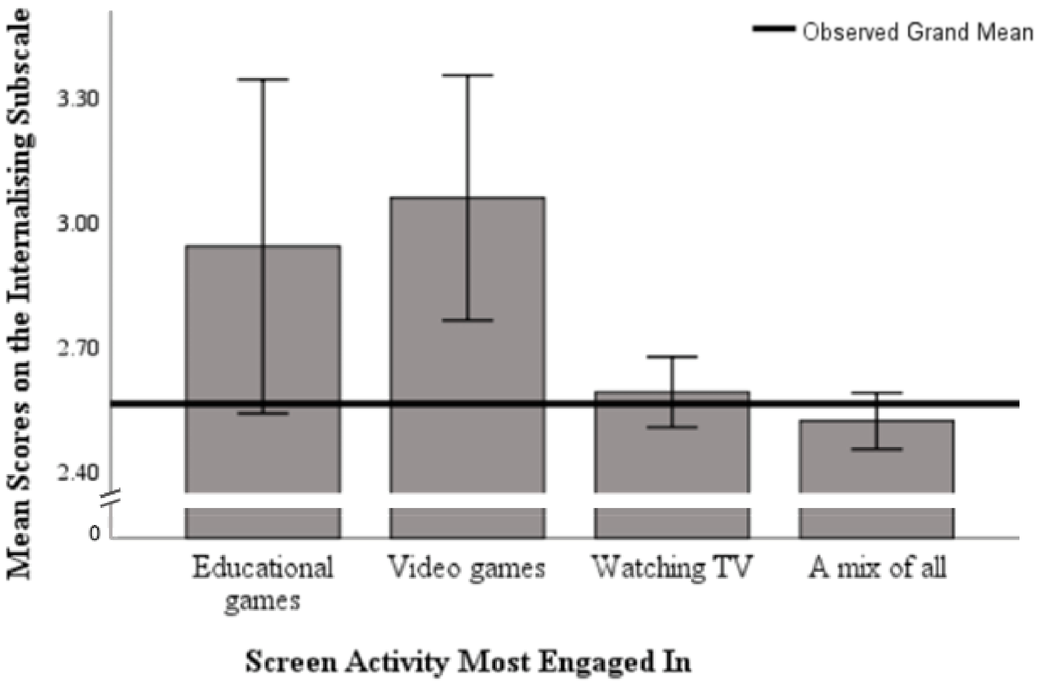


Figure 8. Mean internalising scores based on screen activity.

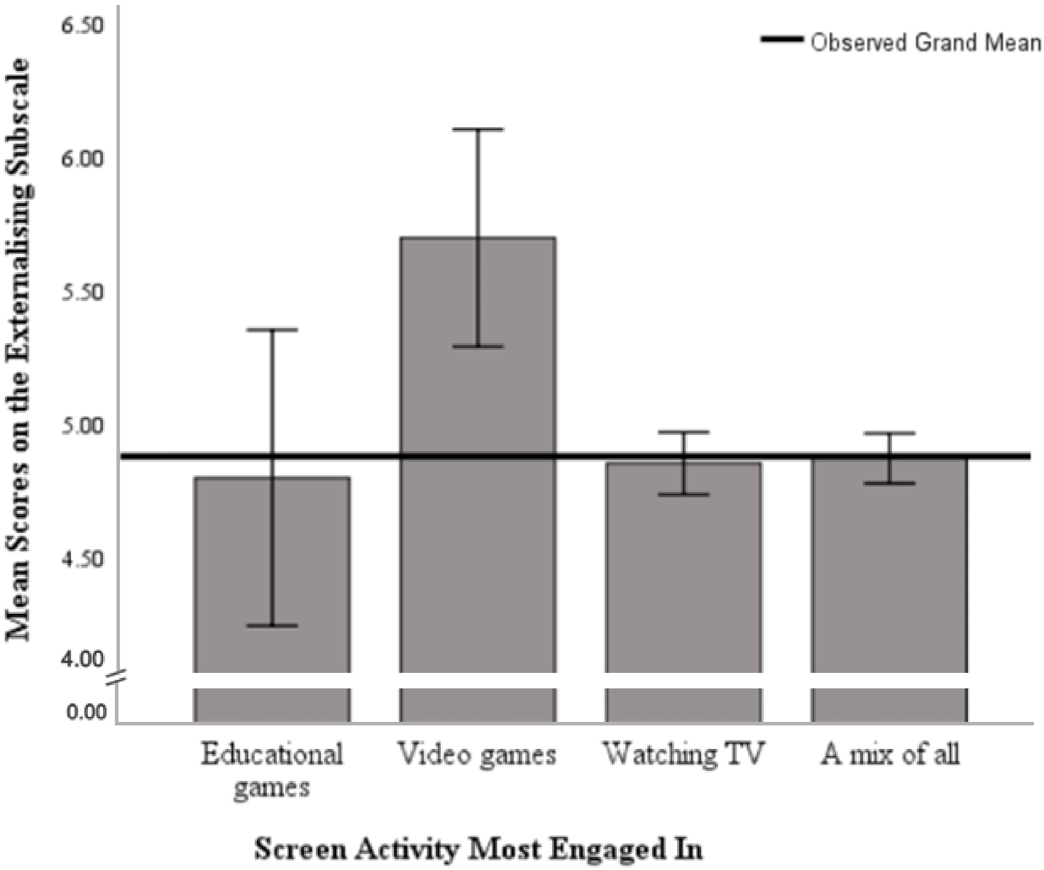


Figure 9. Mean externalising scores based on screen activity.

The ANOVA test results suggest that both screen time and screen activity have an influence on the 5-year-old's socio-emotional development, at least cross-sectionally. To further assess whether these findings remained significant after controlling for factors known to influence on socio-emotional development, such as the parent-child relationship, hierarchical multiple regressions were also conducted. The screen use variables were dummy coded in the same way as the previous chapter (screen activities: Educational games, Video games, Mix of all activities, and Watching TV/Videos; and screen time: No screen time, Less than 2 hours, 2 to less than 3 hours, and 3 or more hours). The reference categories used were 'mix of all activities' and 'less than 2 hours', and the order that the variables were entered (screen activity, then screen time, then environmental factors) were also the same as the previous chapter.

Hierarchical Multiple Regression models. At Step 1 in the internalised behaviour regression model, screen activity accounted for 0.1% of the variation in the children's scores, $R^2 = .001$, $F(3,8547) = 5.249$, $p = .001$. Only video games significantly differed from the reference category, as also seen in the ANOVA tests. Screen time explained an additional 1.4% of variation in Step 2, $R^2 = .014$, $F(6,8544) = 23.495$, $p < .001$. Interestingly, all screen activities became significant in the second step, indicating a possible interaction effect between screen time and activity. However, the standardised beta (β) coefficients indicated screen time to have more of an influence on internalised behaviours than screen activities (Table 15, Step 2). The final step including the environmental factors explained an additional 7.7% of the variation, $R^2 = .077$, $F(9,8541) = 97.032$, $p < .001$. The final model with all variables entered accounted for 9.2% of the variance in internalising scores. With the additional factors included, screen activity and time remained statistically significant, although parent-child closeness scores had the largest influence on internalised behaviour, as seen by the β coefficients (Table 15, Model 3).

Table 15. Regression model of screen use variables and internalising scores.

	Models								
	Model 1			Model 2			Model 3		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1: Screen Activity ('Mix of all activities' as reference category)									
Educational games	.417	.021	n.s	.508	.026	.017	.335	.017	n.s
Video games	.535	.037	.001	.584	.040	<.001	.487	.034	.001
Watching TV	.088	.017	n.s	.162	.032	.004	.109	.021	n.s
Step 2: Screen Time ('Less than 2 hours' as reference category)									
No screen time				.052	.003	n.s	.055	.003	n.s
2 to less than 3 hours				.386	.070	<.001	.284	.052	<.001
3 or more hours				.848	.118	<.001	.578	.080	<.001
Step 3: Environmental Factors									
Education level							-.067	-.063	<.001
Household income							-.051	-.059	<.001
Closeness with child							-.318	-.257	<.001
R²	.001, *p* = .001			.014, *p* <.001			.077, *p* <.001		
Total Δ*R²*							.092		

Note. n.s = non-significant.

The second regression explored the influence of screen use on externalised behaviour. The model indicated that at Step 1, screen activity accounted for 0.2% of the variation in the children's externalised behaviour, $R^2 = .002$, $F(3,8546) = 5.639$, $p = .001$. Only video games significantly differed from the reference category, as also seen in the ANOVA tests. Screen time explained an additional 1.5% of variation in Step 2, $R^2 = .015$, $F(6,8543) = 26.078$, $p < .001$. Again, children who engaged in 3 or more hours of screen time per day had the highest β coefficient values (Table 16, Model 2). The final step explained an additional 8.3% of the variation, $R^2 = .083$, $F(9,8540) = 106.375$, $p < .001$. The final model with all variables entered accounted for 10% of the variance in externalising scores, and all of the environmental factors significantly predicted externalised behaviour. In the final model, video games and screen time of over 2 hours per day were all significant unique contributors to externalising scores in the 5-year-olds (Table 16, Model 3).

Table 16. Regression model of screen use variables and externalising scores.

	Models								
	Model 1			Model 2			Model 3		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1: Screen Activity ('Mix of all activities' as reference category)									
Educational games	-.011	<.001	n.s	.116	.004	n.s	-.119	-.004	n.s
Video games	.876	.044	<.001	.951	.048	<.001	.786	.039	<.001
Watching TV	-.020	-.003	n.s	.086	.012	n.s	.006	.001	n.s
Step 2: Screen Time ('Less than 2 hours' as reference category)									
No screen time				.044	.002	n.s	.059	.003	n.s
2 to less than 3 hours				.461	.061	<.001	.284	.038	.001
3 or more hours				1.28	.129	<.001	.835	.084	<.001
Step 3: Environmental Factors									
Education level							-.153	-.104	<.001
Household income							-.079	-.066	<.001
Closeness with child							-.425	-.249	<.001
R^2	.002, *p* = .001			.015, *p* <.001			.083, *p* <.001		
Total Δ*R^2*							.100		

Note. n.s = non-significant.

The prosocial behaviour regression model indicated that type of screen activity did not significantly predict prosocial scores in Step 1, as also indicated by the ANOVA tests. In Step 2, screen time accounted for 0.5% of the variation in the children's prosocial scores, $R^2 = .005$, $F(6,8544) = 8.789$, $p < .001$. As per the ANOVA tests, children who engaged in over 2 hours of screen time per day had significantly lower β coefficient values than the other time brackets (Table 17, Step 2). The environmental factors were added to the regression model in Step 3 and explained an additional 10.4% of the variation, $R^2 = .104$, $F(9,8541) = 117.41$, $p < .001$. The final model with all variables entered accounted for 10.9% of the variance in prosocial scores. Screen time of over 2 hours per day remained significant in the final model, however the level of closeness between caregiver and child had the highest influence on prosocial scores, as seen in the β coefficients (Table 17, Model 3).

Table 17. Regression model of screen use variables and prosocial scores.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1: Screen Activity ('Mix of all activities' as reference category)									
Educational games	.103	.008	n.s	.065	.005	n.s	.195	.015	n.s
Video games	-.100	-.010	n.s	-.121	-.013	n.s	-.100	-.100	n.s
Watching TV	.028	.008	n.s	-.003	-.001	n.s	.026	.007	n.s
Step 2: Screen Time ('Less than 2 hours' as reference category)									
No screen time				-.014	-.001	n.s	-.019	-.002	n.s
2 to less than 3 hours				-.167	-.046	<.001	-.147	-.040	<.001
3 or more hours				-.358	-.075	<.001	-.259	-.054	<.001
Step 3: Environmental Factors									
Education level							-.009	-.013	n.s
Household income							-.008	-.014	n.s
Closeness with child							.265	.323	<.001
R^2	<.001, p = .534			.005, p <.001			.104, p <.001		
Total ΔR^2							.109		

Note. n.s = non-significant.

Summary of findings

The current cross-sectional findings suggest that the 5-year-olds' screen use, specifically their amount of daily screen time, is associated with their socio-emotional scores, even when contextual factors are controlled for. For each aspect of socio-emotional development measured, higher screen times were associated with poorer developmental scores, as seen in the ANOVA tests. Children who engaged in no screen time did not differ significantly from those who engaged in less than 2 hours a day. Therefore, the children's socio-emotional scores were only significantly influenced by screen time if they were spending 2 or more hours a day on screens. This was also confirmed in the regression models where over 2 hours of daily screen time uniquely contributed to more negative socio-emotional scores. Additionally, the β coefficients show that those who engaged in 3 or more hours of screen time a day had the highest socio-emotional difficulties scores, and lowest prosocial scores.

The screen activities that the 5-year-olds mostly engaged in was also shown to be associated with socio-emotional scores. Digital games, specifically video games, had the strongest negative influence on the 5-year-olds' internalised and externalised behaviour scores. While not statistically significant, educational games had the next strongest association with socio-emotional difficulties scores. However, screen activity had no influence on prosocial scores, showing digital games to only be associated with socio-emotional difficulties and not positive socio-emotional abilities. Notably, the association between video games and socio-emotional difficulties scores remained significant after adjusting for environmental factors. This suggests that the 5-year-olds' video game play uniquely contributed to their socio-emotional development scores at this age.

While the screen use variables remained significant after controlling for the environmental factors in this study, the model suggests that these factors may have a mediating effect. As shown by the β coefficients, the negative influence of both screen activity and time was reduced in the final models. Parent-child closeness contributed most to all three models, with the largest β coefficient values. This variable was also the only significant environmental predictor for prosocial scores. This finding suggests parent-child relationships to be the strongest predictor of socio-emotional outcomes in the current study.

Screen time and activity also appeared to significantly interact in the internalised behaviour model, where the introduction of screen time in the second step of the model caused all screen activities to have a significant association with internalising scores (see

Table 15, Model 2). This may suggest that educational games and TV watching to have no negative influence on internalised behaviour if they are engaged with for less than 2 hours a day. As in the previous chapter, it is necessary to conduct longitudinal analyses to further assess these findings, as past screen time may be influencing the 5-year-olds' concurrent socio-emotional scores more than their screen time at time of testing (Wang & Cheng, 2020). To do so, data from Wave 2 of the GUI Study were additionally used in Study 4 to explore the influence of the 5-year-olds' screen time at age 3 years on their socio-emotional scores at age 5 years.

Study 4: Exploring the longitudinal influence of screen time on socio-emotional development

This study aimed to examine the longitudinal influence screen time at age 3 years had on the 5-year-olds' socio-emotional development scores, using Wave 2 and 3 of the GUI Study. In line with what past screen time research has suggested, Study 4 aimed to observe and report any causal and reverse-causal longitudinal associations that are present after adjusting for ecological factors such as baseline development scores and environmental variables. A longitudinal design was therefore implemented to assess whether screen time or socio-emotional scores at age 3 years predicts these outcomes at age 5 years.

Method

Participants

As reported in the previous chapter, the GUI Study data collection began with 11,134 primary caregivers in Wave 1, with 9,793 of the families participating in the second Wave of data collection at age 3 years. Of these children, 9,785 had their SDQ scores and corresponding screen time data available. Longitudinal data for screen time and SDQ scores at age 3 and age 5 years were available for 8,697 of the children.

Measures

The screen time and SDQ variables used for analysis in the current study were the same as those reported in Study 3, as both were measured at age 3 and age 5 years in the GUI Study. The corresponding environmental factors at age 3 years were also included. As described in the previous chapter, screen time was only measured as "Time per day watching TV in minutes" at age 3 years. Screen time at this age was coded as None; Less than 2 hours; 2 to 3 hours; 3 or more hours for longitudinal consistency. Descriptive statistics could then be run with the recoded variables to assess the influence of screen time on the 3-year-olds' socio-emotional scores.

Data analyses

The relevant variables of interest were extracted from the original datafiles and input to a merged file that combined the Wave 2 and 3 data based on the Household ID code. This allowed for longitudinal analyses to be conducted after the cross-sectional tests for this study were complete. To ensure consistency of variables across ages, the SDQ scores in Wave 2 were coded into internalised, externalised, and prosocial behaviour subscales. Statistical analyses were conducted using IBM SPSS version 24.0.

For odds ratio tests to be conducted, screen time was collapsed to two levels to assess whether children with Low or High levels of screen time (Under 2 hours, or 2 or more hours) were more likely to attain Low or High scores on the socio-emotional subscales (coded in correspondence with the SDQ cut-off scores; Goodman, 1997). The odds ratio tests could then provide an exploratory analysis of the causal associations. Further longitudinal analyses exploring these association were conducted through the use of hierarchical multiple regression models, which also controlled for baseline differences. The regression models included the predictor variables of screen time and SDQ scores, and the control variables of parental education, income, and closeness to child, all at age 3 years. The dependent variables of screen time and socio-emotional development at age 5 years were used in the regressions models to explore the causal and reverse-causal longitudinal associations between screen time and socio-emotional development. All assumptions were met (Appendix D).

Results

Descriptive findings

The children's scores on the internalised (*M* = 2.57, *SD* = 2.22) and externalised (*M* = 5.41, *SD* = 3.38) behaviour scales at age 3 years ranged from 0 to 14, and 0 to 20, respectively. The average score on the prosocial behaviour score was 7.94 (*SD* = 1.77), with scores ranging from 0 to 10. Similar to the findings reported in Study 2 in the previous chapter, children's SDQ mean scores were most positive if they engaged in at least some screen time daily, rather than no screen time, at 3 years of age. Those who had up to 2 hours of daily screen time performed best on the SDQ subscales. Children in this time bracket accounted for nearly half of the sample (48.94%, see Table 18). Those who had the highest socio-emotional difficulty scores were in the '3 or more hours' time bracket, which accounted for a fifth of the sample (19.98%).

Table 18. Mean SDQ subscale scores based on screen time at age 3 years.

Screen time at age 3 years	Internalised Behaviour		Externalised Behaviour		Prosocial Behaviour			
	M	SD	M	SD	M	SD	N	%
No screen time	3.00	2.54	5.52	3.43	8.01	1.92	233	2.39
Less than 2 hours	2.36	2.09	5.13	3.31	8.01	1.69	4788	48.94
2 to less than 3 hours	2.52	2.15	5.34	3.26	7.93	1.71	2806	28.69
3 or more hours	3.05	2.49	6.10	3.65	7.77	1.98	1958	19.98

The longitudinal influence of screen time on internalised behaviour scores at age 5 years

Screen time and SDQ scores for the 3- and 5-year-olds were coded for the purpose of running odds ratio tests, as described in the method section of this chapter. The first chi-square test showed screen time at age 3 years to have a significant association with internalising scores at age 5 years, $\chi 2$ (1, *N* = 8697) = 51.27, *p* < .001, *Cramer's V* = .077, with the children who had 2 or more hours of screen time being 1.37 times more likely to score high on the internalised behaviour scale at age 5 years (*OR* = .730, *RR* = .826), thus suggesting a significant causal longitudinal association.

As confirmed in Study 3, the cross-sectional odds ratio for the 5-year-olds showed that those who had 2 or more hours of screen time were 1.41 times more likely to score high on the internalised behaviour scale (*OR* = .710, *RR* = .815, *p* < .001). The odds ratio tests also showed a significant reverse-causal association, $\chi 2$ (1, *N* = 8697) = 37.31, *p* < .001, *Cramer's V* = .066. The children who had high internalising scores at 3 years of age had 1.31 higher odds of having over 2 hours of screen time a day at age 5 years (*OR* = .763, *RR* = .894), compared to those with low internalised behaviour at age 3 years. Taken together, the tests show the cross-sectional association to have the highest relative risk values, followed by the causal longitudinal association, and then the reverse-causal longitudinal association (Table

19). These findings suggest screen time and internalised behaviour to have significant longitudinal bi-directional associations.

Table 19. Odds ratio and significance values for the internalised behaviour odds ratio tests.

	Screen time at age 5 years	Internalising scores at age 5 years
Screen time at age 5 years		*OR* = .710, $p < .001$
Screen time at age 3 years		*OR* = .730, $p < .001$
Internalising scores at age 3 years	*OR* = .763, $p < .001$	

To further explore the longitudinal associations, hierarchical multiple regressions were used. The regression models aimed to confirm that these associations remain significant (as shown by the odds ratio tests), after controlling for internalising scores and environmental factors at age 3 years. For the first model exploring the causal longitudinal association between screen time at age 3 and later internalised behaviour at age 5 years, the scale variable of screen time at age 3 years was entered into the regression in Step 1, and internalised behaviour scores at age 3 in Step 2. The environmental factors were then entered into the regression in the final step.

The regression model confirmed the findings of the odds ratio tests, whereby screen time at age 3 years was a significant predictor of internalising scores at age 5 years, $R^2 = .013$, $F(1,7750) = 106.627$ $p < .001$. Internalising scores at age 3 also predicted internalising scores at age 5 years ($R^2 = .194$, $F(2,7749) = 1036.131$, $p < .001$) and accounted for 19.4% of the variation in the 5-year-olds' internalising scores. Environmental factors at age 3 years also significantly contributed to the model, $R^2 = .004$, $F(5,7946) = 424.147$, $p < .001$. The final model, with all variables entered, accounted for 21% of the variance in internalising scores at age 5 years (see Table 20). Screen time at age 3 years remained a significant predictor of internalising scores at age 5 years, even after other factors were controlled for.

Table 20. Regression model exploring the longitudinal influence of screen time on internalising scores.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Screen time at 3 years	.004	.155	<.001	.002	.068	<.001	.002	.057	<.001
Step 2:									
Internalising scores at 3 years				.497	.442	<.001	.480	.427	<.001
Step 3: Environmental Factors									
Education level							-.022	-.026	.019
Household income							-.036	-.020	n.s
Closeness with child							-.067	-.052	<.001
R^2	.013, *p* <.001			.194, *p* <.001			.004, *p* <.001		
Total ΔR^2							.210		

Note. n.s = non-significant.

The second regression model explored the reverse-causal longitudinal association, investigating if internalising scores at age 3 years predict screen time at age 5 years, even after other factors are controlled for. The model included internalising scores of the 3-year-olds in Step 1, and screen time at 3 years in Step 2. The environmental factors were again entered in the final step. The regression model confirmed the findings of the odds ratio tests, where internalising scores at age 3 years did have a significant association with screen time at 5 years, R^2 = .006, $F(1,7952) = 46.173$, $p < .001$. Screen time at 3 years was the highest predictors in this model (R^2 = .113, $F(2,7951) = 537.678$, $p < .001$), accounting for 11.3% of the variance. Environmental factors contributed 0.4% of the variance to the model in the final step, R^2 = .004, $F(5,7948) = 223.212$, $p < .001$, although only parental education level significantly contributed to the model. The final model with all variables entered accounted for 12.3% of the variance in screen time at age 5 years (see Table 21).

Table 21. Regression model exploring the longitudinal influence of internalising scores on screen time.

	Models								
	Model 1			Model 2			Model 3		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Internalising at 3 years	.026	.076	<.001	.014	.040	<.001	.011	.031	.005
Step 2:									
Screen time at 3 years				.004	.339	<.001	.004	.324	<.001
Step 3: Environmental Factors									
Education level							-.015	-.056	<.001
Household income							-.007	-.014	n.s
Closeness with child							-.007	-.017	n.s
R^2	.006, p <.001			.113, p <.001			.004, p <.001		
Total ΔR^2							.123		

Note. n.s = non-significant.

The longitudinal influence of screen time on externalised behaviour scores at age 5 years

As in the analyses above, the associations between screen time and externalised behaviour were first explored using odds ratio tests. The chi-square tests for externalising scores found that screen time at age 3 years had a significant causal longitudinal association with externalising scores at age 5 years, $\chi 2$ (1, N = 8697) = 46.62, p < .001, *Cramer's V* = .070, with high screen time at age 3 years associated with 1.32 higher odds of having high externalising scores at age 5 years (*OR* = .755, *RR* = .859), in comparison to low screen time. However, the cross-sectional values showed children with high screen time at age 5 years had 1.50 higher odds of attaining high scores on the externalised behaviour scale at age 5 (*OR* = .667, *RR* = .807, p < .001).

The longitudinal odds were higher in the reverse-causational findings, *χ2* (1, *N* = 8697) = 83.99, $p < .001$, *Cramer's V* = .098, which showed 3-year-olds with high externalising scores to have 1.50 higher odds of engaging in high screen time at 5 years of age (*OR* = .668, *RR* = .846) than those with low screen time. These findings again suggest screen time at age 3 years has longitudinal bi-directional associations (see Table 22).

Table 22. Odds ratio and significance values for the externalised behaviour odds ratio tests.

	Screen time at age 5 years	Externalising scores at age 5 years
Screen time at age 5 years		*OR* = .667, $p < .001$
Externalising scores at age 3 years	*OR* = .668, $p < .001$	
Screen time at age 3 years		*OR* = .755, $p < .001$

To assess if the longitudinal associations remained after controlling for baseline development scores and environmental variables, regression models were conducted. The first regression exploring the longitudinal association between screen time at age 3 years and externalising scores at age 5 years had the variables entered in the same manner as reported above for the internalised behaviour models. The model indicated that screen time at age 3 years did significantly contribute to later externalised behaviour, $R^2 = .008$, $F(1,7949) = 61.825$, $p < .001$. Externalising scores at 3 years was again the highest predictor in the model ($R^2 = .299$, $F(2,7948) = 1761.248$, $p < .001$), accounting for nearly 30% of the variation in later externalising scores. Environmental factors contributed 0.6% of the variance to the model, $R^2 = .006$, $F(5,7945) = 723.370$, $p < .001$. Interestingly, the significant longitudinal association reported in the odds ratio test became non-significant in the final model with both baseline developmental scores and environmental factors considered. The final model with all variables entered accounted for 31.3% of the variance in externalising scores at age 5 years (see Table 23).

Table 23. Regression model exploring the longitudinal influence of screen time on externalising scores.

	Models								
	Model 1			Model 2			Model 3		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Screen time at 3 years	.004	.088	<.001	.001	.028	.003	.001	.015	n.s
Step 2:									
Externalising scores at 3 years				.551	.550	<.001	.530	.529	<.001
Step 3: Environmental Factors									
Education level							-.054	-.046	<.001
Household income							-.024	-.010	n.s
Closeness with child							-.108	-.061	<.001
R^2	.008, p <.001			.299, p <.001			.006, p <.001		
Total ΔR^2							.313		

Note. n.s = non-significant.

The final regression model explored the reverse-causal longitudinal association with the variables entered into the model in the same manner as that reported for the internalised behaviour regression model. The results confirmed the significant association observed in the odd ratio tests, where externalising scores at age 3 years did have a significant association with screen time at 5 years, $R^2 = .009$, $F(1,7952) = 72.501$, $p < .001$. Externalising scores and screen time at 3 years both had a significant contribution on later externalised behaviour at age 5 years, $R^2 = .112$, $F(2,7951) = 546.912$, $p < .001$. Environmental factors contributed 0.3% of the variance to the model in the final step, $R^2 = .003$, $F(5,7948) = 225.575$, $p < .001$, and again only parental education level significantly contributed to the model. The final model with all variables entered accounted for 12.4% of the variance in screen time at age 5 years (see Table 24).

Table 24. Regression model exploring the longitudinal influence of externalising scores on screen time.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Externalising at 3 years	.021	.095	<.001	.013	.059	<.001	.011	.047	<.001
Step 2:									
Screen time at 3 years				.004	.336	<.001	.004	.323	<.001
Step 3: Environmental Factors									
Education level							-.014	-.053	<.001
Household income							-.007	-.012	n.s
Closeness with child							-.005	-.013	n.s
R^2	.009, p <.001			.112, p <.001			.003, p <.001		
Total ΔR^2							.124		

Note. n.s = non-significant.

The longitudinal influence of screen time on prosocial behaviour scores at age 5 years

The final chi-square tests showed that screen time at age 3 years did have a significant causal longitudinal association with prosocial scores at age 5 years, $\chi2$ (1, N = 8697) = 7.62, p = .006, *Cramer's V* = .030, with the odds ratio test showing that the children who engaged in 2 or more hours of screen time a day at age 3 years had 1.13 higher odds of scoring low on the prosocial scale at age 5 years (*OR* = .883, *RR* = .958), in comparison to those with lower screen time at 3 years. Cross-sectionally, there was a slightly higher relative risk of attaining a low prosocial score if engaging in high screen time (*OR* = .807, *RR* = 930, p < .001), where the 5-year-olds with high screen time had 1.24 odds of having low prosocial scores at age 5.

The final odds ratio test suggested a significant reverse-causal longitudinal association, $\chi 2$ (1, N = 8697) = 15.45, p < .001, *Cramer's V* = .042, where children who scored low in the prosocial scale at age 3 years had 1.19 higher odds of engaging in 2 or more hours of daily screen time at age 5 years (*OR* = .841, *RR* = .932; see Table 25) than those with high prosocial scores at 3 years. These findings suggest screen time at age 3 years to have a longitudinal bi-directional association with prosocial behaviour, before accounting for control variables (see Table 25).

Table 25. Odds ratio and significance values for the prosocial behaviour odds ratio tests.

	Screen time at age 5 years	Prosocial scores at age 5 years
Screen time at age 5 years		*OR* = .807, *p* < .001
Prosocial scores at age 3 years	*OR* = .841, *p* < .001	
Screen time at age 3 years		*OR* = .883, *p* = .006

As in the previous analyses, hierarchical multiple regressions were conducted to further explore the longitudinal associations between screen time and prosocial scores. The first regression model confirmed the causal longitudinal association found in the odds ratio tests where screen time at age 3 significantly predicted prosocial scores at age 5, although less so than that seen for in the internalised or externalised longitudinal regressions, R^2 = .002, F(1,7950) = 61.825, p < .001. However, as seen for externalised behaviour, the significant association reported in the odds ratio test became non-significant in the final model when both baseline developmental scores and environmental factors were considered. Prosocial scores at 3 years of age accounted for 20.4% of the variation in prosocial scores at 5 years, R^2 = .204, F(2,7949) = 1035.442, p < .001. Environmental factors contributed 1.4% of the variance to the model, R^2 = .014, F(5,7946) = 450.512, p < .001, although only parent-child closeness was a significant predictor of prosocial scores. Still, this is notably higher than the R^2 values for environmental factors reported in the internalised and externalised longitudinal regression models. The final model with all variables entered accounted for 22% of the variance in prosocial scores at age 5 years (see Table 26).

Table 26. Regression model exploring the longitudinal influence of screen time on prosocial scores.

	Models								
	Model 1			Model 2			Model 3		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Screen time at 3 years	-.001	-.043	<.001	-.001	-.024	.018	<.001	-.019	n.s
Step 2:									
Prosocial scores at 3 years				.428	.453	<.001	.393	.416	<.001
Step 3: Environmental Factors									
Education level							.004	.007	n.s
Household income							-.017	-.015	n.s
Closeness with child							.108	.124	<.001
R^2	.002, *p* <.001			.204, *p* <.001			.014, *p* <.001		
Total ΔR^2							.220		

Note. n.s = non-significant.

The final regression model in this study explored the reverse-causal longitudinal association between these variables. This also confirmed the odds ratio test with prosocial scores at age 3 years significantly contributing to screen time at age 5 years, $R^2 = .002$, $F(1,7952) = 14.471$, $p < .001$, although, this contribution was again less than that seen for internalised and externalised behaviour. Prosocial scores and screen time at 3 years accounted for 11.5% of the variation in later prosocial scores at age 5 ($R^2 = .115$, $F(2,7951) = 533.218$, $p < .001$), which was comparable with the other internalised and externalised reverse-causal longitudinal regression models. Environmental factors contributed 0.5% of the variance to the model (R^2 = .005, $F(5,7948)$ = 222.564, p < .001) with only parental education being a significant predictor of prosocial scores in this model. The final model with all variables entered accounted for 12.2% of the variance in screen time at age 5 years (see Table 27).

Table 27. Regression model exploring the longitudinal influence of prosocial scores on screen time.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1:									
Prosocial at 3 years	-.018	-.043	<.001	-.012	-.027	.011	-.011	-.025	.025
Step 2:									
Screen time at 3 years				.004	.342	<.001	.004	.325	<.001
Step 3: Environmental Factors									
Education level							-.015	-.058	<.001
Household income							-.009	-.017	n.s
Closeness with child							-.006	-.016	n.s
R^2	.002, p <.001			.115, p <.001			.005, p <.001		
Total ΔR^2							.122		

Note. n.s = non-significant.

Summary of findings

The initial descriptive findings of the 3-year-olds' socio-emotional scores and screen time showed that only the 3-year-olds who engaged in 3 hours or more, or no screen time, showed poorer performance on the socio-emotional scales. This inverted-U trend was also seen in the previous chapter in Study 2, where the descriptive findings at age 3 years also suggested that engaging in some screen time was related to higher mean cognitive development scores. Interestingly, these inverted-U trends were not found for the 5-year-olds in either Study 1 reported in the previous chapter or Study 3 reported in this chapter.

The inferential findings in this study explored the longitudinal associations between screen time and SDQ scores, with the odds ratio tests comparing the longitudinal relative risk values with those observed for the cross-sectional associations. The tests revealed that the strength of the longitudinal association between screen time at age 3 years and socio-emotional development at age 5 years differed for each measure of socio-emotional development. Importantly however, all associations in the chi-square tests were statistically significant. For internalised behaviour, the highest relative risk values were seen in the cross-sectional association, followed by the causal longitudinal association, then the reverse-causal longitudinal association. For externalised and prosocial behaviour, the risk values for the longitudinal reverse-casual associations were higher than for the causal longitudinal associations. This may suggest that high levels of screen time at age 3 had higher longitudinal risk for internalised behaviour at age 5, compared to the other socio-emotional measures. Conversely, 3-year-olds with high externalising scores and low prosocial scores had higher longitudinal risk for high levels of screen time at age 5, compared to the 3-year-olds with high internalising scores.

However, when baseline development scores and environmental factors were considered in the regression models, some of these associations no longer remained significant. The regression models revealed that when the aforementioned variables were adjusted for, the causal longitudinal associations for both externalised and prosocial behaviour was no longer significant. However, the reverse-causal longitudinal associations all remained significant in the final regression models. This suggests that baseline socio-emotional development at age 3 years may be a stronger predictor of later screen time than screen time being the initial causing factor of socio-emotional development. The findings also suggest early screen time to be more strongly associated with later internalised behaviour than other socio-emotional development measures.

In all causal longitudinal regression models, parent-child closeness was the strongest environmental predictor of later positive socio-emotional development. For the reverse-causal regressions, only the primary caregiver's educational attainment significantly predicted later screen time. Looking to the β coefficients, these factors mediated the influence of the longitudinal associations, although not significantly so in the reverse-causal models. This suggests parental relationships to have a mediating role in the longitudinal association between screen time at age 3 years and socio-emotional development at age 5 years, for externalised and prosocial behaviour. While this was not the case for internalised behaviour, the β coefficient values seen for screen time were smaller in the final model, suggesting environmental factors may mediate this association to some extent, even if not significantly so in the current study. These coefficient values also showed that parental education had a stronger association with later screen time than baseline prosocial scores in the final reverse-causal longitudinal models. As in the previous studies, this provides empirical evidence for the importance of considering screen time from an ecological perspective when measuring its influence on early child development.

Discussion

The aim of this chapter was to explore the cross-sectional and longitudinal influence that screen use in the home had on the 5-year-olds' socio-emotional development, as measured by the SDQ, drawing on data from the national representative sample of children in the Growing Up in Ireland Study. The following section discusses these findings in light of the existing literature and findings in the field, while also assessing what evidence-based claims can be made about early screen use and socio-emotional development through an ecological lens.

The role of screen time

The initial descriptive and cross-sectional findings in the first study of this chapter (Study 3) indicated that the 5-year-olds' concurrent amount of daily screen time did influence their socio-emotional development scores. The ANOVA tests showed that those who had 2 or more hours of screen time scored significantly higher on the internalising and externalising subscales, and significantly lower on the prosocial scale, than those with less than 2 hours of screen time. These findings provide empirical evidence on the influence early screen time has on various measures of socio-emotional development, using a large-scale study. Past researchers have also found this to be the case, such as Zimmerman and Christakis (2007) and Kano et al. (2007) who found higher amounts of screen time at a young age to have significant associations with socio-emotional difficulties. Others however have found no meaningful relationship between this amount of daily screen time and socio-emotional outcomes. For example, Przybylski and Weinstein (2019), and Kardefelt-Winther (2017) found screen time to only have a negative association with socio-emotional development if children engaged in excessive amounts (more than 7 hours daily). However, both of these studies suggested that external factors also be included in future screen time analyses as their findings indicated that there is little or no harmful link after external factors and practical effect sizes were considered.

Interestingly, the regression models in Study 3 showed that screen time continued to be a significant predictor of socio-emotional development even after environmental factors were controlled for. Additionally, the largest R^2 value seen between screen time and socio-emotional scores was for externalised behaviour despite some past research noting screen time to account for little variance in externalising symptoms (e.g., Stevens & Mulsow, 2006; Kostyrka-Allchorne et al., 2020). However, similar to these studies, environmental factors did account for much more of the variance in all measures of socio-emotional development than screen time itself. In Study 3, the environmental factors accounted for 5.5 times more of the variance in internalising and externalising scores than screen time, and for prosocial scores they accounted for 20 times more of the variance. This is also comparable to Chonchaiya et al. (2015) whose study explored the associations between infants' TV watching and socio-emotional difficulties. Similar to the current findings, the explained variance in socio-emotional scores in their final regression models was between 7 and 11%. The researchers noted that the variance explained by screen time within that percentage was relatively low to be considered a predictor of behavioural concerns.

With contemporary research such as Liu et al. (2021) still highlighting that few longitudinal studies have investigated the association between early screen time and emotional and behavioural problems, Study 4 explored the longitudinal associations of screen time and socio-emotional development between the ages of 3 and 5 years. Comparing across the two studies in this chapter, the R^2 values seen in the cross-sectional regression models indicate that these associations are stronger than the longitudinal associations. For externalised behaviour, the cross-sectional R^2 value for screen use in Study 3 is .015, while the causal longitudinal R^2 value for screen use is only .008 in Study 4. Similarly, for prosocial behaviour, the cross-sectional R^2 value for screen use was .005, and only .002 in the causal longitudinal regression model. In both of these longitudinal regressions, screen time was not significant in the final model, while screen time was a significant contributor in the final model of the cross-sectional regressions.

All the while, the reverse-causal longitudinal regression models for both of these subscales were significant in Study 4. These findings suggest that the cross-sectional and reverse-causal longitudinal associations are stronger for both externalised and prosocial behaviour than the causal longitudinal associations, indicating screen time to have no long-lasting influence on these scores between age 3 and 5 years. This would contradict the research that suggests early screen time to have a longitudinal effect on externalised behaviour (e.g., Cheng et al., 2010; Liu et al., 2021). However, it is in line with the findings of Levelink et al. (2021) whose study found a cross-sectional association between screen time television and externalising scores at age 2 years, although no significant longitudinal association was observed.

Interestingly, the largest relative risk value seen in the odds ratio tests was for externalising scores at age 3 years and screen time at 5 years. This, along with the regression models, implies that for the 5-year-olds in the GUI Study, early externalising problems were a bigger indicator for later screen use than early screen use was for later socio-emotional outcomes. This finding is in line with the research of Ebenegger et al. (2012) who found reverse-causal associations between externalised behaviour and later screen time. Similarly, Stevens and Mulsow (2006) found screen time to account for close to zero of the variance in ADHD symptoms despite these variables being significantly associated, indicating that a reverse-causal association may better explain the relationship between screen time and externalising symptoms.

The only significant causal longitudinal association in Study 4 was for internalised behaviour. The regressions using internalising scores showed the R^2 values for screen time in the cross-sectional model (.014) and the casual longitudinal (.013) model to be relatively similar. The reverse-causal R^2 value was much lower, which is in contrast to that observed in the externalised and prosocial behaviour regressions. This finding indicates that after controlling for baseline factors, screen time at age 3 years and screen time at age 5 both significantly contribute to internalised behaviour at age 5, although a significant bi-directional effect was also observed. In contrast to this, after adjusting for baseline ecological factors, both Cheng et al. (2010) and Chonchaiya et al. (2015) found significant associations between screen time in infancy and later externalised and prosocial behaviour, but no significant association was present for internalising scores. However, directionality was not assessed in these studies and so the current findings provide a wider, more contextualised view of the relationship between early screen time and socio-emotional behaviour.

These findings also add to the small amount of literature suggesting that screen time may not have a unidirectional effect on internalised behaviour, such as emotional problems (e.g., Poulain et al., 2018; Kostyrka-Allchorne et al., 2020; McArthur et al., 2022). The results of Study 4 however also controlled for baseline ecological factors and was conducted with a large-scale prospective cohort, both of which are limitations in previous studies such as these. The current findings therefore add to the limited research that has explored the cross-sectional and longitudinal associations between screen time and socio-emotional development in early childhood. Furthermore, few studies have collectively explored these types of associations in a nationally representative prospective cohort, where internalised, externalised and prosocial behaviours could be measured in the same sample. While this addresses the call for more research on the role of screen use as an initial causing factor for later socio-emotional development, studies such as those by Parkes et al. (2013) and Hinkley et al. (2018) have noted that the influence of screen time on SDQ scores may be mediated by the type of screen activities children mostly engage in. This highlights the importance of exploring whether the 5-year-olds' screen activities may have varying influences on socio-emotional developmental scores.

The role of screen activity

In the current research, the screen activity that the 5-year-olds mostly engaged in was also shown to influence their concurrent internalising and externalising scores, although to less of a degree than screen time itself. Screen activity also had no significant influence on prosocial scores. The ANOVA tests showed that those who mostly engaged in video games scored significantly higher on the internalised and externalised behaviour subscales than the children who mostly watched TV or engaged in a mix of all screen activities.

This finding compares to the literature on video games and aggression, inattention, and emotional conduct in older children (e.g., Anderson & Bush, 2001), and on younger children (e.g., Ferguson, 2015). In Ferguson's meta-analytic study, there was a reported association between video games and socio-emotional difficulties, although the R^2 values ranged from .00 to .06 with the largest effect sizes being noted for externalised behaviour, followed by internalised, then prosocial behaviour. While the children in the studies reviewed in the meta-analysis were aged between 5.5 and 17 years, the findings are similar to that of the current study. This highlights that while video games are associated with socio-emotional difficulties in later children, this may also apply to younger children, as seen for the 5-year-olds in Study 3. However, the size of the effect should be considered in the interpretation of these results, as despite the significant p value, the R^2 values only ranged from .00 to .02, suggesting that screen activities accounts for a very small portion of the variance in SDQ scores.

However, these findings are also somewhat surprising given the recent research outlining the benefits of active screen time, particularly game play, for socio-emotional development (e.g., Passmore & Holder, 2014; Sanders et al., 2019; Saleme et al., 2020). The authors collectively noted that play, including screen-based gameplay, has been associated with positive self-concept, friendship networks, and conduct, in older children and adolescents. Based on the current findings, this does not appear to be the case for younger children. Therefore, digital games may not fall under the same category as other types of play activities in the early home environment when considering their role in early socio-emotional development. When comparing screen activities, Przybylski and Weinstein (2017) and Sanders et al. (2019) both found TV watching to be more strongly related with externalised behaviour than computer games for older children (aged 10 years and older), even after controlling for ecological factors, which is again in contrast with the findings of Study 3. This may suggest that video games are perhaps more developmentally beneficial to older children than younger children. Poulain et al. (2018) similarly noted that the benefits of digital activities may only be present at certain developmental stages. The current findings should therefore encourage future researchers to continue replicating large cohort studies examining the influence of screen activities across various age brackets.

Poulain et al. (2018) and Hinkley et al. (2018) did compare the difference in various screen activities on socio-emotional development in children under the age of 5 years. Similar to the studies above, both found TV viewing to be the largest predictor of later socio-emotional difficulties. These findings were thought to be due to the variety of social differences between TV watching and other types of screen use that often prompt children to respond and interact with characters (Hinkley et al., 2018), which has also been highlighted as a key difference between passive and active screen activities in their contribution to development (e.g., Lieberman, 2012; Sweetser et al., 2012). However, both studies noted their sample sizes as a limitation and encouraged more research with large prospective cohorts to be conducted on this topic.

Lastly, as mentioned above, screen activities had no significant cross-sectional influence on prosocial scores, which again contrasts with the findings of various systematic reviews and meta-analytic studies such as those conducted by Coyne et al. (2018) and Saleme et al. (2020). These papers showed content to be an important factor in media's influence on socio-emotional competencies, with educational and prosocial media shown to have a positive influence on prosocial behaviour for children aged 7 and older. Similarly, Rideout et al. (2003) reported that preschool children are more likely to mimic prosocial behaviours viewed on TV than violent behaviours. In this study, 87% of parents noted that their child had imitated positive behaviours while only 47% reported that their child mimicked aggressive behaviour.

The work of Friedrich and Stein (1973) and van Evra (2004) also suggests that educational TV viewing in early childhood has been associated with increased prosocial behaviour. While later studies also showed this to be the case (e.g., De Leeuw et al., 2015; Mares & Woodard, 2012; Coyne et al., 2018), these studies have been mostly conducted on children aged 6 and above. Unfortunately, whether the TV content being viewed by the 5-year-olds was mostly of an educational or entertainment nature was not measured in the GUI study and so that is a limitation to the current study. Future research should therefore also consider the influence of content in addition to activity when assessing the influence of early screen use on socio-emotional development.

The current findings relating to the role of screen activity in children's socio-emotional development show that while screen activity did not contribute to socio-emotional scores as much as screen time itself, it remains an important measure of screen use to be considered in future screen time research. There are various strengths to the research in the current chapter, with Levelink et al. (2021) and Tamana et al. (2019) outlining the necessity for further longitudinal studies in the field, and research that separates screen activities, to improve the understanding of screen time's influence on early development. Additionally, the findings provide empirical evidence on the influence that screen use has in early childhood, an area that has been under-researched to date. This has also been highlighted by some recent reviews on the topic (e.g., Ferguson, 2015; Kardefelt-Winther, 2017; Coyne et al., 2018; Sanders et al., 2019), all of which noted early childhood as an area that required more attention. Therefore, considering the role of ecological factors, and comparing this with the role of screen use variables, is an evident strength of Study 3 and 4, which is also an important point of discussion.

The role of ecological factors

As seen in the previous chapter, the bioecological model was firstly drawn upon by using multiple measures of a development to assess the role of screen use in cognitive development. This is also a strength of the current research as the role that screen time had in socio-emotional development differed significantly based on whether internalised, externalised, or prosocial behaviour was being measured. Given that a large amount of research in the area has been conducted solely on externalised behaviour, the studies provide more knowledge on the influence screen time has on early development by using a more holistic measure of socio-emotional development. The findings also address the gap in the research on screen time's association with internalised and prosocial behaviour at an early age, which have been noted as areas that have not received a lot of attention in the research to date (e.g., Coyne et al., 2018; Saleme et al., 2020).

In line with past research, environmental factors known to influence socio-emotional development were also considered in Study 3 and 4, by being included in the regression models. Although both screen time and screen activity remained significant in the final models in Study 3, the children's environmental factors accounted for far more of the variance than the screen use variables. This was especially true for the primary caregiver's closeness to the study child, which made this biggest contribution to the variance in all socio-emotional development scores. These findings are consistent with those of Kühhirt and Klein (2020), indicating that the effects of screen use at an early age is less pronounced than that of other ecological factors. This is also in line with further screen time research which has demonstrated that the inclusion of such variables reduces the influence that screen use has on socio-emotional development (e.g., Stevens & Mulsow, 2006; Schmiedeler et al., 2014).

The bioecological model also suggests factors in the micro and macrosystem, such as those considered in the regression models, to influence the developing child. Furthermore, as discussed in the introduction of this chapter, developmental theorists such as Bowlby and Vygotsky highlight the importance of positive parent-child relations for healthy socio-emotional development. The current findings also confirm this. Therefore, a further strength of the study is the inclusion of contextual factors that have been shown to have theoretical (e.g., Bowlby, 1980; Vygotsky, 1978) and empirical (e.g., Stevens & Mulsow, 2006; Schmiedeler et al., 2014; Kühhirt and Klein, 2020) influence on early socio-emotional development, such as the parent-child relationship.

Despite the larger effect size that parent-child closeness had in the regression models, a possible limitation of the current research relates to the inability to assess parental engagement during screen time as this was not measured in the GUI Study. This was also a limitation of the previous chapter. Therefore, parental engagement, and wider factors that may be associated with engagement rates such as parental screen beliefs (John et al., 2021) and screen activity (Pempek et al., 2011), are important aspects of early screen use for future research to consider. Parental factors, such as parental screen engagement and beliefs, are also factors of importance that have been outlined in the screen time research and the bioecological model but have not yet been included in the research analyses in the current research.

As noted in the PPCT research model, it is necessary to control for individual factors and time, in addition to contextual factors, when assessing the influence of a process (such as screen time) on developmental outcomes. Using a longitudinal approach, and adjusting for baseline individual factors, Study 4 utilised the PPCT research model to assess the causal and reverse-causal longitudinal associations between screen time and socio-emotional measures. This is a further example of how the influence of screen time was explored from an ecological perspective. The findings also demonstrate the importance of doing so as baseline externalising and prosocial development scores significantly predicted later screen time.

Similarly, baseline contextual factors mediated the influence of screen time longitudinally for these measures. These screen time findings also differed to those reported cross-sectionally.

This is somewhat in line with the recently published findings of McArthur et al. (2022) who stated that existing studies have not examined screen time in conjunction with baseline ecological factors and how these are associated with socio-emotional outcomes. Their study with 1,994 mother-child dyads revealed screen time to not be a cause of developmental changes longitudinally, but rather a mechanism through which ecological risk factors influence development, as indirect effects from these risks were found for internalising symptoms via screen time. Similar to the findings from the reverse-causal longitudinal regressions in Study 4, parental education was found to be a correlate of screen time and mediate its influence on externalised behaviour in a study by Kühhirt and Klein (2020).

Longitudinal analyses have been shown in the screen time research to provide more in-depth, and reliable interpretations (Ferguson, 2015) and allow for necessary bi-directional testing (Levelink et al., 2021), which highlights the strengths of Study 4. As this is an under-utilised research design in developmental studies (Kostyrka-Allchorne et al., 2020), the analyses add novel findings in an already under-explored cohort. The use of a bioecological research model to explore the cross-sectional, longitudinal, and reverse-causal associations between screen time and socio-emotional development, using a nationally representative sample of young children, shows how this study addresses a number of the gaps identified in the screen time literature.

However, there are also certain avenues of interest that could not be explored in this study due to the limitations of the screen use data collected in the GUI Study. While the screen activity that the children mostly engaged in was measured, and a distinction was made between education games and video games, all TV watching was summed as one activity.

The literature has shown that educational content may vary in its influence on development in comparison to entertainment content (e.g., Barr et al, 2010; Duch et al., 2013b). Similarly, the screen device mostly used by the children was not measured. Data was also not available for parental engagement, or the factors that may be associated with this (e.g., screen activity or parental screen beliefs), during screen time in the GUI Study. As these variables are noted to be of great importance in both the screen time research and the bioecological model, further research including these aforementioned variables is warranted. This may produce further fine-grained findings, and a more nuanced understanding, on the role of screen use in early psychological development.

Conclusion

The studies in this chapter provide empirical findings on the cross-sectional, longitudinal, and reverse-causal associations between screen time and socio-emotional development in early childhood from an ecological perspective. The findings suggest that the 5-year-olds' concurrent screen time had a stronger influence on their socio-emotional scores than their screen time at age 3 years, with screen time only having a significant causal longitudinal association with internalised behaviour in the adjusted models. Additionally, the reverse-causal associations for all measures of socio-emotional development remained significant after adjusting for ecological factors, suggesting screen time may not be the driver of the developmental scores but rather the outcome of baseline ecological factors. In relation to the screen activity that the 5-year-olds mostly engaged in, video games were shown to have the most negative influence on the concurrent internalised and externalised behaviour but had no influence on prosocial behaviour.

The use of the bioecological model provided a valuable framework for exploring the influence of screen time in the home on early socio-emotional development as the findings show psychological predisposition, contextual factors, and time to all have a mediating effect on screen time's role in this developmental domain. Controlling for these factors, while measuring the influence of both screen time and activity on three separate measures of socio-emotional development in a representative young prospective cohort, has not been collectively done in the literature to date. However, important factors included in the bioecological model and the screen time literature (i.e., TV content, parental engagement during screen time, and wider factors such as parental screen beliefs that may be related to these) were not included in the current studies. Therefore, the next and final empirical chapter will aim to address some of these limitations to further expand the understanding of the role screen use has in early childhood.

Chapter 5:

Exploring the influence of screen use factors in early development, and their relationship with parental factors

Literature review

The previous chapters of this thesis explored the influence of early screen use, both time and activity, in two aspects of cognitive developmental and three aspects of social-emotional development. The studies in these chapters produced valuable empirical findings in the under-researched area of the influence of naturalistic early screen use on psychological development. Additionally, these studies highlighted the bioecological model as a useful theoretical and research framework for understanding the role of early screen use in development from an ecological perspective. Factors within this framework, such as contextual and individual factors, and time, all provided unique findings related to the associations between screen use and the developmental measures. In some instances, especially for the longitudinal analyses, the former factors even mediated these associations. This would suggest that ecological factors have an influence on understanding and interpreting the role of early screen use in children's psychological development, highlighting the importance of considering the bioecological model and various screen use factors when exploring early screen use in developmental studies.

However, as noted in the previous chapters, certain screen use factors and elements of the bioecological model could not be explored using the Growing Up in Ireland (GUI) data.

While the GUI Study includes an extensive amount of data relating to Irish children's activities and psychological development, the ability to explore certain important ecological factors was restricted by the screen use data that were available. For example, the GUI Study did not collect data on parental engagement during screen time, or the type of screen activities that were mostly engaged in outside of the Wave 3 data with the 5-year-olds. Additionally, while digital games were separated by content into educational games and video games at age 5 years, this was not the case for TV/video watching. As there is an extensive amount of research suggesting the influence of early television viewing differs based on the type of content children are mostly exposed to, it would seem important to separate this screen activity by content also.

Furthermore, since the GUI Infant Cohort 08' data were collected, other screen devices have become prevalent in the home, and so including these as a further measure of screen use would also be warranted to provide a deeper understanding of the differing role various types of screen use have in early psychological development. Exploring these variables with young children, particularly those under 3 years of age, is of particular importance given the limited knowledge base available on the natural incidental screen use habits of this age group in the early home environment. Lastly, given the screen time research noting the importance of measuring parental factors, it would be of interest to further examine the association between early screen use and levels of parental engagement and screen beliefs, and to further explore whether these parental factors are associated with the children's age.

As noted above, the GUI data provided a strong foundation from which the relationship of further ecological and screen use factors can now be explored. To achieve this, primary data were collected which included parental and screen use factors to further build on the findings of the previous studies. The aim of the research reported in this chapter is to add to the discourse on the influence of various screen use factors in the home on early psychological development when a holistic view is taken. It is therefore important to first review the literature that is available on these factors, such as the influences of screen content and devices on development, along with the literature on parental engagement during screen time and parental beliefs on early screen use.

The influence of screen content and devices on psychological development

The research conducted in the previous chapters showed that screen time has varying influences on psychological development depending on whether activity, longitudinal effects, and ecological factors were considered. However, an element that has been outlined in the literature as important to consider is the type of content children are exposed to during this screen time. As with the screen time research discussed thus far, the literature on whether screen content has an influence on early psychological development has shown conflicting results.

As briefly mentioned in Chapter 3 of this thesis, some educational television programmes such as Sesame Street, Dora the Explorer and Blue's Clues have been shown to scaffold the development of language in young children (e.g., Rice et al., 1990; Linebarger & Walker, 2005). Engaging in educational screen content, rather than entertainment content, in the preschool years has also shown to improve academic performance in later school years (Wright et al., 2001). In relation to socio-emotional development, the foundational research suggests screen content to also play a role in this. A meta-analysis by Wood et al. (1991) on media content's influence on children's and adolescents' socio-emotional difficulties found that this was only applicable to entertainment content. A further meta-analysis by Paik and Comstock (1994) suggested similar findings, however they also noted the issues with interpretability given the small effect sizes in many of the studies included in their analysis.

The largest effect sizes seen in Paik and Comstock's analysis were presented in the studies with preschool children, indicating young children may be the most susceptible to learning antisocial behaviour from screen media. This highlighted the importance for later research to continue exploring the role of screen content on developmental factors in early childhood. Despite this, it has been noted that additional research with younger cohorts in this area is still warranted (Cheng et al., 2010).

For example, in their meta-analysis, Madigan et al. (2020) found that the combined effect sizes in the studies in their analysis showed educational content to positively influence language skills. However, the researchers noted that screen content was only measured in a few of the studies in the available research, with no studies including screen activities outside of TV watching with children aged under 3 years of age. For older children, research has found educational screen-based games to benefit cognitive skills (e.g., Fessakis et al., 2013; Fisch et al., 2014). For socio-emotional skills, meta-analytic studies conducted by Coyne et al. (2018) and Saleme et al. (2020) found content to be an important factor, with educational and prosocial media being positively associated with prosocial behaviour for children aged 7 and older. In relation to video games, researchers such as Greitemeyer and Osswald (2010) and Whitaker and Bushman (2012) have also reported that in comparison to action games, educational and prosocial games were found to not just improve socio-emotional skills but also lower aggressive behaviour.

However, the research that is available on younger children has not always been in agreeance with Paik and Comstock (1994), who noted screen content to potentially have the largest effect for preschool children. For example, Tomopoulos et al. (2010) measured the influence of both screen duration and content on the cognitive development of 259 infants from low socio-economic backgrounds. Interestingly, when adjusting for environmental factors, only screen time had a significant effect on later cognitive outcomes. Screen content, educational or not, had no significant relations with developmental scores. This was also shown by Duch et al. (2013b), who found that for 119 toddlers the amount of daily screen time, particularly if it was more than 2 hours, led to the increased odds of lower language scores on the Ages and Stages Questionnaire at a 1-year follow up. Although content was measured in these studies, screen time itself had a larger relationship with later cognitive abilities. Similarly, in an experimental study by DeLoache et al. (2010), 12- to 18-month-olds were broken into two groups with one group being exposed to infant DVDs and the other as a control group. The infants in the DVD group did not perform any better in a word-learning task than those in the control group.

However, Barr et al. (2010) found that screen content did play a role in cognitive development for children in this age bracket. In their study, 60 parents completed television diaries when their children were 1 and 4 years of age, while also completing an assessment of their children's cognitive skills at age 4 years. While viewing age-appropriate content was not found to be associated with cognitive outcomes, viewing adult-directed content was associated with poorer cognitive skills. In their paper, they concluded that "television content is an important factor in understanding the relation between media exposure and developmental outcomes" (Barr et al., 2010, p. 21). This was echoed in the research by Conners-Burrow et al. (2011) who found that lower social skills in pre-schoolers were only reported when the children were viewing non-educational content. Interestingly, amount of screen time was not related to these outcomes, implying that content had a more negative influence on the children's social development than high daily screen time. Tomopoulos et al. (2007) also found that socio-emotional difficulties were only present for the 10% of toddlers in their study who were exposed to teen or adult media.

Looking to the benefits of educational content, when measuring the effects of watching Sesame Street, Mares and Pan (2013) found that watching the show was associated with learning about letters, numbers, shapes, and sizes. It was also associated with more prosocial reasoning about social interactions and more positive attitudes toward various out-groups. The researchers noted, similar to the past studies, that educational content serves a different purpose to purely entertainment content, and so the two should be separated and controlled for when assessing the influence of screen time on young children. Using a representative American sample, Zimmerman and Christakis (2007) additionally found television watching in infancy to not predict hyperactivity by age 3 years if the content was educational. In their review, Wilkinson et al. (2021) suggested that it is feasible to assume that pre-schoolers can learn early cognitive and social skills from educational television programmes, based on the available literature on older children. However, the researchers did note that there remains insufficient empirical evidence on the influence of, and engagement with, various screen activities or devices outside of TV viewing.

With research suggesting educational TV programmes to possibly be more beneficial for developmental outcomes in early childhood, it can be hypothesised that similar findings may be present for the activities carried out on other screen devices. One of the limitations of the GUI data was that TV/video content was not separated into educational or entertainment programmes. A further limitation was that more contemporary screen devices such as tablets or smartphones were not explicitly accounted for. Since the release of the iPad in 2010, tablets and touchscreen devices quickly became commonplace in the average household, with young children soon becoming a target audience for these devices (e.g., Marsh et al., 2015; Lauricella et al., 2015; OECD, 2020).

As these devices became more popular with young children, researchers began to note the different types of engagement these devices could afford, and how they may differ from the more traditional types of screen time. The element of physical interaction has allowed for a more immersive experience of screen time where learning can occur, which has been established in the field of cognitive theory known as embodied cognition (e.g., Barsalou, 1999; Thelen, 2000; Niedenthal, 2007). For example, Smith and Olkun (2005) found that when 9-year-olds were presented with shapes on a computer screen, those who could interact with, and manually rotate, the shapes as opposed to viewing them rotate on the screen were more likely to mentally rotate objects in a later test. In a study with adults, those who could drag objects with a computer mouse, as opposed to simply viewing them, performed better on a later recall and recognition test (Schwartz & Plass, 2014). This begs the question of whether screen activities that involve interaction, such as screen-based games or the use of touchscreen devices, show differing results to the research on passive content consumption for young children.

Some research has explored this with preschool and school-aged children. Neumann's (2018a) study was a pre-post-test design and followed 48 preschool children over a 9-week programme, with 24 of the children in an iPad group where they spent 30 minutes a week using apps ('Endless Alphabet', 'Letter School' and 'Draw Buddy') on the iPad, which were literacy focused. These sessions were supervised by early childhood educators in the children's education and care centres. The educators at the centres that were not in the iPad group used traditional teaching resources and materials when covering literacy focused content. The results showed significantly higher emergent literacy skills for the children in the iPad group, with these children showing higher letter name and sound knowledge, and name writing skills. This was thought to be attributed to the interactive and engaging nature of the digital games provided.

This is similar to the results reported by Cubelic and Larwin (2014) and Russo-Johnson et al. (2017) who also found interactive screen content, in the form of educational apps on a tablet, to be more beneficial to cognitive outcomes in younger children than traditional teaching methods. However, this was not found by Lin (2019) who reported that the children in the non-tablet group in their study yielded significantly higher scores in a variety of cognitive measures. While these recent studies add to the scarce literature on touchscreen device use in early childhood and its influence on development, they all compare tablet use to other teaching methods. As a result, few empirical findings are available on the differences observed across screen devices, such as whether developmental outcomes differ based on whether children mostly use a touchscreen device or watch television at a young age, for example. Additionally, these studies did not explore the prevalence of these activities in a naturalistic setting, and whether young children have access to these devices and educational screen content in the home.

The field of embodied cognition, in addition to the research above, provides theoretical reason for future screen time studies to classify and separate screen time by device as well as by content. Furthermore, contemporary screen devices also allow for more social interaction during screen time. In relation to socio-emotional development, researchers such as Kirkorian and Pempek (2013) and Roseberry et al. (2014) found that pre-schoolers could learn from screen activities such as video calling if their on-screen partner was directly socially interacting with them. This was in line with the researchers' hypothesis that word learning relies on social contingency, and that learning can occur via screen activities if the content is socially and physically contingent.

In a study that compared screen devices and their influence on early socio-emotional development, Hinkley et al. (2018) found that poorer social skills were only associated with high levels of TV watching. The research found video games and hand-held game use to not be associated with any of the social skill outcomes in contrast to watching TV. In their previous research, Hinkley et al. (2014) also investigated screen activity and developmental outcomes across 8 European countries consisting of 3,604 young children, aged 2 to 6 years. Their longitudinal study showed television viewing to be more consistently associated with poorer outcomes than other types of screen use. However, little research since these studies has examined cognitive or socio-emotional development in relation to the screen devices mostly used by young children.

Furthermore, despite there being a sizeable amount of research on computer gaming and touchscreen use in older childhood and adolescence, studies exploring whether these activities are being engaged in at a younger age are scarce. Given the research that shows various screen content, activities, and devices to differ in their role in developmental outcomes, it seems necessary to explore what type of screen use young children, especially those under 3 years of age, are naturally engaging in within the early home environment. Lin (2019) suggested that studies on computer use at a young age have historically not been conducted as the motor skills required to use traditional computers had not been developed by children under 4 years of age. However, children are now using devices, such as tablets and smartphones, within their first year of life (Kabali et al., 2015). This highlights a gap in the literature that is yet to be addressed, as there is little known regarding the frequency of use of these screen devices and activities in the home by infants and toddlers.

Touchscreen devices and digital games now allow very young children to engage in a range of interactive digital experiences such as creating stories, videos, and music (Marsh et al., 2015). While these experiences can take place independently, Cristia and Siedl (2015) found the best developmental benefits may occur when an adult is present during screen use. In their study, touchscreen activities were often accompanied with rich language and social interactions if there was an adult engaged with the child during this screen time. As these socio-cultural interactions are important for scaffolding to take place, it is worth reviewing what is known about parent involvement during screen time, and the role that both parental engagement and screen beliefs play in children's early screen use.

The role of parental engagement and screen use beliefs

The above research suggests screen content and devices may be important factors of screen time to consider when measuring the influence of screens on development. Another element that may also be useful to consider is the level of interaction a child has with an adult during screen time. The researchers who created the 'Content, Context, Connections' screen time classifications outlined the connections aspect, or parental engagement, to be particularly important in promoting positive behaviour and social connectedness (Blum-Ross & Livingstone, 2016). To date, the screen time literature also suggests this factor of screen use to be important to consider.

Some of the earlier research has shown parental engagement during television viewing to be associated with increased examples of social interactions and scaffolding behaviour (Tanimura et al., 2007; Barr et al., 2008). Barr et al. (2008) additionally found children engaged more with television content when a parent was present. Co-viewing child-directed programmes has also been found to promote later parent-child interactions (Pempek et al., 2011). In this study, the researchers observed 152 infant-parent dyads in laboratory sessions. The participants were broken into three groups: a control group, a group that was assigned to watch Baby Einstein, and a group assigned to watch Sesame Beginnings. After watching the programmes in a laboratory session, the parents in the latter groups were found to have greater parent-child interactions than those in the control group in a later laboratory session of free play. The researchers noted these parents to use language and content from the programmes as a way of interacting with their infant. Examples of this were labelling objects, praising, and making music (Pempek et al., 2011).

Similarly, Lavigne et al. (2015) found that parental engagement during television watching resulted in more new words being introduced into the children's vocabulary than during free play. In their study, the quantity of words used during co-viewing sessions was less than parent-child dyads in free play sessions. While the parents in the TV watching condition spoke less, they used richer vocabulary as they labelled objects and actions depicted on screen. This increased vocabulary richness was also seen during the 15-minute post-viewing free play session. This is also congruent with the findings of Mendelsohn et al. (2010), which was one of the first studies to explore the role of parental interactions on language development in a naturalistic setting. Using data from the recall diaries of 253 mother-infant dyads, they found that parental engagement during screen time had beneficial associations with language scores.

A later study by Supanitayanon et al. (2020) followed a similar approach to Mendelsohn et al. (2010) and found that over 90% of the 249 parents engaged with their infants during screen time. This engagement resulted in enhanced language development but had no influence on other measures of cognitive development. Unfortunately, the researchers did not distinguish between screen devices, so it is unknown if this mostly related to TV watching or other screen activities. However, there is evidence to suggest that older children have better cognitive outcomes after engaging in touchscreen games and videos if they are co-viewing this with an adult, or if there is a more knowledgeable other to facilitate live demonstration of challenging activities (Christakis et al., 2019; Strouse et al., 2018). Despite this limitation, Mendelsohn et al. (2010) and Supanitayanon et al. (2020) provided results on the under-reviewed area of naturalistic parent-infant co-viewing that takes place in the early home environment.

The above literature suggests parental engagement to be an important factor in early screen use for enhancing development. However, most of the research has focused on TV viewing with little research exploring if this engagement also takes place with young children during different screen activities. The few studies that have covered this topic have shown similar results to those above, with benefits being evident in children's learning ability and social connectivity. For example, during home-visits Takeuchi and Stevens (2011) observed that co-viewing screen media allowed for opportunities for scenes to be re-enacted and discussed with family members, enhancing experiences of social connectedness.

Plowman and McPake (2013) also noted in their study on 3 and 4-year-olds' interaction with various screen devices, that the children learned social skills during touchscreen use when a sibling or parent was present. The collective findings of their case studies showed that co-viewing screen content allowed for shared experiences and discussions, the stimulation of questions, an increase in role play, and increased social interactions. Additionally, using a prospective cohort of 1,323 older children, Gentile et al. (2014) found that parental monitoring and involvement in children's media preferences between the ages of 9 and 11 years resulted in lower instances of aggressive behaviour, and higher prosocial behaviour and overall school performance based on teachers' reports.

Taken together, the literature discussed so far suggests the presence of an adult to scaffold the child's learning makes parental engagement an important screen use factor to measure when considering the role of screen time in development. It is likely that more contemporary forms of screen use would also allow for such opportunities for engagement to take place. However, little research has explored this area in early childhood despite studies noting it as a future direction for screen use research (e.g., Li et al., 2020). Additionally, while the literature in this area establishes the potential benefit of parental engagement during screen time, few studies have established the frequency in which parents tend to do this in the home, and whether rates of engagement differ based on the screen activity and the children's age. Furthermore, there is research to suggest that parental beliefs on early screen time can influence children's exposure and restrictions to screen media in early childhood, which is a further aspect of parental supervision that recent research (e.g., John et al., 2021) has suggested as important to consider in future research.

In a 2007 study, 30% of parents indicated that learning and brain development were among their primary reasons for providing screen time to their infants (Zimmerman et al., 2007b). Following this, Ruangdaraganon et al. (2009) were the first to explore positive parental perceptions of early television viewing and child development in a Thai population. However, they cautioned that such perceptions could be detrimental to development if the content the children were being exposed to is not educational in nature, although these developmental effects were not measured in this study. Similarly, Vandewater et al. (2005) found that parents who considered educational programmes to be beneficial for early development were twice as likely to permit their children a high amount of screen time in the home. Wartella et al. (2010) also found that nearly 90% of the 76 parents in their study reported infant-directed television to be important for their children's intellectual development. However, whether these beliefs were associated with children's screen use was not explored.

Duch et al. (2013a) again found that the large majority of families in their study (84%) believed television viewing to hold benefits for their children's learning, with their qualitative findings identifying the factors that influence these beliefs but not how these beliefs influence the children's screen use. Cost et al. (2021) also reported parents' screen use to be related to parental screen beliefs but noted that the role of these beliefs on the children's screen use was not explored in their study, despite this not being extensively reported on in the literature. It is therefore important for future research to further explore parents' screen beliefs to assess whether they are associated with children's early screen use and the frequency in which parents engage with their children during screen time. While some exploratory studies have been conducted on these contextual factors of early screen use, few have assessed parental screen beliefs and screen engagement together, along with their relationship with children's screen use, within the same sample. This is especially the case for children younger than 3 years of age. There is therefore a gap in knowledge on the associations between these ecological factors of screen use, and whether age or developmental stage may also be associated with these factors.

Using the bioecological model to explore the influence of screen use factors, and their association with parental factors

The previous chapters outlined the bioecological model as a useful framework for understanding the influence of early screen use on both cognitive and socio-emotional development. The use of PPCT research model in conjunction with the screen use factors encouraged the exploration of various screen activities, contextual factors, and time in the previous chapters. The findings in the previous studies suggested these factors are all important in understanding and interpreting the influence of early screen use in the home on children's psychological development. This research approach therefore had clear strengths in producing findings on screen use from a holistic and ecological perspective. However, it was evident from the results that there were key aspects of screen use and the PPCT model that were not controlled for in the analyses.

The prevalence and engagement with wider screen use factors (e.g., screen content and device) in the home were not extensively explored in the previous studies. These factors have been highlighted above as having potential mediating effects on the influence of early screen time, however, little is known on infants' naturalistic screen use in the early home environment. While various elements of the PPCT model were included in the previous studies, there are further aspects of the bioecological model that still remain to be explored in relation to understanding the influence of early screen use from an ecological perspective. For example, parental screen beliefs and screen time engagement can be seen as contextual factors in the child's microsystem. Assessing these variables will allow for the associations between these factors and early screen use in the home to be explored.

A further area of interest is whether various screen uses available to young children, such as the possibility of engaging in educational games on touchscreen devices, have varying associations with psychological development in comparison to more traditional screen types such as television. The research on digital activities and the opportunities they provide for play would suggest these screen uses to have more theoretical and pedagogical values than noted in the research on early TV watching. This variety of screen activities, devices, and content available to young children is an important change in the early home environment to explore in screen use research. This ties in greatly with the need to consider changes within the chronosystem, as outlined in the bioecological model.

As highlighted throughout the thesis, screen use and screen time habits have changed considerably since the turn of the millennium (see also Beatty & Egan, 2020c). In a study with 2,000 pre-schoolers, Marsh et al. (2015) found that by 3 years of age, nearly two-thirds of children were able to effectively navigate a tablet, including the ability to turn it on and off, drag and swipe, and open and exit apps. This ease of use and access is resulting in TV being rivalled by newer screen devices that allow for more interaction and engagement among their young users. To test this aspect of the chronosystem it would also be important to explore what type of screen use young children (aged under 3 years) are engaging in, and to what extent. Including children from various developmental stages in such an analysis would also provide a deeper understanding of whether, and to what degree, screen use in the home varies across age brackets.

When it comes to young children's screen time, it is advised (e.g., by the Canadian Paediatric Society, and the Royal College of Paediatrics and Child Health) that it should be engaged in by both the parent and the child, to facilitate the best outcomes for social interactions and the learning process. As noted by Ansari and Crosnoe (2016), ecological theory would suggest that children develop through the dynamic and reciprocal transactions between them and those in their environment. It is therefore of interest to explore whether various screens activities encourage or interrupt these interactions by taking an ecological approach and examining the associations between screen use factors and parental factors, such as parental screen beliefs and engagement in the current research.

The current studies

The final two studies of the thesis aim to address some of the gaps and limitations in the previous studies by using primary data that was collected for this purpose. The bioecological model and the screen time research together note parental engagement, beliefs, and the type of screen use (i.e., activity, content, and device) to be important elements of screen time and the child's ecological systems to control for. Studies that have controlled for these factors have produced conflicting findings based on the age of the children in their research. This is in line with Bronfenbrenner's statement on the need to incorporate children's individual differences, and developmental stages and domains, into developmental research (Bronfenbrenner & Morris, 1998). It also emphasises the importance in measuring the influence of screen use across various ages, including infants and toddlers.

The objective of the current studies therefore is to build on the GUI findings by measuring various screen use factors inclusive to screen content, activity, device, and parental engagement and screen beliefs. While digital games were separated by content in the GUI Study, the main single screen activity the children were mostly engaged in was television. Therefore, it seems beneficial to assess whether the influence of screen use differs based on whether the children were mostly exposed to entertainment or educational content. Additionally, it would be worth examining whether the content that the children are exposed to, and the screen devices they use, differs based on their age as this is not an area comprehensively reported on, especially for those aged under 3 years. Whether parental screen beliefs are associated with this screen use and levels of parental engagement will also be explored, along with the associations between levels of parental engagement and the children's type of screen use. A more foundational question that has not been explored in great depth in the existing research to date, however, relates to the frequency in which parental engagement during screen use takes place in the home in the first instance.

To collect this primary data, a set of survey-based screen use questions were designed to build upon and expand on the data available from the screen use questions in the GUI Study. These questions related to children's educational and entertainment screen uses, device ownership, as well as the frequency of parental engagement during, and beliefs on, screen use. The screen use survey questions were included as part of a larger set of survey questions designed to explore the many factors in children's home environments that may influence their play, learning, or developmental outcomes. As in the previous chapters, the children's wider environmental factors such as SES and parental education were also measured. Therefore, the two main aims of the current studies are to:

1. Explore the prevalence and type of early screen use in the home environment, and its influence on psychological development.
2. Explore the associations between parental screen beliefs and engagement and children's early screen use.

To address these aims, the current research comprises of two studies that are drawn from the same dataset. The first study (Study 5 of this thesis) explores screen use factors, such as device ownership and the frequency of various screen activities engaged in by young children from various developmental stages aged 6 years and under. As reported in the previous chapters, the GUI Study only collected data on screen activities for the 5-year-olds. Therefore, this study addresses a current gap in the research by including more extensive screen use measures (i.e., content and devices, as well as time and activities) and including children in various stages of early childhood (e.g., under 3 years of age). Study 5 implements a cross-sectional design to examine the influence of the screen variables on the children's cognitive and socio-emotional development.

Study 6 also utilises a cross-sectional design to explore parents' beliefs on early screen use and whether these beliefs are associated with children's screen use factors and the frequency of parental engagement. The rate and frequency of parental engagement during screen time, and whether it is associated with the type of screen activity being engaged in or the age of the children is also explored. The results of these studies therefore contribute to the current discourse on whether screen use is a contributing factor in young children's psychological development, and whether ecological factors such as age, parental screen beliefs and engagement, are associated with early screen use.

Study 5: Exploring the prevalence and type of early screen use in the home environment, and its influence on psychological development

An important focus of the current study was to build on the screen use findings from the GUI data by collecting primary data on further early screen use factors, across various developmental stages. To achieve this, an online parental-report survey including questions on children's engagement with various screen content, activities, and devices in the home was designed and created. Questions related to the frequency of parental engagement during screen time, and parental screen beliefs, were also included to explore these factors in a naturalistic setting. These questions of interest were included as part of a larger set of data collected on Irish children's (aged 6 years and under) home learning environment, known as the Play and Learning in the Early Years (PLEY) Study.

The PLEY Study gathered demographic information from the parents, including factors that may influence child development (e.g., education levels; adapted from GUI Study), questions regarding the frequency of child activities (e.g., technology use, outdoor play), parental engagement in child activities (adapted from the GUI Study), influences on the child's play and learning activities (based on ecological systems theory; Bronfenbrenner, 1979), parental attitudes to play and learning, and other barriers & supports to engagement in play (adapted from GUI Study). The survey used for the PLEY Study also included parental-report developmental measures of attention, language, and socio-emotional development.

Parents with young children were invited to participate through social media platforms and through Irish primary schools. The PLEY survey link was shared across various social media platforms with parent associations, early years centres, and parents of young children who are active on social media. In an effort to minimise sampling bias and access a more representative sample, including parents who are not active on social media, 3 urban and 4 rural primary schools were also approached. The principals of the seven primary schools were contacted (both face-to-face and by email) and were made aware of the study via an information pack, which included a study letter (Appendix E) and a letter of recruitment for parents (Appendix F), which contained an online link to the PLEY Survey. The principal could then disseminate the survey link, if they wished, via email or text message to the parents of their junior and senior infant pupils.

All participants completed the PLEY Study survey via the online link created on Qualtrics™ software (Qualtrics, Provo, UT, 2019). This link was also included on the online recruitment notice (Appendix G) shared on social media platforms. The information sheet, consent form, PLEY Survey, and debrief sheet were uploaded to Qualtrics and combined in the respective order to create one survey (Appendix H) that participants could complete through the disseminated link. The survey was open for five months from June through October 2019, after which the survey was closed, and the link made invalid. The PLEY Study adhered to the ethical standards of the Psychological Society of Ireland's Code of Professional Ethics, (4.2.7; PSI, 2010), and ethical approval was received from the Mary Immaculate Research Ethics Committee.

Method

Participants

Research participants for the PLEY Study were 313 parents of children aged 6 years and under. However, 37 participants only completed the demographic questions, and were therefore excluded from further analyses. Only parents residing in Ireland were included (n = 262) from the remaining 276 participants to best simulate the GUI data used in the previous studies. The final sample therefore consisted of 262 participants (mean age = 38 years; *SD* = 4.52). Similar to the GUI Study, the survey collected demographic data on both the primary and secondary caregiver, therefore both caregivers (i.e., mothers and fathers, or other relatives) were invited to participate in the study. However, 96% of the respondents were mothers. Further demographic information about the sample is provided in Table 28.

By providing a unique ID number, the participants could also complete the survey for more than one child. Once they completed the survey, they had the opportunity to re-enter their ID number which would re-open the survey allowing them to skip the demographic section of the survey and begin at the play and learning section (see Measures below for more detail on these sections). The participants' children (54.2% male; 45.8% female) were aged from 6 months to 6 years and 11 months. The mean age of children was 3.89 years (*SD* = 1.46), with 62 children being under 3 years of age, 99 being 3- or 4-year-olds, and 101 being

5- or 6-year-olds. Data were collected on children across this age range as infancy to 6 years of age represents the broad developmental stage of early children (Kail, 2021), which coincides with the first two developmental stages of Piaget's (1936) theory of cognitive development, with the concrete operational stage of development beginning at age 7 years, representing the progression into middle childhood. Collecting data on this age range allows for inferences on the influence of screen use in the home on all stages of early childhood to be made.

Table 28. Percentages for the participants' demographic variables.

Demographic Variables		**Percentage**
Parents' Education	Education up to third level	24.5%
	Third level degree	27.6%
	Postgraduate degree	47.9%
Parents' Employment	Full-time	43.3%
	Part-time/student	33.7%
	Looking after family/on leave	21.8%
	Unemployed	1.2%

Measures

The survey consisted of main 3 sections (see Appendix H). The first section contained questions relating to demographic information (11 questions). The second section was concerned with various aspects of play and learning (broken into 8 parts, including the screen use questionnaire) and the third section related to parental reports of child development (3 scales). The below highlights the questions of interest to the current study from each of the three sections.

Demographic section. The demographic section of the PLEY Study was created to somewhat mirror the GUI demographic questions and allow data to be comparable across the two studies. Participants were asked about their age, gender, relation to the child, country they resided in, and their child's gender and age. Participants were also asked to indicate their current economic status and education level. The response options for participants' educational attainment were similar to the GUI Study, ranging from 'No formal education' to 'Doctorate degree'. The response options for economic status were also similar to the GUI Study, with participants noting their usual situation in regard to work (e.g., 'Working full-time', 'Unemployed', 'On leave', 'Home duties'). These two variables were of interest to the current study as both have been noted to influence children's cognitive and socio-emotional development.

Play and learning section. This section was interested in examining children's play and learning, including time and resources for play, influences on the child's play, parents' beliefs about playtime experiences, supports and barriers to play, and experiences in the child's home and neighbourhood. The following questions are those from each scale that are most relevant to the current study. While many of the questions' phrasing and response options were similar to those in the GUI Study, some questions had expanded response options to allow for a more fine-grained investigation of the variables. Additional questions that were not asked in the GUI Study were also included to extend knowledge on children's screen use in the home.

Availability of screens in the home. There were three questions concerned with the availability of screen devices in the home in this section. The first question relating to children's screen use asked: "Does your child ever play with or use the following devices:", where parents could indicate whether the child did not engage with any of the devices, or whether they owned or used a parents' TV, computer/laptop, tablet, smartphone, handheld console, or game console. This was included in the current study to assess the rate of child and home ownership of screen devices, which could not be answered using the GUI data.

A follow up question to this was: “What screen device do they mostly use?”, which included the responses of ‘Computer/Laptop’, ‘Tablet/Smartphone’, ‘TV’, ‘Handheld/Game Console’, ‘Mix of all devices’, or ‘Other’. This is an additional question that was not asked in the GUI Study and allows for the screen devices in which the children mostly engage with to be assessed. While the previous question provides an overall picture of device use and ownership, this question builds on this by exploring the devices mostly used by the children. This will provide an insight to the rate of various digital device use in the early home environment and whether these devices have varying influences on children’s development in comparison to other screen devices.

The last screen use question in this section asked: “What screen activity does your child mostly engage in?”, with the response options being ‘Entertainment games’, ‘Educational games’, ‘Watching entertainment TV’, ‘Watching educational TV’, ‘Video calls’, ‘Mix of all activities’. Although this question is present at age 5 years in the GUI data, the response options are more expansive in the current study as they separate TV content into educational and entertainment, and include video calls as an activity. Furthermore, the screen activity mostly engaged in was only measured for the 5-year-olds in the GUI Study, while the current study could provide insight on what activities are mostly being engaged in at a younger age.

Daily time spent on screens. Parents were asked to indicate how much time per day their child typically spent on screen time on any screen device. They were asked to indicate their response using the following categories: ‘No Time’, ‘1-30 minutes’, ‘31-60 minutes’, ‘61-90 minutes’, ‘91-120 minutes’, ‘2-3 hours’, and ‘More than 3 hours’. These response options allow a more fine-grained investigation of screen time in comparison to the GUI Study, where there were only four screen time brackets available for analysis at age 5 years (No screen time, Less than 2 hours, 2 to 3 hours, More than 3 hours), and over half of the sample in Wave 3 were contained in the 'Less than 2 hours bracket'. The current measure allows daily screen time to be broken down further while still allowing for comparisons of screen time across the two studies to be made.

Child Development Section. This section consisted of three separate scales to measure aspects of child development through parental reports. The first aspect of development measured was attention, using the Attentional Focusing subscale from the Children's Behaviour Questionnaire (Rothbart et al., 2001). This scale was chosen as attentional ability has been shown in the previous chapters to be an important aspect of both cognitive and socio-emotional development. The Attentional Focusing Scale asks parents to respond to statements about their children's reactions in 9 different situations (e.g., has difficulty leaving a project s/he has begun), and indicate on a 5-point Likert scale how true these statements were of their child (ranging from 'Extremely untrue' to 'Extremely true'). This 9-item subscale was reported to have high internal consistency, α = 0.74. In the current study, the scale had an internal consistency of α = 0.66.

The second aspect of development measured was language, measured using the Alberta Language and Development Questionnaire (Paradis et al., 2010). It measures early developmental milestones, such as current abilities in the first language which can help assess if there is evidence of any delay or problems in the first language. These language-related questions were used in the current study to assess the child's use of language using a brief parental-report measure. Answers to the questions (e.g., Compared with other children of the same age, how do you think that your child expresses him/herself?) were indicated on a 4-

point Likert scale (‘Not very well’, ‘A little less well’, ‘The same’, ‘Very good/better/one of the best’). A higher score was related to greater language and communication ability. This scale had high internal consistency in the current study, $\alpha = 0.81$.

The third aspect of development measured was socio-emotional development using the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). This is the same parental report measure of socio-emotional development used in the GUI Study. As described in the previous chapter, the SDQ is a 25-item behavioural screening questionnaire that assesses emotional health and problem behaviours in children across five subscales: ‘Emotional Problems’, ‘Conduct Problems’, ‘Hyperactivity’, ‘Peer Problems’, and ‘Prosocial’. The SDQ was used in the current study to ascertain the parents’ perception of the child’s social and emotional well-being. Similar to the previous chapter, the SDQ items were coded into three subscales with the following Cronbach’s alpha values: internalised behaviour ($\alpha = 0.65$), externalised behaviour ($\alpha = 0.77$), and prosocial behaviour ($\alpha = 0.75$).

Data analyses

The data were cleaned and organised where incorrect values, such as those outside of the bounds of the scale parameters, were removed and incomplete data were coded as missing. Where appropriate, data were coded in a similar way to the GUI dataset so as findings from the analyses could be considered in light of previous results. Statistical analyses were conducted using IBM Statistical Package for the Social Science (IBM SPSS) version 24.0. The frequency and prevalence of early screen use according to the children’s age was explored using chi-square tests. The influence that screen use variables had on the cognitive and socio-emotional scores were also tested using one-way Analysis of Variance (ANOVA) tests, with post hoc analyses as appropriate. Hierarchical multiple regression models were also used to assess whether statistically significant findings remained after environmental factors were controlled for. The data were shown to meet the assumptions for this analysis, with scatterplots indicating the relationship between the independent and dependent variables were linear, and P-P plots suggesting the assumption of homoscedasticity and normality were met (Appendix I).

Results

The prevalence and type of early screen use in the home

The findings from the survey provide a timely snapshot of the amount of time young children spent on screens, and the resources available to them. Most children aged 6 years and under had access to screen devices, with 17% owning their own screen device (12% of children owned one device and 5% of children owned more than one device). The device with the highest level of child ownership was a tablet, with 12% of children in the sample owning one and 37% of children using a family members' device. However, television was the most used screen device, with 82% of parents reporting their child had access to one. Consoles and laptops/computers were the screen devices least used by the children, with TV, tablets, and smartphones being the most accessed screen devices by young children in the home overall (see Table 29).

Table 29. Percentage of children with access to, or ownership of, various screen devices.

	TV	Smart-phone	Tablet	Computer/ Laptop	Game Console	Handheld Console
Uses a parent's or sibling's	81.9	45.4	36.9	18.8	4.3	3.1
Uses their own	2.7	0.4	11.9	0.8	1.9	5.4
Does not use	15.4	54.2	51.2	80.4	93.8	91.5

According to the parental report, only 3.5% of the children in the current study engaged in more than 3 hours of daily screen time, while 11.2% of the children had no engagement with screens in the home. These figures differ markedly from that seen in the GUI Study, where only 2.7% of the 5-year-olds, and 2.4% of the 3-year-olds were reported to have no daily screen time. Similarly, 12.9% of the 5-year-olds and 19.4% of the 3-year-olds in the GUI data engaged in over 3 hours of daily screen time in the home. While 56.7% of the 5-year-olds in the GUI Study engaged in under 2 hours of screen time per day, in the current study 79.1% of the children engaged in under 2 hours of daily screen time. However, the time brackets used in the current study provide a more detailed breakdown of daily screen time as this was measured in half hour increments. From this, it can be seen that the majority of children spent between half an hour and an hour on screen time per day (31.5%), followed by less than 30 minutes of daily screen time (27.2%; see Table 30).

Table 30. Percentage of children in each screen time bracket.

No screen time	Up to 30 minutes	31 – 60 minutes	61 – 90 minutes	91 – 120 minutes	2 – 3 hours	More than 3 hours
11.2	27.2	31.5	15.4	5.0	6.2	3.5

However, the range of ages in the current study is quite large (6 months to 6 years and 11 months) and accounts for children under the age of 3 years, which is also in contrast to the GUI Study. This may explain some of the differences in screen time seen across the studies. To further explore this, a bivariate correlation was conducted to assess if there was a correlation between daily screen time and age. A Spearman's rho test revealed that screen time was related to age, $r = .125$, $p = .043$. It was therefore decided to break the sample into three age brackets (Under 3 years of age; 3- and 4-year-olds; and 5- and 6-year-olds) to explore screen use differences based on age. These age ranges were chosen to best mirror the GUI Infant Cohort Waves. This allowed for comparisons to made with the results from Wave 3 of the GUI Study. It also extends findings of the GUI Study, and addresses a limitation within the screen use literature, by allowing for investigation of the naturalistic screen use habits of children aged under 5 years.

Due to the large number of participants in the current study who reported that their children engage in less than 60 minutes of screen time per day, and the small number of children who engaged in over 2 hours, screen time was coded into five different time brackets (No screen time; Under 30 minutes; 30 to 60 minutes; 1 to 2 hours; More than 2 hours). While the brackets still simulate the time brackets used in Wave 3 of the GUI dataset, they do vary slightly but allow for more fine-grained investigation of lower levels of screen time and its role in early development. Figure 10 illustrates how the children's screen time differed based on their age, using the new coded measures of age and daily screen time, $F(2,227) = 3.317$, $p = .038$. A minority of children under the age of 3 years had no screen time at all (21.3%), although most of these children engaged in less than an hour of screen time per day (52.4%). In contrast, fewer children aged 3 years and over had no screen time at all or less than 30 minutes per day on average.

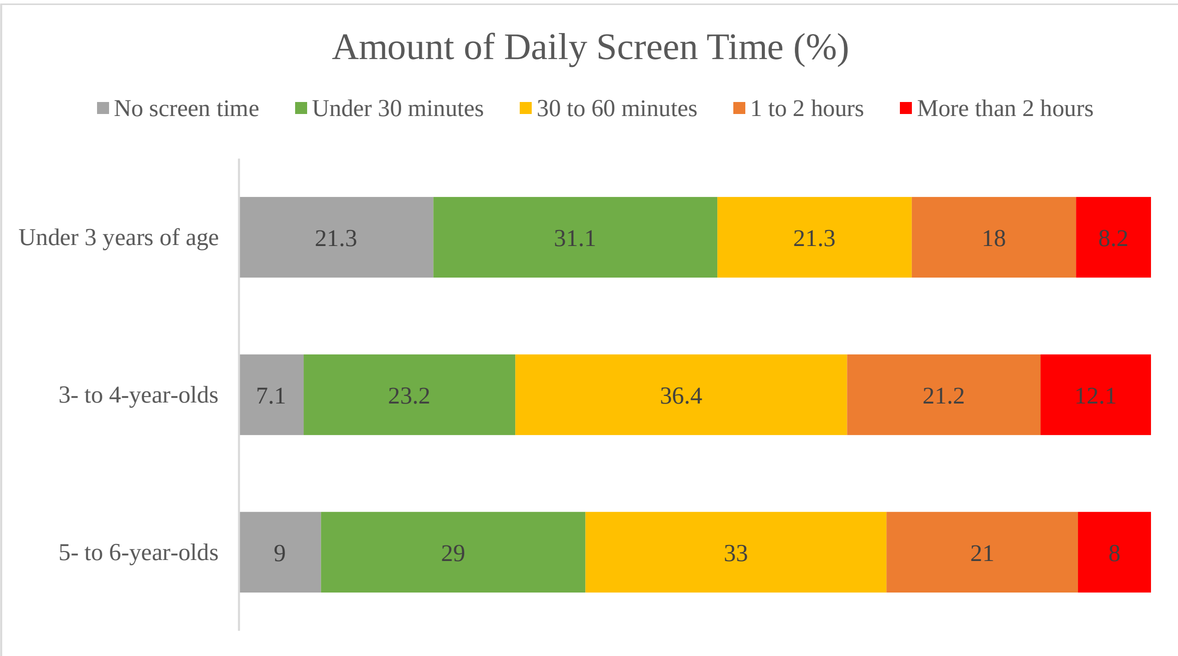


Figure 10. Percentages for each screen time bracket based on the children's age.

In relation to the screen activity that the children mostly engaged in, a chi-square test showed that this was also associated with the children's age, $\chi 2$ (4, N = 248) = 10.82, p = .029, *Cramer's V* = .144. Figure 11 illustrates these differences, where it can be seen that educational content was less popular with the older children. Only 9.5% of the children aged 5 to 6 years mostly engaged in educational TV versus 26.8% of the children under 3 years of age. A similar trend is seen for educational games, with the under 3-year-olds being the age bracket that were most likely to engage in this screen activity. This is an important finding given the scarcity of research on the incidental type of screen use children in this age bracket engage in within the early home environment. It also highlights that educational screen content and activities are being engaged with by nearly a third (32.2%) of infants and toddlers in the home.

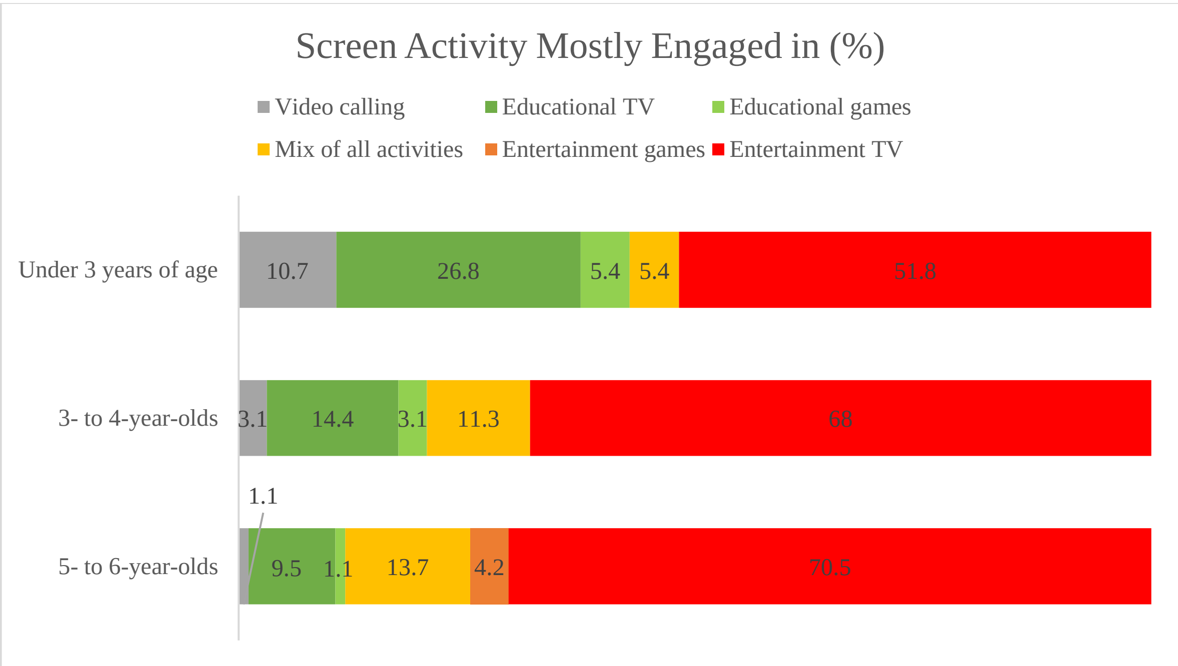


Figure 11. Percentages for the screen activity mostly engaged in based on the children's age.

The opposite trend can be seen for entertainment content, where children aged 5 and 6 years were the age bracket most likely to watch entertainment TV or play entertainment games, as the main screen activity they engaged in. Nonetheless, the most popular screen activity in each age bracket was TV viewing, with entertainment TV being the content most viewed by the children in the current study. These findings are noteworthy as they suggest that the screen activities in the home that children engage in differ with age, which is not extensively reported on in the literature to date. Additionally, they provide a snapshot of the incidental amount and type of daily screen use engaged in by infants and toddlers. This builds on the GUI data by measuring various screen factors under the age of 5 years, while also expanding on the types of screen activities and content being engaged in by 5- and 6-year-olds in the home environment.

A further chi-square test was also conducted on the screen devices mostly used by the children. The results showed that device use had no significant association with age, $\chi 2$ (4, N = 258) = 5.13, p = .274, *Cramer's V* = .099. Figure 12 shows that touchscreen devices (i.e., tablets and smartphones) were the most used devices after TV sets for all ages, although these devices were somewhat more popular with the older children. However, only 1% of the children mostly used game consoles, and only 8.3% mostly used a computer or laptop. This would suggest that the screen-based games being played by the children were mostly being played on touchscreen devices. These findings again shed light on the screen use habits of young children in the home (and importantly the prevalence of naturalistic screen activity and device use by infants and toddlers) and provide insight to how age or developmental stage influences early screen use.

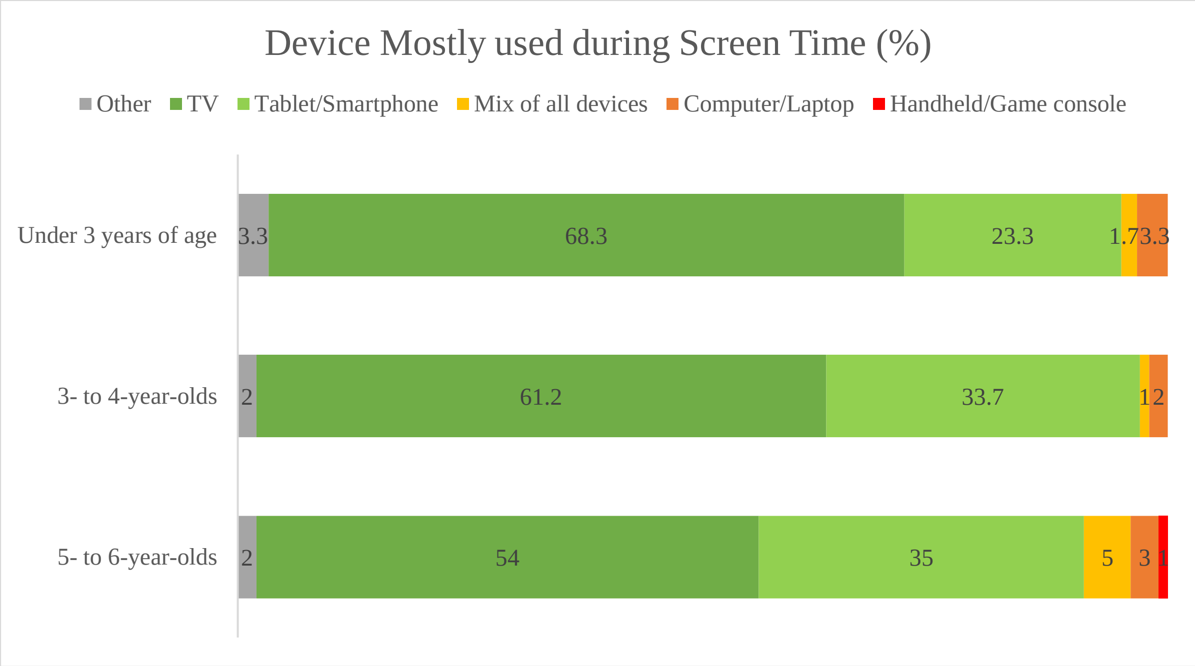


Figure 12. Percentages for each screen device mostly used based on the children's age.

These initial findings highlight the prevalence and type of early screen use in the home, and that various screen activities and devices are being engaged in at various ages. However, it also important to explore whether these various screen use factors have an influence on psychological development for the children in this study. To assess the influence that this early screen may have on development, ANOVA tests were carried out, comparing these screen use factors against the children's developmental scores.

The cross-sectional influence of early screen use factors on psychological development

Scores for the attention and language scales were totalled, respectively, to create Total Attentional Ability and Total Language Ability scales, which were used to measure these aspects of early cognition. The scores on the SDQ were coded into three total scores for Internalised Behaviour, Externalised Behaviour, and Prosocial Behaviour. For the ANOVA tests, children were not separated by age brackets due to the small sample sizes within the screen activity and device variables. Therefore, the influence of the screen use factors on developmental scores was assessed using all children from the dataset.

The children's scores for attentional ability ranged from 15 to 45 (*M* = 31.98, *SD* = 5.45), and scores for language ability ranged from 4 to 16 (*M* = 14.07, *SD* = 2.86). Internalised (*M* = 2.83, *SD* = 2.50) and externalised (*M* = 5.55, *SD* = 3.48) behaviour scales ranged from 0 to 13, and 0 to 16, respectively. The average score on the prosocial behaviour score was 7.48 (*SD* = 2.01), with scores ranging from 1 to 10. Looking to the means for the cognitive scores based on screen time (Table 31), the children who had the lowest attention scores were those who engaged in more than 2 hours of screen time a day (*M* = 28.35), while those who engaged in 1 to 2 hours a day had the lowest mean language score (*M* = 13.83).

In relation to screen activities, those who mostly engaged in entertainment games had the lowest mean cognitive scores (attention *M* = 29.67; language *M* = 13.00), with children who mostly played educational games scoring much higher than average for attention (*M* = 37.67). Looking at the screen device mostly used, children who mostly used touchscreen devices during screen time also had the highest mean attention score (*M* = 32.09). For language scores, the highest mean scores were for those who mostly used a computer/laptop (*M* = 31.33). However, the means for language ability did not differ much based on the children's screen use in comparison to the means for attention. The highest mean language score was seen for those who mostly engaged in a mix of screen activities during screen time (*M* = 14.68).

Table 31. Mean cognitive scores based on screen use categories.

	Attention Ability		Language Ability	
Screen Use Categories	**M**	**SD**	**M**	**SD**
Screen Time				
No screen time	33.67	4.75	13.88	2.15
Under 30 minutes	32.59	4.96	14.03	2.36
30 to 60 minutes	32.01	5.81	14.22	1.94
1 to 2 hours	32.11	5.24	13.83	2.79
More than 2 hours	28.35	5.60	14.46	2.23
Screen Activity				
Entertainment TV	31.94	5.53	14.06	2.26
Educational TV	30.31	5.69	13.91	2.91
Entertainment Games	29.67	1.52	13.00	1.41
Educational Games	37.67	3.98	14.17	3.25
Video Calling	31.67	3.70	13.67	1.87
Mix of All	32.74	4.47	14.68	1.46
Screen Device Mostly Used				
TV	32.05	5.71	14.28	2.29
Tablet/Smartphone	32.09	4.53	13.84	2.25
Computer/Laptop	31.33	9.18	14.67	2.34
Game Console	-	-	-	-
Other	31.80	8.26	13.33	1.53
Mix of All	31.00	4.56	12.17	2.40

Note. Where data are not provided, n < 2.

For socio-emotional scores (see Table 32), the screen use categories' means for internalised behaviour show that those who engaged in more than 2 hours of screen time a day had the highest internalised behaviour in comparison to the other time brackets, with children who mostly used laptops or computers having the lowest internalising scores (*M* = 1.83). For externalising scores, those who engaged in more than 2 hours of daily screen time again had the highest scores in comparison to the other time brackets. The children who mostly engaged in educational games scored well below the average externalised behaviour scores (*M* = 2.83). Meanwhile, children who mostly played entertainment games had the highest prosocial scores (*M* = 9.50), while those who engaged in no screen time at all scored lowest on the prosocial scale (*M* = 6.58). ANOVA tests further assessed these variances between the levels of the screen use variables to test for statistically significant differences.

Table 32. Mean socio-emotional scores based on screen use categories.

	Internalised Behaviour		Externalised Behaviour		Prosocial Behaviour	
Screen Use Categories	**M**	**SD**	**M**	**SD**	**M**	**SD**
Screen Time						
No screen time	2.62	1.95	5.21	2.60	6.58	2.17
Under 30 minutes	2.88	2.67	5.45	3.09	7.42	1.93
30 to 60 minutes	2.34	2.04	5.96	3.60	7.42	2.00
1 to 2 hours	3.09	2.54	4.62	3.37	8.04	1.89
More than 2 hours	3.75	3.40	6.75	4.67	7.79	2.06
Screen Activity						
Entertainment TV	2.45	2.39	5.54	3.52	7.62	1.88
Educational TV	3.84	3.11	6.47	3.72	6.97	2.48
Entertainment Games	3.50	2.12	4.00	1.41	9.50	.707
Educational Games	2.33	1.97	2.83	2.23	9.00	.001
Video Calling	3.67	1.73	5.44	2.70	6.67	1.23
Mix of all	2.78	1.68	5.43	3.74	7.61	2.02
Screen Device Mostly Used						
TV	2.97	2.67	5.62	3.48	7.47	2.00
Tablet/Smartphone	2.55	2.26	5.38	3.50	7.65	1.81
Computer/Laptop	1.83	1.33	4.83	2.93	8.17	2.56
Game Console	-	-	-	-	-	-
Other	4.67	3.06	5.00	4.36	-	-
Mix of All	2.50	2.26	6.83	4.96	7.33	2.88

Note. Where data are not provided, n < 2.

The first two sets of ANOVA tests showed that the screen device and the screen content that the children mostly engaged with had no influence on their cognitive or socio-emotional scores (all *p*'s > .05). The third set of ANOVA tests assessed the influence of the children's daily screen time on their developmental scores. The tests showed that screen time had no significant influence on the children's development scores (all *p*'s > .05), with the exception of attention scores, $F(4,219) = 3.463$, $p = .009$, $\eta p2 = .059$. The post hoc analyses revealed that the children who engaged in more than 2 hours of daily screen time had significantly lower attention scores compared with all of the other time brackets (all *p*'s <

.05; Figure 13). The final set of ANOVA tests assessed the screen activity the children mostly engaged in and found this to have no influence on the developmental scales (all *p*'s > .05), with the exception of attention scores, $F(4,204) = 2.527$, $p = .042$, $\eta p2 = .047$. The post hoc tests showed that the children who played educational games had higher attention scores than those who mostly watched educational TV ($p = .023$; Figure 14).

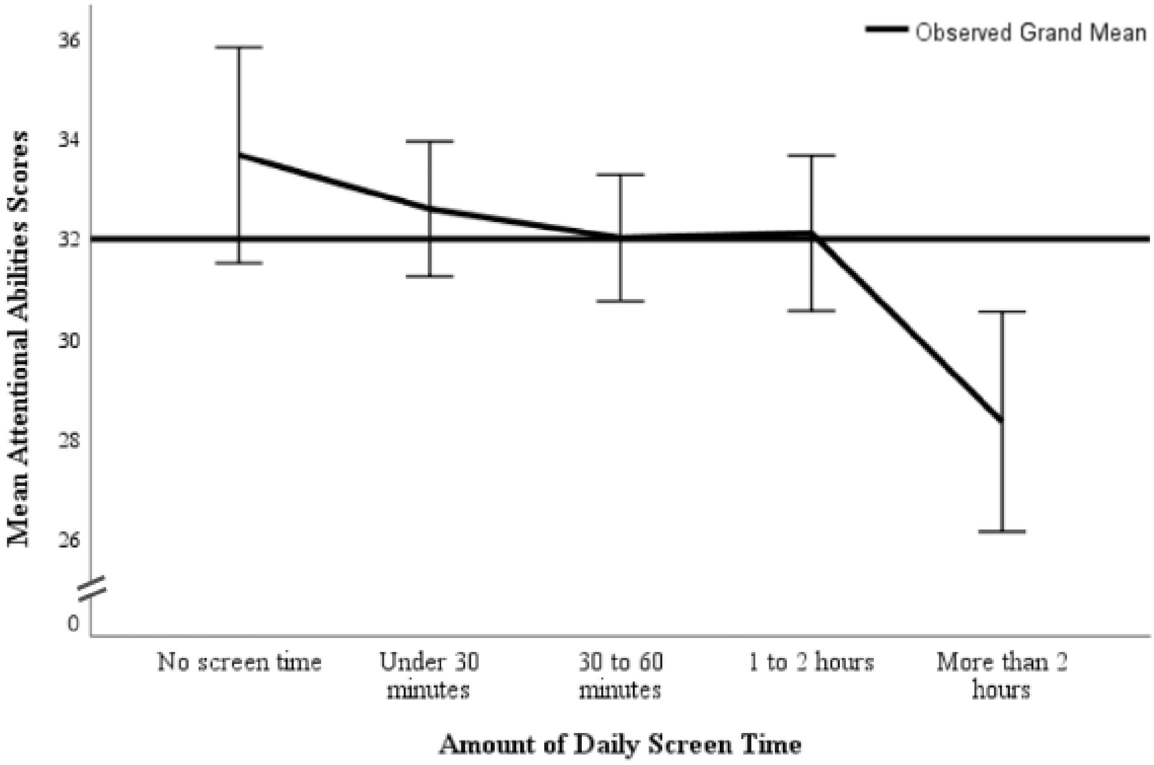


Figure 13. Mean attention scores based on screen time brackets.

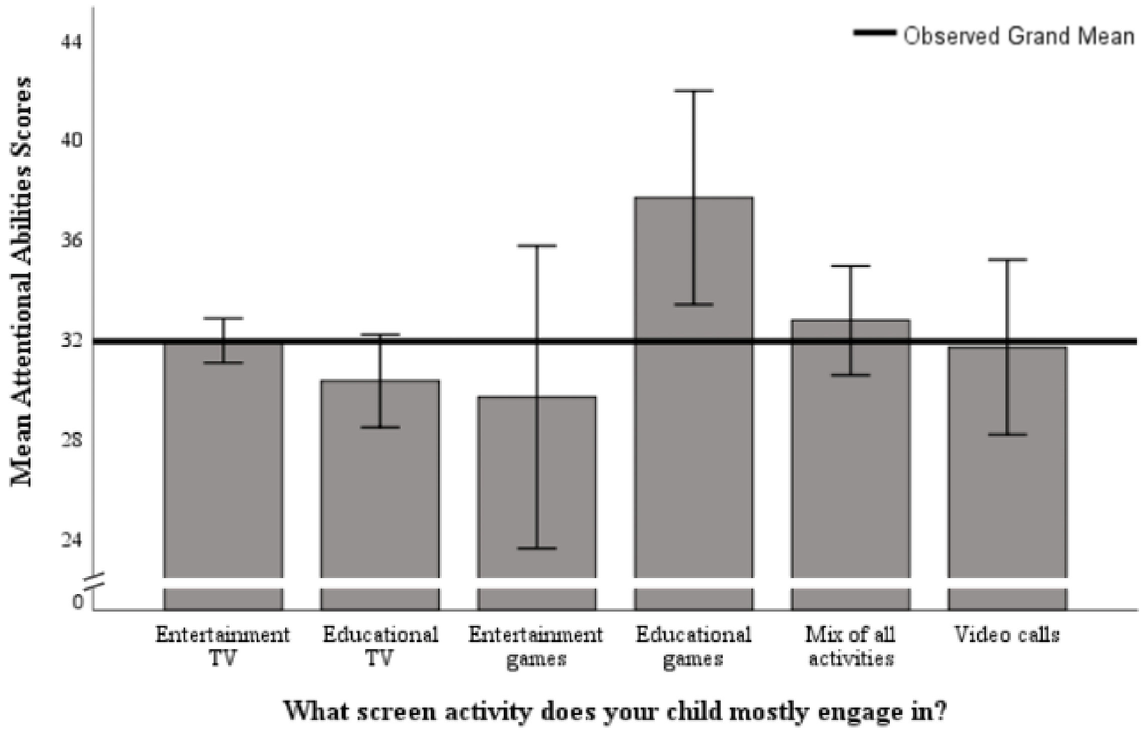


Figure 14. Mean language scores based on screen activity.

A hierarchical regression model was therefore conducted to assess whether these findings remained after controlling for environmental factors. Prior to running the regression, screen time was dummy coded so as each level could be entered into the regression independently, with '1 to 2 hours' used as a reference category to best fit with the regression analyses from the previous chapters. Screen activities was also included in the second step to again mirror the regressions conducted with the GUI data. Pertaining to this purpose, 'A mix of all activities' was used as the reference category in this step after the screen activity variable was dummy coded. In the third step the family factors (primary caregiver's educational attainment and the family's economic status) were included.

The regression model showed at Step 1, screen activity accounted for 4.6% of the variation in attention scores, $R^2 = .046$, $F(4,220) = 2.653$, $p = .034$. Screen time explained an additional 5.8% of the variance, $R^2 = .058$, $F(8,216) = 3.132$, $p = .002$. Environmental factors had an R^2 change value of .007, and did not contributed significantly to the model, R^2 = .007, $F(10,214) = 2.663$, $p = .060$. The findings were similar to the results from the ANOVA tests, with educational games and more than 2 hours of daily screen time differing significantly from the reference categories, with both remaining significant in the final model (Table 33, Model 3).

Table 33. Regression model of screen use variables and attention scores.

	Models								
	Model 1			**Model 2**			**Model 3**		
Block of Predictors	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Step 1: Screen Activity ('Mix of all activities' as reference category)									
Entertainment TV	-.801	-.071	n.s	-.757	-.068	n.s	-.803	-.072	n.s
Educational TV	-2.42	-.156	n.s	-2.21	-.143	n.s	-2.22	-.143	n.s
Educational games	4.93	.146	.038	4.91	.146	.036	5.02	.149	.034
Video calls	-1.07	-.039	n.s	-2.12	-.077	n.s	-2.41	-.087	n.s
Step 2: Screen Time ('1 to 2 hours' as reference category)									
No screen time				1.31	.075	n.s	1.25	.071	n.s
Under 30 minutes				.618	.051	n.s	.527	.043	n.s
30 to 60 minutes				-.250	-.021	n.s	-.270	-.023	n.s
More than 2 hours				-3.80	-.212	.005	-3.55	-.198	.009
Step 3: Family Factors									
Education level							.340	.076	n.s
Economic status							-.095	-.028	n.s
R^2	.046, $p = .034$			.058, $p = .002$			.007, $p = .060$		
Total ΔR^2							.111		

Note. n.s = non-significant; entertainment games were excluded from the model as n < 2.

Summary of findings

The initial findings on the prevalence and type of early screen use showed that 17% of the children owned at least one screen device and that 11.2% of children have no engagement with screens in the home. As noted in the results section, the latter is markedly different to the descriptive statistics from the GUI data seen in Study 1 where less than 3% of the 3- and 5-year-olds had no screen time. Again, however, the current study included a more expansive age range (6 months to 6 years and 11 months) which may explain the difference in these percentages.

When the children were broken into age brackets, it could be seen that those aged under 3 years had the least screen time and were most likely to engage in under 30 minutes of screen time per day. During this screen time, the under 3s were mostly watching entertainment TV, which was the same for all age brackets. However, the under 3s engaged in educational TV, educational games, and video calling more than the older children who were more likely to engage in entertainment TV, entertainment games, or a mix of all screen activities than the infants and toddlers in this study.

For the screen devices mostly used, the under 3s were most likely to use a TV for all screen activity, and the least likely to use a touchscreen device, while the children aged 5 and older were the age bracket who mostly used tablets and smartphones and were least likely to use a TV for all screen activity. These findings provide an insight to young children’s current screen use habits in the home by exploring the activities, content, and devices mostly engaged in by these children, in addition to daily screen time. This builds on the knowledge gained from the GUI findings reported in Study 1. The results also document the difference in the prevalence and type of screen use across age brackets with a focus on the under 3s, which remains an under-researched age bracket.

From these findings it can be seen that there is a developmental trajectory of screen use with these factors significantly differing over a relatively brief developmental period between infancy and 6 years of age. This highlights the importance of considering the element of time from the PPCT model, and the chronosystem, when exploring the role of screen use in early development, as age has been shown to be an important factor to consider when interpreting findings in this area. These results also illustrate the issue of using screen time as a sole measure of screen use in young children given the difference in content and activity the children in the study engaged in based on their developmental stage.

The cross-sectional inferential findings further explored the children's screen use in relation to the influence it had on their early psychological development. The ANOVA tests found that children who engaged in more than 2 hours of screen time had lower attentional scores than those in any other screen time bracket. Additionally, children who mostly played educational games had higher attentional scores than those who mostly watched educational TV, and in the regression models those who mostly played educational games had significantly higher scores than any other screen activity. The regression model showed that these findings remained even after controlling for the environmental factors. However, the β coefficient show that the influence of screen time decreased more in the final model in comparison to screen activity, where the β coefficient values remained relatively the same in the final model.

These tests indicate that early screen use, inclusive to time, activity, content, and device, mostly had no statistically significant influence on the children's development scores in the current study, with the exception of the findings on attentional ability. This again differs from the GUI findings reported in the previous chapters where screen time did have a cross-sectional influence on all measures of cognitive and socio-emotional scores for the 5-year-olds in the initial inferential analyses. This difference however may again be explained by the inclusion of various ages and developmental stages in the PLEY data. Furthermore, the effect sizes reported in the GUI analyses were small, and therefore given the smaller sample size in the current study it may not have been possible to detect these small effects found in the previous chapters.

The findings in the current study build on those from the previous studies by including additional screen use factors and exploring the prevalence of screen use in a younger age group, as such screen measures were not included in the GUI data at age 3 years. However, further factors in the home may be associated with this screen use, such as parent's beliefs on the learning benefits of screen time. Similarly, parental engagement during screen use may be associated with the frequency in which children engage in certain screen activities. It is therefore of interest to further explore these parental factors in the following study to gain an understanding on whether they are ecological factors associated with early screen use.

Study 6: Exploring the associations between parental screen beliefs and engagement and children's early screen use

The objective of the current study is to explore parental screen beliefs and the frequency of parental engagement during screen time in the home. Given that early screen use has been shown to have some influence on developmental scores in the previous study, this study aims to assess whether these parental factors are associated with early screen use. A further aim is to explore the factors, such as the children's age, the screen activity mostly engaged in, and parental screen beliefs, which may be associated with the frequency of parental engagement during screen use in the home.

Method

Participants

As in the previous study, the participants were 262 Irish parents who participated in the PLEY Study.

Measures

The same measures relating to screen use factors such as screen time, activity, and device were used in this study. Further measures from the Play and Learning section such as parental screen beliefs and weekly frequency of child and parental engagement in screen activities were also included. These measures are outlined below.

Parental screen use beliefs. Parents' beliefs around early screen use were measured using questions modelled from the Parent Playtime Belief Scale (Fogle & Mendez, 2006). This scale examines parents' beliefs on the value of play and learning in the home and whether they value the developmental significance of play. Example questions include: 'Play can help my child develop social skills, such as cooperating and making friends' and 'Play can improve my child's language and communication abilities'. Items on this scale are answered on a 5-point Likert scale (ranging from 'Strongly disagree' to 'Strongly agree'). The questions related to screen use were: "Watching TV supports my child's learning", and "Playing games on a screen device supports my child's learning".

Weekly time spent on screen engagement. Parents were asked to indicate on a Likert scale ('Never', 'Hardly Ever', 'Occasionally', '1-2 days a week', '3-6 days a week', and 'Everyday') how often their child engaged in the following screen activities in the home; 'Playing educational games', 'Playing entertainment games', 'Watching educational TV, 'Watching entertainment TV', 'Video calls'. These frequencies replicate the GUI Study's measure of play and learning activities that the children engaged in on a weekly basis, although screen time was not an activity included in this measure in the GUI Study.

Separately, parents were presented with the same five items again and asked to indicate how frequently they engaged in these activities with their child. These screen activities were included among a list of 27 items, describing activities the child might engage in within the home environment. This information is of particular importance as it provides data on the level of parental engagement during screen time, which was not available in the GUI Study, while also building on the screen time frequencies and screen activity division that is available in the GUI data.

Data analyses

The cleaned and organised dataset used in the previous study was also used for this study. Statistical analyses were conducted using IBM SPSS version 24.0. The associations between parental screen beliefs and children's screen use factors were explored using chi-square tests and bivariate correlations. To explore the frequency of parental engagement during screen time in the home, and whether this is associated with factors such as parental screen beliefs, the screen activity mostly engaged in, or the children's age, further chi-square tests were conducted.

Results

The associations between parental screen beliefs and children's early screen use factors

Study 5 indicated that nearly 85% of the children from the PLEY Study had access to a TV and nearly half had access to a touchscreen device. The majority of the children had 30 to 60 minutes of screen time per day, with entertainment TV being the screen activity mostly engaged in during this time. It is therefore of interest to explore whether parental beliefs are associated with this early screen use. According to parents' report, nearly half agreed that TV could support their child's learning (47.8%), and only 8.8% strongly disagreed with this statement. This is markedly different to parents' beliefs on whether playing games on a screen device could support learning, with 1 in 4 parents strongly disagreeing with this statement. Only 27.2% agreed that digital games could support learning (see Table 34).

Table 34. Percentage of parents who agree or disagree that screen activities support learning.

Screen Activity	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Watching TV supports learning	8.8	15.1	28.3	45.1	2.7
Digital games support learning	25.0	18.8	29.0	26.8	0.4

Chi-square tests were conducted to explore whether these beliefs differed based on age. Given the small number of parents that 'strongly agreed' with the statements, the variables 'somewhat agree' and 'strongly agree' were collapsed, as were 'somewhat disagree' and 'strongly disagree'. The chi-square tests showed that TV beliefs did not differ based on the children's age brackets as there was no significant association found (TV supports learning: $\chi 2$ (4, N = 226) = 2.14, p = .710, *Cramer's V* = .069). However, parental beliefs on digital games did significantly differ based on age (Digital games support learning: $\chi 2$ (4, N = 224) = 9.59, p = .048, *Cramer's V* = .146). The latter test showed that parents of the 5- and 6-year-olds were three times more likely to agree that digital games support learning (31.8%) than parents of children aged under 3 years (10.6%). However, there was little difference for those who disagreed with the statement across the age brackets (see Table 35).

Table 35. Percentage of parents who agree or disagree that digital games support learning based on age.

Digital games support learning	Under 3 years	3- and 4-year-olds	5- and 6-year-olds
Disagree	48.9	40.2	44.7
Neither agree nor disagree	40.5	28.3	23.5
Agree	10.6	31.5	31.8

To assess whether the children's screen use is associated with these parental beliefs, bivariate correlations and further chi-square tests were conducted using the parental belief variables and the screen use factors: screen time, activity, and device.

The association between parental screen beliefs and children's screen time. Two Spearman's rho tests were conducted to assess whether parental screen beliefs were related to the daily screen time the children had. The first test showed that there was a significant positive correlation between how much parents agreed that TV could support their child's learning and the amount of daily screen time the children had (r = .347, p < .001). There was also a significant positive correlation between digital game beliefs and screen time (r = .171, p = .010). However, it should be noted that the strength of the correlation is weaker for this statement in comparison to the statement on TV and whether it can support learning. To further explore the influence of parental screen beliefs, chi-square tests were conducted to assess whether they were associated with screen activity or device.

The association between parental screen beliefs and screen activity and device mostly engaged with. The first chi-square tests showed that parents' beliefs on whether TV supports their child's learning had no association with the screen activity ($\chi 2$ (10, N = 215) = 26.94, p = .137, *Cramer's V* = .177) or the screen device ($\chi 2$ (10, N = 224) = 28.67, p = .094, *Cramer's V* = .179) that their child mostly engaged with. However, there was a significant association between the screen activity children mostly engaged in and whether parents believed digital games support learning, $\chi 2$ (10, N = 213) = 37.40, p = .010, *Cramer's V* = .210. Engaging in educational games and educational TV was associated with parents agreeing with this statement, while engaging in entertainment TV or video calls was associated with parents disagreeing with the statement. The screen device the child mostly used was also significantly associated with parents' beliefs about the educational value of digital games, $\chi 2$ (10, N = 222) = 48.66, $p < .001$, *Cramer's V* = .234. Using a tablet or mix of devices was associated with parents agreeing that digital games could support learning while using a TV or laptop/computer was associated with parents disagreeing with the statement.

The association between parental screen beliefs and screen use weekly frequencies. Weekly frequencies for screen time activities were also measured in the current study allowing for bivariate correlations to be conducted with parent screen beliefs and the weekly frequency that their children engage in certain screen activities. In contrast to the previous tests, the first Spearman's rho test showed that beliefs on whether TV supports learning were significantly positively correlated with how often children watched both entertainment TV programmes (r = .164, p = .014) and educational TV programmes per week (r = .231, p < .001). This was the same for the statement on digital games, where parents' higher agreement levels were associated with children's higher weekly engagement with both entertainment games (r = .332, p < .001), and educational games (r = .354, p < .001).

The r values of these tests would indicate that parents' beliefs on whether digital games can support learning has a stronger association with the frequency in which children engage with these games in the home, in comparison to the associations between TV beliefs and TV engagement. While the frequency in which children engaged with these screen activities were all significantly correlated with parental screen beliefs, the strongest association was seen between parents believing digital games to have educational value and the frequency that children engaged in educational games specifically. The activity frequency with the weakest correlation with screen beliefs was watching entertainment TV.

Parental beliefs therefore play a role in children's screen use, particularly beliefs around the educational value of digital games. However, whether these beliefs are associated with other factors, such as the frequency in which parents engage with their children during screen use, is still relatively unknown. It is therefore important to explore parental engagement during screen time to assess if, and how often, this is happening in the home, and the various factors that it may be associated with.

The frequency of parental screen engagement in the home, and its associated factors

As noted in the method section of this chapter, parents were asked to indicate on a Likert scale ('Never', 'Hardly ever', 'Occasionally', '1-2 days a week', '3-6 days a week', and 'Everyday') how often their child engages in screen activities on a weekly basis, along with how often they engage with their children during these screen activities. Due to the low frequency of responses in the '1-2 days a week' and '3-6 days a week' categories they were combined to form a category called 'often engages', with responses for 'Hardly ever' and 'Occasionally' combined to form a category called 'sometimes engages'. Therefore, the amount of weekly engagement was collapsed into four levels ('Never engages', 'Sometimes engages', 'Often engages', and 'Engages everyday').

The association between parental engagement and children's age and screen activity. Before exploring the frequency of parental engagement during screen time in the home, chi-square tests were run to assess whether the frequency of engagement differed based on the children's age. The tests showed that the level of parental engagement differed for all screen activities, except video calling, based on the age brackets: Entertainment games, $\chi 2$ (6, *N* = 256) = 27.91, *p* = .002, *Cramer's V* = .234; Educational games, $\chi 2$ (6, *N* = 256) = 49.59, *p* = .001, *Cramer's V* = .236; Entertainment TV, $\chi 2$ (6, *N* = 256) = 22.14, *p* = .014, *Cramer's V* = .208; Educational TV, $\chi 2$ (6, *N* = 257) = 33.33, *p* < .001, *Cramer's V* = .255; Video calling/messaging, $\chi 2$ (6, *N* = 257) = 17.07, *p* = .073, *Cramer's V* = .182. This indicates that parental engagement during screen time not just differs based on the age of the child, but also based on the screen activity they engage in.

The frequency of parental engagement in the home based on children's age and screen activity. As indicated by the *Cramer's V* values, parental engagement during educational TV viewing varied the most based on age (*Cramer's V* = .255) and varied the least across age brackets for entertainment TV viewing (*Cramer's V* = .208). It can be seen from Figure 15 that parents were more likely to co-view educational TV with their children if they were under 3 years of age, with 31% of these parents doing so every day, compared to just 9% of parents of children aged 5 years and older.

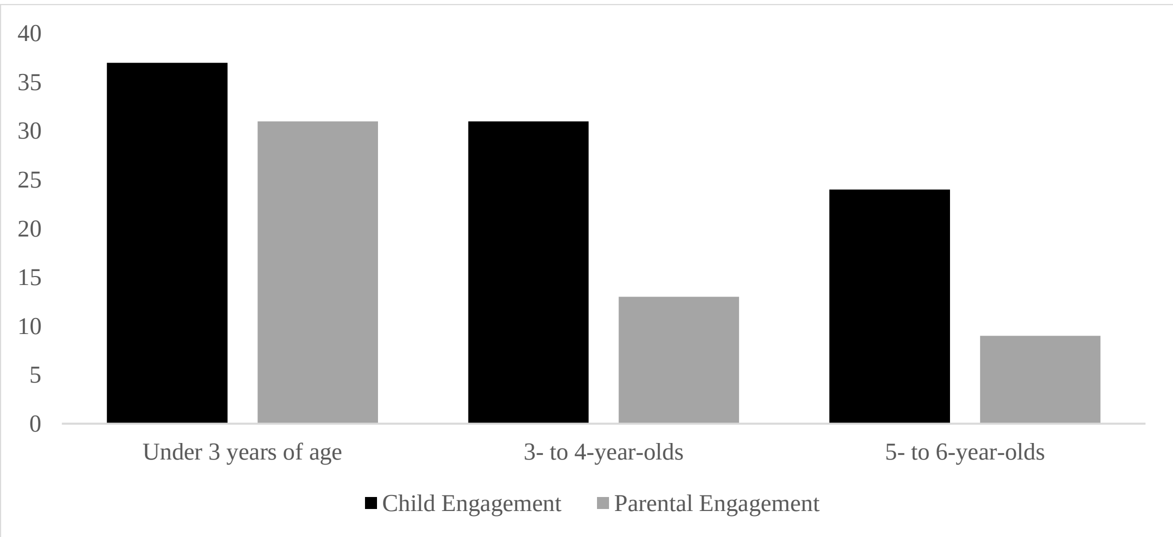


Figure 15. Percentage of children and parents engaged in watching educational TV every day.

This was similar for entertainment TV (Figure 16), with the rate of everyday engagement by the parents dropping from 43% for the children aged under 3 years to 18% for the 5- to 6-year-olds, despite the frequency of child engagement not differing that much across the age brackets. This perhaps suggests a scaffolded approach, with daily parental engagement becoming less as the children mature.

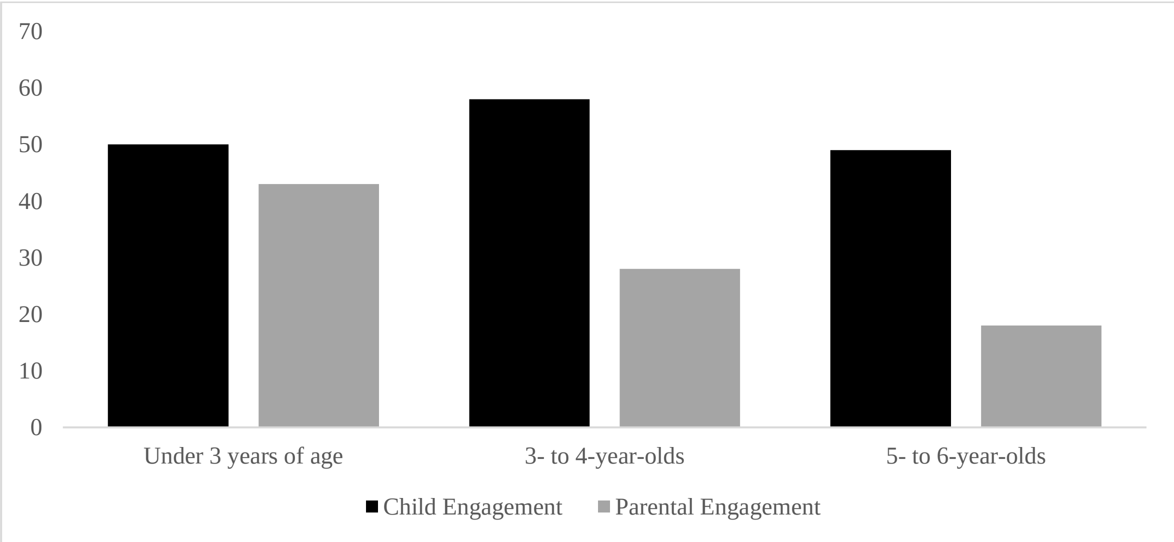


Figure 16. Percentage of children and parents engaged in watching entertainment TV every day.

The above figures were adapted from the data included in a larger figure (Figure 17). This figure includes the percentages of children who spent any time on the specific screen activities. Children who spent no time on the activities were excluded to better highlight the amount of parental engagement with the children who had any engagement with these activities. Figure 17 also provides an insight to young children's frequency and type of screen use on a weekly basis, which allows for a more nuanced understanding of both children's weekly screen use habits and the corresponding levels of parental engagement.

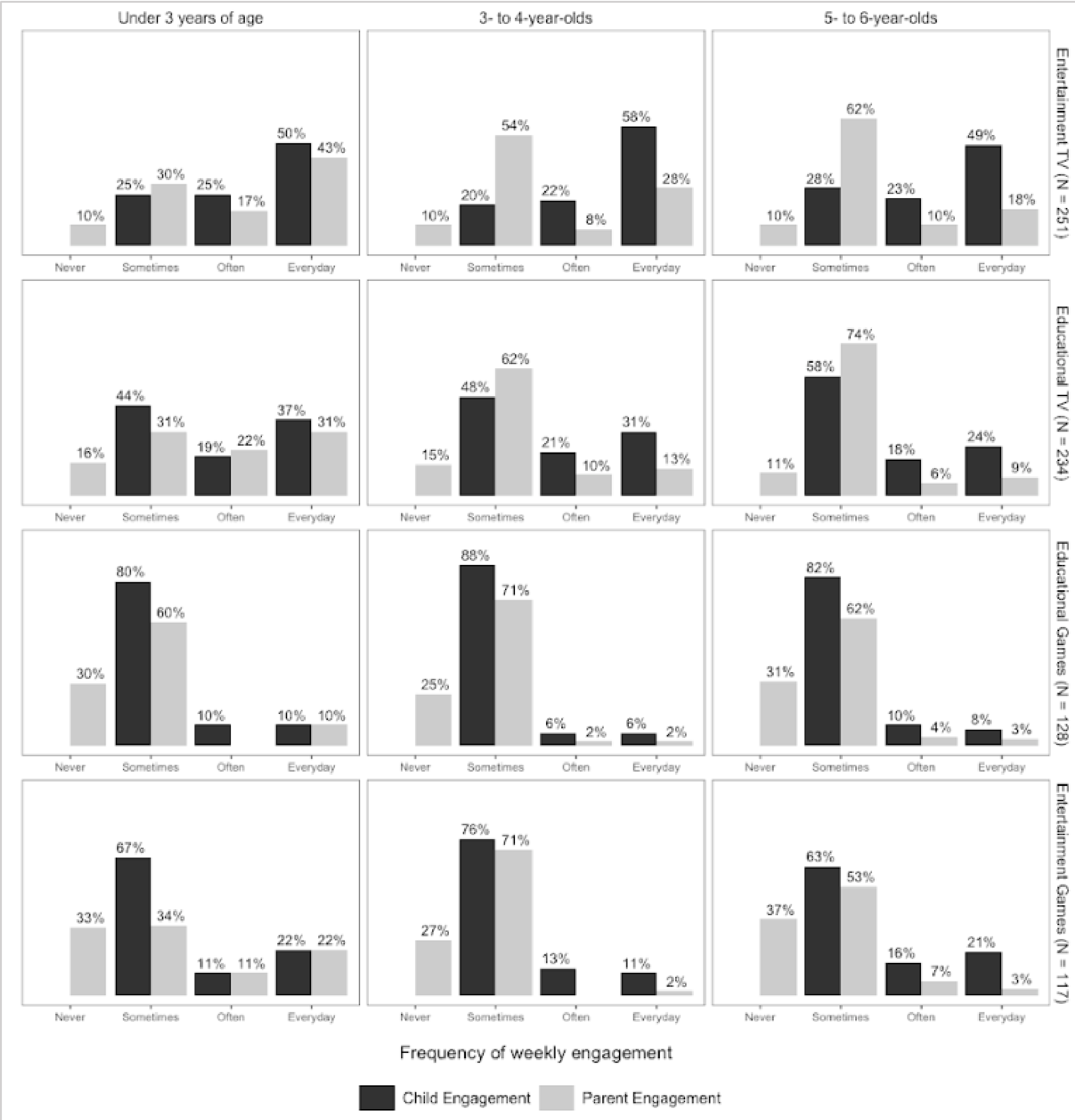


Figure 17. Percentages for the frequency of child and parent engagement with screen activities.

Similar to Figure 11 that looked at the screen activities mostly engaged in on a daily basis, entertainment TV was also the most popular screen activity engaged in on a weekly basis, with 251 children in the sample having any engagement with the activity. Entertainment games were the least popular, with only 117 children ever engaging in this activity. Figure 17 also shows that games were more popular with the older children, with only 16% of the under 3s having any weekly engagement with educational games versus 70% of children aged 5 years and older. A similar trend was seen for entertainment games.

Parents of children under the age of 3 years had the highest frequency of engagement with their children during screen use. These parents were more likely than parents of older children to engage in screen use with the child every day. While they were least likely to engage in TV watching with their children every day, over 80% of parents whose infants watched TV every day were also present during this time. Additionally, these children were always supervised if they were playing digital games (entertainment or educational) every day. The frequency of parent and child engagement levels were also the most similar in this age bracket.

Most parents of children aged 3 years and older engaged in screen use 'sometimes', regardless of the screen activity or their child's frequency of engagement with an activity. These parents were least likely to engage with their child when they were playing entertainment games. Less than 20% of parents whose 3- and 4-year-old children played entertainment games every day also played with them every day; this was less than 15% for parents with children aged 5 years or older. Entertainment games was also the activity that had the highest percentage of parents who never engaged with their children during this activity for all age brackets, ranging from 27% to 37%. This was the opposite for entertainment TV with only 10% of parents from each age bracket indicating they never watch entertainment TV with their children. However, an interesting finding is that the percentage of parents who never engage with their child during screen time does not differ that much across the age brackets.

The association between parental engagement and parental screen beliefs. The chi-square tests and corresponding figures above highlight that parental engagement is higher for certain screen activities and certain age groups. Parental screen beliefs were also related to the frequency in which parents engage with their child during screen time. Chi-square tests showed that there were significant positive associations between how much parents believed screens could support their children's learning and how often they engaged in entertainment screen activities with their children specifically: Entertainment games, $\chi 2$ (6, N = 221) = 48.89, $p < .001$, *Cramer's V* = .235; Entertainment TV, $\chi 2$ (6, N = 222) = 42.78, p = .002, *Cramer's V* = .220. There were also significant positive associations found for educational content but to less of an extent, with the *Cramer's V* values showing educational TV to be the activity parents were least likely to engage in if they believed screens could support their child's learning: Educational games, $\chi 2$ (6, N = 221) = 38.13, p = .009, *Cramer's V* = .208; Educational TV, $\chi 2$ (6, N = 223) = 32.78, p = .036, *Cramer's V* = .192. This is perhaps due to the belief that educational TV programmes can scaffold learning.

Summary of findings

Nearly half of parents agreed that TV supports their child's learning, while less than 30% agreed that digital games support learning. These beliefs were shown to be related to early screen use as bivariate correlations showed that the children's daily screen time was positively associated with parents' beliefs that TV or digital games could support their learning. The screen activity, content, and device mostly used by the children also differed based on whether the parents believed digital games could support learning. Children were more likely to engage in both educational games and educational TV if their parents agreed with the statement. They were also more likely to use a tablet or a mix of devices.

In terms of weekly frequencies, the Spearman's rho tests showed positive significant correlations between parents' agreement levels with the statement that TV supports their child's learning, and the weekly frequency in which their child watched both entertainment and educational TV programmes. This was also seen for the statement on digital games and children's weekly engagement with entertainment and educational games, although the correlations were stronger than that reported for TV beliefs. The screen activity most strongly associated with parental beliefs was educational games, with entertainment TV having the weakest significant relationship with parental screen beliefs. This means that watching entertainment TV is the screen activity least affected by whether parents believe screens can support their children's learning or not.

This would indicate that parental beliefs on the learning benefits of digital games had a stronger association with children's engagement with educational screen content than parental beliefs around the benefits of TV. Therefore, parental screen beliefs can be viewed as a factor related to early screen use. Given that the previous studies showed screen use to influence early development, these findings provide an insight to how parental screen beliefs are an ecological factor within the microsystem that are associated with early screen use and should be considered in further screen use research. A further ecological factor of interest was parental engagement during screen time, the frequency in which this occurs in the home, and its associated factors.

Chi-square tests showed that the children's age and the screen activity being engaged in were factors associated with the frequency of parental engagement during screen time. Parents with children aged under 3 years were more likely than parents of older children to engage in screen use with the child every day, whereas most parents of children aged over 3 years indicated that they engaged with their child during screen time 'sometimes'. This was especially true for entertainment games, where parents with children under 3 years were more than 7 times more likely to engage in this activity every day with their child in comparison to those with older children. Only 10% of parents in each age bracket reported that they never engage in entertainment TV with their children which was statistically different from entertainment games where over 27% of parents said they never engage with their child during this activity.

In addition to the children's age and the screen activity being associated with frequency of parental engagement, parent's screen beliefs were also found to be associated with engagement. Chi-square tests showed a significant association between how much parents agreed that TV and digital games could support their children's learning and the weekly frequency in which the parent's engaged in these activities with their children. While all were statistically significant, the *Cramer's V* values indicate that screen beliefs influenced the frequency of parental engagement during entertainment content the most, specifically entertainment games (*Cramer's V* = .235). Parental engagement during educational TV was the least significantly associated with parental screen beliefs (*Cramer's V* = .192).

This would suggest that parents are least likely to co-view educational TV with their children if they believe screen use supports their child learning. This may be due to the belief that educational content can scaffold their children's learning minimising the need for engagement. This reflects the findings from Figure 15 and 16 where it can be seen that parents were more likely to co-view entertainment TV with their children rather than educational TV. These findings add to the literature on parental engagement during screen time by providing a timely snapshot of the frequency in which this happens in the home and the potential factors that are associated with this frequency of engagement, such as age, screen activity, and parental screen beliefs. Additionally, this provides empirical evidence on the various ecological factors that are associated with very early screen use in the microsystem, which is an area that has received little attention in the screen use research to date.

Discussion

The aim of the current studies was to provide further evidence on the influence of screen use in the home, and the factors influencing it, on the early development of Irish children, by adding to the findings already reported in the previous chapters using the GUI data. The research reported in the current chapter explored additional aspects of screen use (relating to activity, content, and device) across a greater range of ages in early childhood, further ecological factors such as parental screen beliefs and the amount of parental engagement during screen time, and whether these are associated with children's screen use or age. This allowed for a more comprehensive analysis on the various factors that are associated with early screen use and the prevalence of various screen activities engaged in at a young age in the early home environment.

The prevalence, type, and influence of early screen use on early childhood

The first study in this chapter explored the prevalence of various types of screen use by young children. The initial descriptive findings showed that 88.8% of children had access to, and used, a screen device in their home. 17% of the children owned at least one screen device, with tablets being the device with the highest child ownership. The following analyses showed that screen habits did differ based on the children's age, and so, the children were broken into three age brackets to provide a more fine-grained exploration of children's screen use based on their developmental stage. These age brackets mapped on to the ages in Waves 2 and 3 of the GUI Study (ages 3 and 5 years respectively), while also exploring screen use in children aged under 3 years, which had not been examined through the GUI Study. As little is known about natural incidental screen use in the under 3s, this was an age bracket of particular interest.

The descriptive statistics indicated that the prevalence of screen use in children aged under 3 years was high, with 79% of parents reporting that their child does use a screen. 52% of these infants and toddlers spent up to an hour a day on screens, with 26% using a screen for over an hour daily. Most of these children spent this screen time watching TV (68%) but for a substantial amount of the minority their main screen use was on a tablet or smartphone (23%). Given the known associations between early screen use and later screen use and later developmental scores, figures such as these highlight the importance of measuring screen use from the youngest age. They also highlight the importance of ensuring that the screen time measures include the latest devices and screen activities children are engaged in (e.g., screen use in the GUI study at age 3 only asked about the amount of time spent watching TV). Therefore, these findings provide an insight to the screen use habits of Irish infants that was not previously available from the GUI data. The prevalence of screen activity and device use at this young age also illustrates the importance of moving past screen time as a sole measure of screen use as time alone no longer provides an accurate contextual snapshot of early screen use.

Despite this, further findings showed that the infants and toddlers in this study had the least daily screen time, in comparison to the older age brackets. The most popular screen activity for all age brackets was entertainment TV, which is comparable to other studies that have found cartoons to be the most common type of content that children under 5 years watch (Shirley & Kumar, 2019; John et al., 2021). However, the under 3s were also the most likely age group to engage in educational content (both TV programmes and games) and video calls. The 3- and 4-year-olds were the age bracket most likely to have more than 2 hours of daily screen time, which is comparable to the GUI findings where 19.43% of the 3-year-olds engaged in more than 2 hours of screen time per day while only 12.87% of the 5-year-olds had this amount of daily screen time. This is also similar to past research that found 5- to 6-

year-olds to be less likely to engage in over 2 hours of screen time a day than 3- to 4-year-olds. For example, in their research, Vandewater et al. (2007) found around 40% of 3- to 4-year-olds had more than 2 hours of daily screen time, with only 30% of 5- and 6-year-olds having more than 2 hours of screen time a day. A potential reason for the drop in screen time at this age may relate to more time being spent in school, or on after-school activities.

The 3- and 4-year-olds were also more likely to engage in educational content than the 5- and 6-year-olds, but less so than those aged under 3 years. This finding suggests that educational content is more likely to be viewed during screen time by infants and pre-schoolers with entertainment content becoming more popular with children aged 5 years and older. The current findings also show that at this age children are more likely to play entertainment games, as the children who mostly played these games were only in this age bracket. This is a somewhat positive finding given the body of research that has shown educational content to be an important screen use factor for positive developmental outcomes in infants (e.g., Herodotou, 2018; Huber et al., 2018; Madigan et al., 2020).

These findings build on what was known from the analyses conducted with the GUI data. By expanding on the type of screen use, and including content and device, it shows infants are more likely to engage in this content than older children, although the most popular screen activity and content for all age groups was still entertainment TV programmes. The findings also indicate that infants are engaging in a variety of screen activities and devices in the home. Despite researchers and organisations noting that infants are engaging with more screen devices than in previous decades (e.g., Marsh et al., 2015; OECD, 2020), the current findings provide empirical evidence of the various screen devices that are being engaged with by this age bracket, and the prevalence in which they are being used in the early home environment.

The chi-square tests also showed that the infants' and toddlers' screen use varied significantly from the screen use habits of the older age groups, and so, statements on the influence of early screen use from studies on pre-schoolers and older children's screen use should not be inferred to infants. This highlights the need for more specificity around different ages and developmental stages in the literature to avoid broad statements on the psychological influence of children's screen use. Early childhood is one of the most rapid periods of development during the lifespan and represents a critical period in cognitive and socio-emotional development, which plays a key role in later academic and personal success (High, 2008). Therefore, future screen time researchers should acknowledge and include infants when assessing the influence of various early screen uses on development, as they remain an under-researched group.

Study 5 also explored if the children's screen use influenced cognitive and socio-emotional developmental scores. Given that only screen time was measured at age 3 in the GUI Study, these analyses provided an opportunity to explore how various aspects of screen use may influence psychological development at a younger age. The ANOVA tests showed that both screen activity and time had an influence on the attention scores for the children in the current sample. In relation to screen activity, those who mostly played educational games had significantly higher attention scores than those who mostly watched educational TV. This finding is of interest as there is little existing research to suggest that educational games could be beneficial for attentional ability in young children. However, more research is needed to investigate this area further.

For older children, educational and prosocial video games have been found to improve socio-emotional skills in some studies (e.g., Greitemeyer & Osswald, 2010; Whitaker & Bushman, 2012). However, there has been a negative portrayal of digital games when it comes to their influence on the development of social skills and adjustment, with past research emphasising the negative influence of video games on conduct problems (Anderson & Bushman, 2001). Madigan et al. (2020) also found in a meta-analysis of 42 studies, that educational TV programmes were associated with improved children's literacy and mathematic skills, but included no measure for educational apps or digital games.

In research with preschool children, Thakker et al. (2006) found some evidence that viewing cartoons has a negative effect on attentional abilities. However, this was not compared to other types of screen activities. In a more recent study, Huber et al. (2018) measured children's working memory and impulsivity before and after either watching an educational TV programme, playing an educational app, or watching an entertainment TV programme. Similar to the current findings, the children who engaged with the educational games had improved working memory in comparison to the other two groups, and lower impulsivity in comparison to the entertainment TV group. While this supports the current findings, Huber et al.'s (2018) study contained no measure of attentional ability. Additionally, the above studies did not assess incidental engagement with educational content but rather compared the influence of educational content on development in a controlled setting.

Interestingly, the R^2 values in the regression model reported in Study 5 suggest screen time to be the variable that contributed most to the model, while the ANOVA tests showed that the type of screen devices had no influence on early development. This contrasts with the growing body of research on screen content and devices that suggests these factors to be important aspects of screen use in moderating its influence on early developmental outcomes. In a paper assessing children's use of touchscreen devices, Konok et al. (2021) conducted a cross-sectional and experimental study where 40 4- to 6-year-olds were separated into groups (pre-existing high touchscreen use, experimentally induced touchscreen use, and little/no use), with their attention levels later assessed. The findings showed that the children in the former two groups had lower divided, and higher selective, attention in comparison to the third group. The advantage of the higher selective attention was however eliminated if the content was fast paced, suggesting entertainment games may be associated with worse attentional outcomes than educational games, or the non-digital games that were present in the third condition.

These findings were similar to Poulain et al. (2018) who found that pre-schoolers who mostly used digital devices during screen time showed higher conduct problems and more signs of hyperactivity and inattention than children who did not use these devices. The children's behavioural difficulties were measured using the SDQ, with multiple logistic regressions also showing TV viewing at age 3 years to have no association with behavioural difficulties, which is somewhat in line with the current findings. A possible reason that no differences were seen in the children's developmental scores for the various screen devices and activities could relate to the small sample sizes observed for certain activities and devices, and so, these screen use factors could not be explored across the age brackets in greater depth. This is a main limitation to the current study, and so future researchers should consider including such measures of screen use in the design of larger cohort studies with a representative sample.

A further limitation relates to the cognitive measures used in the current study, with these measures being parental report as opposed to administered battery tests with the children themselves, as used in the GUI Study. This could also explain why the findings relating to screen use and development from the Study 5 did not replicate the cross-sectional findings reported in Study 1 using the GUI data. However, it is important to note that different cognitive abilities and age ranges were included in Study 5, which may have led to these differences. Additionally, the smaller sample size may have meant that the small effect sizes reported in the similar analyses in previous chapters were too small to be observed in the current chapter.

Despite these limitations, the current analyses explored an area that is under researched in the screen use literature, that being screen use habits in very early childhood and its associations with psychological development. While TV screen time was measured at the age of 3 years in the GUI Study, the findings reported above provide a more fine-grained investigation of the prevalence and type of screen use by infants and toddlers. This data serves as an extension to the findings reported in the previous chapters by including further measures of screen use (i.e., activity, content, and device), while also addressing the gap in knowledge of infant's screen use habits in the home. Therefore, the current study provides a unique contribution to the literature and with theoretical implications regarding the importance of separating developmental stages when assessing the influence of screen use on early development. A further strength of the research within this chapter is the inclusion and exploration of further ecological factors that were not measured in the GUI Study, such as parental screen beliefs and parental engagement during early screen use, which were reported in Study 6.

The associations between screen use factors and parental factors

Study 6 explored factors associated with screen use habits in young children, namely parental screen beliefs and the frequency of parental engagement during screen time in the home. The descriptive statistics showed that more parents believed that TV could support their children learning (47.8%) than digital games could (27.2%), and that the latter belief did statistically differ based on the children's age. These findings may explain why more children were exposed to TV programmes than digital games, as noted in Study 5.

The percentage of parents who believed TV to have educational benefits was somewhat higher than what has been reported in past research. For example, Zimmerman et al. (2007b) found that 29% of parents believed television viewing was good for their infant's brain and stated the largest reason they allow their infants screen time was because they believed TV to be educational. In a nationally representative study, Rideout and Hamel (2006) reported that 42% of parents with children under the age of 6 years indicated that television helps children's learning. Interestingly, when asked about infant-directed and educational TV shows specifically, Duch et al. (2013a) found that 84% of parents believed these had a positive effect on their children's learning. Vandewater et al. (2005) also reported that caregivers who believe television to be educational are twice as likely to leave televisions on for large portions of the day. However, these studies did not explore parent's perceptions of other screen activities, nor did they explore whether these parental beliefs were associated with their children's screen use.

A more recent European-wide study by Miguel-Berges et al. (2020) assessed parental perceptions of pre-schooler's television viewing and its association with their total screen time. However, the measures used related to whether parents set rules around screen time rather than assessing whether they believed screens to have educational value. The findings showed that the children of parents who set screen time rules in the home spent less time using screens. However, based on previous research, little was known about whether parents' beliefs on the educational value of TV and digital games influences the prevalence and type of early screen use in the home.

In Study 6, the bivariate correlations showed that the children's daily screen time was significantly associated with parental beliefs, where children had more screen time if their parents agreed with either of the screen belief statements, consistent with previous findings (e.g., Vandewater et al., 2005). Chi-square tests revealed that children of parents who believed digital games could support their child's learning engaged more with educational games and educational TV. Children's touchscreen use was also positively associated with these beliefs. Spearman's rho tests also showed significant positive correlations between weekly engagement with educational content and parents' agreement levels on both the TV and digital games statements.

These findings are consistent with Egan and Beatty (2021) who conducted research during the Covid-19 pandemic with school-aged children aged 5 to 10 years. Their finding indicated that parental screen beliefs were positively associated with the amount of time their children spent engaging in educational screen content during the lockdown period. In a systematic review of early screen use correlates, Duch et al. (2013a) stated that while ecological factors such as the level of cognitive stimulation in the home and maternal mental health have been widely explored and associated with early screen time, parental screen beliefs have not been examined with enough frequency to draw conclusions. Additionally, little research to date has assessed parental beliefs on screen activities outside of television viewing, illustrating how this study contributes novel empirical-based findings on this early screen use factor.

As parental screen beliefs were shown to be associated with the frequency and type of early screen use, it was important to assess whether these beliefs were also associated with the frequency of parental engagement during screen time. Parental engagement during screen time has been shown to reduce socio-emotional risks related to screen time (Christakis et al., 2013; Gentile et al., 2014) and increase language use during television viewing, resulting in higher language development (Neumann & Neumann, 2014). In their review, Linebarger and Vaala (2010) also suggested parental engagement during screen use to be one of the most important ecological factors for infants' learning during screen use to take place. In addition to this, parental engagement during screen time was noted to be an important aspect of the screen time classifications for promoting positive digital behaviour for children, and social connectedness (Blum-Ross & Livingstone, 2016). However, while parental engagement has been shown in the literature to be an important aspect of screen time for positive developmental outcomes, a more fundamental question relates to the frequency in which parental engagement happens in the home and what factors are associated with it. Despite these engagement levels being noted as an important screen time factor, the naturalistic incidental rates of parental engagement in the early home environment has not been widely reported on in the previous literature.

The findings in Study 6 indicated that the majority of parents did engage with their children during screen time, with at least 63% of parents engaging on a weekly basis. However, chi-square tests revealed that certain factors were associated with the frequency of engagement. The children's age was the main factor associated with parental engagement, with parents engaging during screen time significantly more if their child was younger than 3 years. At least 86% of these parents indicted that they engaged with their child during screen time 'everyday', while parents of older children were more likely to indicate that they engage with their child 'sometimes' during screen time. The youngest age bracket was also the only age bracket to always be supervised while playing digital games, if they played every day. Screen activity was a further influencing factor in the frequency of parental engagement in the home, where parents were more likely to engage with their child during TV viewing than playing digital games. 10 to 16% of all parents in the study indicated that they never engage with their child during TV viewing, while 25 to 37% said they never engage with their child while they play digital games.

Interestingly, the findings showed that parental screen beliefs were also associated with the parents' frequency of engagement. The analyses showed that the more in agreeance parents were with whether TV or digital games could support learning, the more frequently they engaged with their children during all screen time activities. The *Cramer's V* values showed this was especially true for entertainment content. The overall findings of Study 6 therefore indicate that parent screen beliefs and screen time engagement have a symbiotic relationship, where the more positive beliefs parents have on early screen time the more likely their children are to view educational content, and the more likely they are to have a parent engage with them during screen time when viewing entertainment content.

This is a positive finding in light of the previous research on parental beliefs that has suggested that positive parental perceptions of screen use may be negative for early development. For example, Ruangdaraganon et al. (2009) stated that despite the research available on the negative influence of entertainment TV at an early age, infants may be exposed more to this type of screen content if their parents believe TV to have developmental benefits, and therefore do not consider types of programming. Researchers have also investigated how screen time interferes with language development when there are no interactions between young children and their caregivers during screen time (Tanimura et al., 2007; Chonchaiya & Pruksananonda, 2008; Christakis et al., 2019). However, as parental beliefs and engagement were analysed together in Study 6, the findings show that the parents in the current study were more likely to engage with their children during screen time (especially when engaging in entertainment content) if they had positive screen beliefs, and their children were also more likely to be exposed to educational games if they had positive beliefs on digital games.

The findings of Study 6 are of importance given that little research has been conducted on the frequency that parents engage with their young children's during screen time in the home and the factors that may be associated with this frequency. Furthermore, no studies to date have compared parental engagement rates across various screen activities and age brackets using the same sample of young children. While past research has explored the importance of parental co-viewing for best developmental outcomes during early screen use, the current study provides empirical findings on the rate in which this is happening in the home and the various factors associated with the frequency of this engagement.

As parental screen beliefs have been noted as an aspect of parental supervision or engagement (John et al., 2021), it was also an important ecological factor to explore and was shown in Study 6 to be related to early screen use by children and parental engagement during their child's screen time. This is another novel finding in the screen use literature, with the inclusion of these variables being a clear strength of the current research. By doing so, the findings provide an insight to the ecological factors associated with early screen use within the microsystem, and the associations that these factors also have with each other. This therefore suggests that parental engagement and screen beliefs are both important factors to consider in future research to better understand how such ecological factors may mediate the role of screen use in early development, and to encourage future researchers to continue viewing the role of screen use from an ecological perspective.

The role of ecological factors

The above research findings highlight the usefulness of Bronfenbrenner's bioecological framework, by including ecological factors from the children's microsystem and macrosystem in the analyses. The PPCT research model was also employed in the current studies albeit somewhat differently to the previous chapters. Screen use remained the proximal process being considered in terms of its role in the microsystem of the home environment and in early psychological development. However, the inclusion of a more expanded measure of screen use allowed for a more in-depth understanding of the prevalence of screen use in the home, and the frequency in which infants, pre-schoolers, and young children are engaging in various screen devices, content, and activities. This provided a snapshot of the presence and variety of screen uses in the home of young Irish children today.

Further contextual factors, and their association with early screen use, were explored in Study 6. The findings suggested parental screen beliefs and engagement during screen time to both be related to their child's screen use. Given this, it is recommended that future researchers continue to view early screen use through a bioecological lens and control for the influencing ecological factors within the microsystem of the home environment that have been evidenced in the current research. In addition to this, the environmental factors that have been controlled for in the empirical chapters of this thesis, such as parental educational and economic status, have been shown to mediate families' decision-making around screen use habits in the home (Duch et al., 2013a). This highlights the importance of continuing to control for ecological factors in screen use research.

Although Study 5 and 6 were both of a cross-sectional design, the element of time in the PPCT model was still explored in the current research by including measures that replicated those in the GUI Study, which was also a strength of Study 5. By doing so, comparisons on children's screen use habits could be made across the years 2011, 2013 and 2019. Watching TV remained the activity that the children mostly engaged in despite the possible rise in the prevalence of touchscreen devices available to young children in the home in 2019, in comparison to 2013. These devices were however the second most popular with the children in the current study. While TV was still the most popular source of screen media in Study 5, few children owned their own TV (2.7%) in comparison to touch screen devices (12.3%).

Interestingly, children in the current studies engaged in less screen time overall in comparison to those in the GUI Study, with the majority of children aged 3 years and over in the current chapter engaging in under an hour of screen time daily. These children were also, on average, three times more likely to engage in no screen use at all in comparison to those in the GUI Study. However, there were differences in the demographics across both studies with parents in the current studies being mostly well-educated, full-time workers. This finding would add to the body of literature that shows parent educational level and socio-economic status to be correlates of children's amount of daily screen time (e.g., De Decker et al., 2012; Lauricella et al., 2015). The somewhat homogenous participant sample may also explain why the environmental factors controlled for in the regression models had no significant influence on early development. This is in contrast with the findings in the previous chapters and, most notably, developmental theories and research that have continuously shown parental educational levels and socio-emotional development to influence child development. This is important to note when drawing comparisons across these studies, and highlights cause for more screen use analyses to be conducted on large, representative datasets.

However, being able to make such comparisons and monitor the change of screen use habits over time (with reference to differing participant demographics) is a further use of the bioecological framework, which places importance on the chronosystem. Bronfenbrenner's work on the chronosystem also suggests the child's age to be an important factor to consider when interpreting the influence of certain predictors on developmental outcomes, which was explored using a wider age range (from 6 months to 6 years) in the current studies. The findings in the current studies therefore provide empirical data on the changes in early screen use, across time and age, and the ecological factors associated with this screen use. This may be of particular interest to researchers in this period of rapid technology evolution aiming to create models for healthy screen use in early childhood, which is also a period of rapid psychological development.

Conclusion

The current studies expanded on the findings in previous chapters related to the influence of early screen use in the home on psychological development. Study 5 explored the screen use habits of young children from infancy to early childhood and showed that young children are engaging in a wide range of screen activities and devices in the home. With the exception of attentional ability, the findings from Study 5 did not indicate screen use to influence the children's development scores, although this may be due to the lower sample size in the study compared with that in the previous chapters, and the known small effect sizes that were reported from the GUI study. Study 6 explored the ecological factors of parental screen beliefs and engagement during screen time and found both to be associated with early screen use.

The chapter therefore provides evidence-based findings on early screen use in the home by utilising various screen use measures and the bioecological model as a research framework. These areas have received little attention to date in previous literature, particularly in children aged under 3 years. These findings, in conjunction with those of the previous chapters, provide an ecological and holistic view on early screen use and its influence on early development, contributing to a field of research where more robust and high-quality findings are being more frequently called for. With developmental abilities known to vary starkly between this age cohort and later childhood, it is not possible to infer that the influence of screen use on development reported in the related literature with older children are present in early childhood. Therefore, future research should continue to evidence any influence screen use has on children's psychological development in younger cohorts, as little empirical research on this topic for children under 3 years of age is available. The findings of the current study can be seen as a contribution to this under-researched area.

Chapter 6:

General Discussion

The current research aimed to examine the influence of screen use in the home on early psychological development, namely cognitive and socio-emotional development, and the factors associated with it. To additionally account for the influence of ecological factors across these variables, the research design and methodology was framed by Bronfenbrenner's bioecological model. This provided a framework whereby the role of various aspects of screen use in early development could be examined in conjunction with further important factors such as socio-economic status (SES), individual differences, parental factors within the microsystem, and development over time. Using this framework helped to address methodological flaws that have been identified in previous screen time research, where screen use and developmental researchers have expressed the need for more comprehensive research approaches to improve inferences made regarding the influence of screen use on early development.

Over the course of six empirical studies, screen use in the home was found to have a modest influence on early cognitive and socio-emotional development. However, various factors (consistent with the theoretical framework) such as contextual variables, and time, did mediate this influence. Additional factors such as what aspect of these developmental domains were being measured (e.g., language development, or reasoning or attentional abilities, or socio-emotional difficulties), reverse-causal associations, and varying effect sizes, also need to be considered before drawing conclusions from these findings. The following chapter provides a summary of the main findings while discussing these factors and their influence on interpreting the findings, before considering the implications of these findings for research, theory, and practice. Suggestions for future research and avenues for the incorporation of Bronfenbrenner's work in screen time research are also discussed along with the strengths and limitations of the current research.

Summary of main findings

The main research questions explored across the three empirical chapters in this thesis were:

1. What cross-sectional influence does early screen use have on various measures of cognitive and socio-emotional development?
2. Does screen time have a longitudinal influence on these psychological development measures?
3. Do the findings remain significant after controlling for ecological factors (e.g., families' socio-economic status, parental education attainment, and parent-child closeness)?
4. What other ecological factors are associated with early screen use (e.g., parental engagement/screen time beliefs, and children's age)?

In order to explore these questions, data relating to screen use variables, standardised measures of development, and environmental factors, were firstly analysed using data from the Growing Up in Ireland (GUI) Study (reported in Chapters 3 and 4). Additional measures of early screen use, and parental factors that may be associated with this, were also designed and analysed as part of the Play and Learning in the Early Years (PLEY) Study (reported in Chapter 5). Table 36 summarises the main findings to these research questions, the study in which each research question was addressed, and the analytical approaches used to explore these questions.

Table 36. Summary of the main findings related to each research question (RQ).

RQ	Study and analytical approach	Main finding
RQ 1	Study 1 (ANOVA tests and regression models)	**Finding 1:** Screen time of 3 or more hours per day resulted in lower reasoning scores for the 5-year-olds in the GUI Study, and mostly engaging in a mix of all screen activities resulted in higher reasoning scores. **Finding 2:** Screen time had no influence on language scores*, but mostly engaging in video games resulted in lower language scores.
	Study 3 (ANOVA tests and regression models)	**Finding 3:** Screen time of 2 or more hours per day resulted in higher internalising and externalising scores, and lower prosocial scores, for the 5-year-olds in the GUI Study. **Finding 4:** Mostly engaging in video games resulted in higher internalising and externalising scores.
	Study 5 (ANOVA tests and regression models)	**Finding 5:** Screen time of more than 2 hours per day resulted in lower attentional scores for the children in the PLEY Study. **Finding 6:** Mostly engaging in educational games resulted in higher attentional scores for the children in the PLEY Study.
RQ 2	Study 2 (Odds ratio tests and regression models)	**Finding 7:** Screen time had no longitudinal influence on the 5-year-olds' reasoning and language scores, despite reverse-causal associations being present*.
	Study 4 (Odds ratio tests and regression models)	**Finding 8:** Screen time only had a longitudinal influence on the 5-year-olds' internalising scores, despite reverse-causal associations being present*.
RQ 3	Study 1 – 5 (Regression models)	**Finding 9:** Findings 2, 7, and 8 were altered after ecological factors were considered, where the role of screen time changed from having a significant influence on the measures of language development, externalised behaviour, and prosocial behaviour to having no significant influence. **Finding 10:** In Studies 1 to 4, ecological variables accounted for much more of the variance in developmental scores than the screen use variables, illustrating their importance.
RQ 4	Study 5 (ANOVA tests and regression models)	**Finding 11:** Age influenced screen use, as children under the age of 3 years were more likely to engage in educational content, video calls, and have under 30 minutes of screen time per day than the older children in the PLEY Study.
	Study 6 (ANOVA tests, chi-square tests, and bivariate correlations)	**Finding 12:** Age influenced how often parents engage with their children during screen time, as children under the age of 3 years had the highest frequency of weekly parental engagement. **Finding 13:** Children were more likely to engage in more daily screen time, educational content, and use a tablet if their parents had positive screen beliefs. **Finding 14:** Parental screen engagement and beliefs were related, as parents with positive beliefs were more likely to engage with their children while viewing entertainment content.

***See Finding 9.**

Each of the studies within the three empirical chapters of this thesis provided insight into the role of early screen use in various aspects of development, along with the ecological mediating variables. When the findings are considered together, they allow for conclusions to be drawn regarding the role of screen use in early childhood development from an ecological perspective, some of which are discussed below.

Screen activity may have more of an influence on cognitive development than screen time

The first research question of interest related to the cross-sectional influence of early screen use, and therefore the first main conclusion from the findings addresses the cognitive development aspect of this research question. The findings from the current research suggest that the type of screen activity that children engage in may play more of a role in cognitive development than screen time itself. This was illustrated in Study 1, which explored the influence of both screen time and activity on reasoning ability and language development for the 5-year-olds in the GUI Study. The initial cross-sectional ANOVA tests found both screen time and activity to play a role in the 5-year-olds' development scores. However, after controlling for the environmental variables in the regression models, screen time no longer had a significant influence on language scores, while screen activity did – specifically, those who mostly played video games had lower languages scores compared to the other screen activities. While both screen factors remained significant for reasoning ability, the β coefficients in the regression model show that the influence of screen activity on reasoning scores remained relatively unchanged in the final model, while the influence of screen time became less.

Study 5 also explored the role of screen time, activity, content, and device in the language development and attentional ability of the children (aged 6 months to 6 years) in the

PLEY data. In contrast to the findings in Chapter 3, the ANOVA tests showed that the children's screen use had no statistically significant influence on language development. However, both screen time and activity did have an influence on attentional scores. The regression was similar to the reasoning regression model in Study 1 where the β coefficients showed the influence of screen activity (specifically, those who mostly engaged in educational games had higher attentional scores in comparison to the other screen activities) to remain relatively unchanged in the final model, while the β coefficient values for screen time showed its influence to be less once environmental factors were controlled for.

The findings of Study 1 and 5 are similar to past research on early screen time and cognitive development where screen time for over 2 hours a day has been noted to have a negative influence on language and attention scores (e.g., Christakis et al., 2014; Zimmerman et al., 2007a; Duch et al., 2013b). While there is a scarcity of past research comparing the influence of screen time with screen activity when assessing their role in cognitive development, research with older children has also shown screen activity to influence cognitive ability. For example, Yang (2012), Fessakis (2013), and Fisch (2014) all found digital games to benefit problem-solving and mathematical abilities. Spence and Feng (2010) also found playing video games improved cognitive abilities, such as multi-taking and spatial awareness, more than playing puzzle games.

Research with younger children has also shown this to be the case for language development. Neumann (2018a) found the use of an educational app-based game to improve pre-schoolers' literacy skills more than traditional teaching methods, while Linebarger and Walker (2005) found watching educational TV programmes influences word fluency. The current findings contrast with these studies, as digital games had a negative influence on language and reasoning development in comparison to the other screen activities in Study 1. However, educational games had a positive influence on attentional ability in comparison to the other screen activities in Study 5. Despite this, screen activity still remained a significant contributor to both cognitive measures while screen time did not for language scores and was mediated more by environmental factors than screen activity in the final regression models.

In addition to screen time having less of a cross-sectional influence on cognitive development, screen time was also shown to have no meaningful longitudinal influence. This was illustrated in Study 2, which explored whether screen time at age 3 years had a lasting influence on both reasoning and language development at age 5 years, while also assessing any reverse-causal associations. The initial odds ratio tests found that for reasoning ability, there was no causal longitudinal association between screen time at age 3 years and reasoning scores at age 5 years. The reverse-causal association was significant; however, this was not the case in the regression analyses, which showed no significant longitudinal associations between screen time and reasoning ability when environmental factors and baseline screen time and developmental scores at age 3 years were controlled for.

In relation to language development, while the odds ratio tests showed significant longitudinal association with screen time to be significant, the following regressions again showed this causal longitudinal association to be non-significant in the second model, indicating that screen time does not predict later language development when baseline language scores are accounted for. Interestingly, the reverse-causal association remained significant in the final regression model showing that language ability does influence later screen time after controlling for baseline screen time and environmental factors. These longitudinal findings would suggest that screen time at age 3 years has no meaningful relationship with later cognitive development, however language ability does have an influence on later screen time where higher language scores were associated with lower later screen time.

While little research has explored the reverse-causal associations between screen use and developmental scores, these findings are in line with Wright et al. (2001) who found early cognitive skills relating to reading ability and vocabulary development to be a predictor of later screen use. However, the findings contrast with a more recent study by Madigan et al. (2019) where screen time was found to be a predictor of later cognitive ability. Despite this, both studies found bi-directional associations, indicating that screen use did have a longitudinal influence on development while the current research only reported a revere-causal association for language development. The overall findings on cognitive development show that screen activity may have more of an influence on scores than screen time cross-sectionally, with screen time also having no influence longitudinally, despite it appearing significant in the initial ANOVA and odds ratio tests. This highlights the importance of considering ecological factors to best understand the role that screen use has in early cognitive development. These factors were also shown to be important when drawing conclusions on the influence of screen time on socio-emotional development.

Screen time and activity both influence socio-emotional development, but mostly cross-sectionally

The second research question of interest related to the longitudinal influence of early screen use on development, and therefore the second main conclusion addresses the socio-emotional development aspect of this research question. The current findings suggest that children's screen time and the activity they mostly engaged in during this time may both play a role in their socio-emotional development. This was illustrated in Study 3, where the 5-year-olds' screen time in the GUI Study was shown to influence all measures of concurrent socio-emotional development in the initial ANOVA tests. The screen activity the children mostly engaged in also had an influence on their internalised and externalised behaviour, with those who mostly engaged in video games scoring higher on these scales than those who mostly watched TV/videos or engaged in a mix of all activities. The regression models showed that all of these findings remained unchanged in the final models, although the β coefficients for screen time showed its influence on all socio-emotional measures to be less once environmental factors were controlled for. However, these cross-sectional findings in Study 3 contrasted with those in Study 5, which found that the children's screen use had no cross-sectional influence on socio-emotional development.

The findings from Study 3 are similar to past research that has explored the influence of screen time on socio-emotional development. For example, Zimmerman and Christakis (2007) and Kano et al. (2007) both found higher amounts of early screen time to be associated with externalising difficulties. However, studies that have measured screen time more recently have found screen time to have no association with socio-emotional development when engaged in for under 7 hours a day (e.g., Kardefelt-Winther, 2017; Przybylski & Weinstein, 2019), which aligns more with the findings for Study 5. Interestingly, Study 5 also used data that measured screen time more recently than the data in Study 3. Therefore, it may be the case that contemporary screen time potentially has less of a negative influence on socio-emotional development than screen time 10 years ago due to wider range of educational content and activities available for young children.

In relation to video games and their negative influence on internalised and externalised behaviour in Study 3, these findings are in contrast to some research discussing how screen-based game play can positively influence socio-emotional development in later childhood (e.g., Passmore & Holder, 2014; Sanders et al., 2019; Saleme et al., 2020). Research with older children has also found TV watching to be more associated with externalising symptoms than playing video games (e.g., Przybylski & Weinstein, 2017; Sanders et al., 2019). Given the contrasting findings to the current research, this suggests that video game may be more beneficial for older children than those in early childhood. This highlights the importance of measuring screen use factors at various developmental stages as the role screen activity has in socio-emotional development may differ based on age.

While screen use was shown to influence socio-emotional development cross-sectionally, early screen use may have little longitudinal influence on this developmental domain. To illustrate this, Study 4 revealed that the cross-sectional odds ratio tests had higher significance values than the longitudinal odds ratio tests, for all socio-emotional measures. Although, these tests did show the causal and reverse-causal longitudinal associations for all measures to be significant. The regressions conducted to further explore these longitudinal associations found that both longitudinal associations for internalised behaviour remained significant after controlling for baseline development scores, screen time, and environmental factors. However, only the reverse-causal associations remained significant for externalised and prosocial behaviour after these control factors were included. The overall findings on socio-emotional development therefore show that screen use has more of a cross-sectional influence on socio-emotional development, after contextual factors are considered, in comparison to a longitudinal influence. The reverse-causal findings also highlight baseline socio-emotional behaviour to be more of a predictor of later screen time rather than screen time being an initial causing factor of later socio-emotional development scores.

The findings of Study 4 are in line with recent research that has shown significant cross-sectional associations between screen time and externalising scores to not be replicated longitudinally (e.g., Levelink et al., 2021). However, in direct contrast with the current findings, previous research has found screen time to have longitudinal associations with both externalised and prosocial behaviour (e.g., Cheng et al., 2010; Chonchaiya et al., 2015). Despite this, these studies did not explore directionality. Studies that have explored this have found that early externalised behaviour may be more of a predictor of later screen time rather than screen time being a predictor of socio-emotional difficulties (e.g., Stevens & Mulsow, 2006; Ebenegger et al., 2012). This would be in agreeance with the current findings as longitudinally, only reverse-causal associations remained in the final externalised and prosocial behaviour regression models. Research with older children has also found baseline developmental scores to influence later screen time (e.g., Heffer et al., 2019; Coyne et al., 2020). While this was not the case for internalised behaviour, it is difficult to draw parallels between this finding and other studies as little research has explored the longitudinal association between screen time in early childhood and socio-emotional development outside of externalised behaviour (Liu et al., 2021).

Finally, when comparing the R^2 values from the regression models across Study 1 to 4, it can be seen that screen time had more of an influence on the 5-year-olds' socio-emotional development than cognitive development. Internalised behaviour also had the only significant causal association in the final regression models for all the developmental measures. These findings highlight the varying influence screen use has based on the developmental domain being measured and the inclusion of ecological factors such as time and baseline differences. This illustrates the importance of considering various developmental measures when assessing the role of early screen use in development, in conjunction with the varying contextual factors within the children's ecological systems as outlined by the bioecological model.

Ecological factors are important in considering the influence that early screen use has on development

The final research questions of interest related to the role of ecological factors and their relationship with early screen use in the home. Therefore, the final main conclusion addresses the importance of exploring the influence of screen use in the home on early development from an ecological perspective. The findings show ecological factors are important to consider when assessing the influence of screen use on development. This was initially illustrated in Study 1 and 2, where accounting for environmental factors in the regression models showed that they mediated the influence of early screen time on language development, both cross-sectionally and longitudinally. In Study 4, these factors mediated the longitudinal influence of screen time on later externalised and prosocial behaviour. Controlling for these factors also allowed for their influence on the developmental measures in comparison to the screen use variables to be seen. For example, in the cognitive development regressions in Study 1, the largest β coefficient values observed was for household income, while for the socio-emotional regressions in Study 3 this was parent-child closeness. Furthermore, the environmental factors accounted for far more of the variance in the 5-year-olds' developmental scores than the screen across these studies.

Similar to these findings, studies that have explored the role of screen time with older children have found SES and maternal factors to mediate the influence of screen time on both cognitive and socio-emotional development (De Decker et al., 2012; van Egmond-Fröhlich et al., 2012; Schmiedeler et al., 2014; Lauricella et al., 2015). Longitudinal studies with older children have also found this to be the case. For example, Ferguson (2011), Willoughby et al. (2012), Breuer et al. (2015), and Etchells et al. (2016) all conducted longitudinal studies that accounted for baseline environmental and family factors, along with video game use. After controlling for these factors and time spent on various types of screen activities, it was found across all studies that video games had minimal influences on well-being and socio-emotional health in later childhood and adolescence.

The findings are also in line with Chonchaiya et al. (2015) who showed that TV viewing in infancy accounted for little variance in socio-emotional difficulties compared to wider environmental factors. The effect size of screen time on socio-emotional development has also shown to be small in more recent studies (e.g., Kostyrka-Allchorne et al., 2020), with parental factors mediating its influence in some cases (e.g., Kühhirt & Klein, 2020). The current findings would also be in agreeance with that proposed by developmental theorists Bowlby (1980) and Vygotsky (1978) who suggested parent-child closeness to be an important factor in socio-emotional development. As this variable had the largest β coefficient values in all socio-emotional regression models, this illustrates the importance of considering the ecological factors that may influence early development when measuring the role of screen use on development.

Study 5 also included the ecological factor of age and expanded on the findings from the GUI data by exploring screen use in the home with a larger age range and using more fine-grained measures of screen use. Screen use factors (including screen device, activity, content, and time) did significantly differ based on age, where children under 3 years of age were more likely to engage in educational content and have less daily screen time. This is a positive finding as past research has suggested educational screen content to have beneficial outcomes for early development, with educational TV programmes scaffolding language and social development (Linebarger & Walker, 2005; Conners-Burrow et al., 2011; Mares & Pan, 2013). More recent research has continued to show the cognitive developmental benefits of engaging in educational screen content from an early age (Herodotou, 2018; Huber et al., 2018; Madigan et al., 2020). This was also shown in the Study 5 where educational games had a positive influence on attentional abilities.

The device mostly used to engage in these activities did not differ across the age brackets, with TV being the most popular device for all the children, followed by touchscreens. Nearly one-quarter of parents with children under the age of 3 years indicated touchscreens to be the device mostly engaged in during screen time. These findings are of importance as little research has been conducted on the prevalence and type of natural and incidental screen use happening in the home for infants, outside of TV watching (Cheng et al., 2010; Tarasuik et al., 2017; Wilkinson et al., 2021). The findings illustrate the high rate of various screen uses by very young children, providing knowledge on infant's screen time and how they spend it. This is important for child advocacy and health organisations to consider when advising parents on best screen use practises in the home.

The current research also found that ecological variables in addition to age, such as parents' screen beliefs and parental engagement during screen time, may be associated with early screen use. This was illustrated in Study 6, which explored the associations between screen use factors and these ecological factors. The findings showed that more parents agreed that TV supports their child's learning (47.8%) than digital games (27.2%). However, both beliefs significantly influenced the children's screen use as both screen time and engagement with educational screen content was higher if their parents agreed with the statements. These beliefs were also associated with the frequency in which parents engaged with their children during screen time. There was a positive association between how much parents agreed with these statements and the frequency in which they engaged with their child during these screen activities on a weekly basis, especially for entertainment content.

Parental engagement during screen time also significantly differed based on the children's age and the screen activity being engaged in. The results indicated that all parents engaged in screen time with their infants every day if playing digital games, and at least 86% engaged with their infant while watching TV every day. At least half of the parents with children aged 3 and 4 years old also engaged with them during screen time every day. However, parents were more likely to engage in all screen activities with their children everyday if their children were under 3 years of age. This dropped off as the child matured, highlighting a potential scaffolding approach during screen time.

These findings highlight how parents in this study had high levels of engagement with their child during screen time, and the scaffolding approach observed is in line with best developmental practice as recommended by theorist Vygotsky (1978) and early screen time researchers. For example, research has shown that children's learning using touchscreen devices can be maximised by educators through joint screen engagement (Takeuchi & Stevens, 2011). This helps build opportunities for language development and fosters collaborative social learning (Neumann & Neumann, 2014). Other research suggests that parental presence and engagement is an important factor that could mitigate potential socio-emotional risks of screen time (e.g., Kirkorian et al., 2008; Christakis et al., 2013; Gentile et al., 2014). It is therefore positive that one of the main findings of Study 6 was that children under 3 years of age had the most parental engagement during screen time.

In relation to screen beliefs, the findings are similar to the findings of Vandewater et al. (2005) and Egan and Beatty (2021) who also found parents' positive screen beliefs to be associated with higher screen time for their children. However, parental screen beliefs is not an ecological factor that has been widely explored in the screen time research, with no research to date assessing its association with children's screen use factors and other ecological factors such as parental engagement and children's age. The findings from Study 6 further highlight the importance of assessing screen use form an ecological perspective, and the various ecological factors within the microsystem of the home that are associated with early screen use. The overall findings on the role of ecological factors show that factors from the micro, macro, and chronosystem are important to control for when exploring the unique contribution screen use has on early psychological development, and the factors that may be associated with it. The importance of these findings and the previously discussed findings have various research, theory, and practical implications, which are discussed below.

Implications of the findings

Research implications

The current research provides many novel contributions to the screen use literature. Broadly, the influence of early screen use on various psychological domains within a representative cohort sample has not been largely explored in past research. The current research allowed for an exploration of the role of screen use in various developmental domains, both cross-sectionally and longitudinally. Additionally, findings could be reported on domains that have not been widely measured in the existing literature. For example, little research has been conducted on reasoning ability and how early screen use may influence this.

While language development and early screen time have been widely measured together, the novel findings on this developmental domain related to the role of screen activity, as little research has compared the varying influence different screen activities have on language development in a young sample. Measuring the screen activity that the children mostly engaged in showed it to be important as the negative influence video games had on language scores remained significant in the final regression model, while screen time itself (both cross-sectionally and longitudinally) did not. This allowed for inferences on the role of screen use in early language development to be made when this would not have been possible if only the amount of daily screen time was measured. The implications of these cognitive findings for future research lie in showcasing the importance of including various measures of screen use, and not solely screen time, when assessing the role of screen use in early development. This is in line with the screen time classifications (Sweetser et al., 2012; Blum-Ross & Livingstone, 2016), which called for researchers to consider elements of screen use (such as activity, content, and context) to produce more holistic findings.

In recent years, there have been debates on research conclusions on the role of screen time in adolescents' development, where researchers have critiqued the methods of measuring screen use (e.g., Ellis, 2019; Orben & Przybylski, 2019; Coyne et al., 2020). These researchers have noted that many of the well-known studies on this topic relied on too crude of measures where often only one measure of screen time and one measure of well-being were assessed together. They suggest that this resulted in problematic conclusions in the screen use and youth mental health research. The current finding further showcases the importance of including multiple measures of development, even within the same domain (i.e., cognition), as early screen use had varying contributions to the reasoning, language, and attention developmental scores. Future research should therefore be cautious in making inferences on the influence of screen use on general cognitive development if only measuring specific areas of this developmental domain.

Novel findings were also produced in the studies that explored the influence of early screen use on socio-emotional development. While much research exists on the negative influences of early screen use on externalised behaviour, research exploring the associations between screens and internalised and prosocial behaviour is less prevalent. The little research that exists has only observed the influence of early TV viewing (e.g., Pagani et al., 2013; Przybylski & Weinstein, 2017), or digital games with older children (e.g., Kovess-Masfety et al., 2016). As in the studies on cognitive development, a unique research contribution of Study 3 and 4 was the measurement of multiple aspects of socio-emotional development, which has been rarely reported within the same sample in the literature. This research approach is of importance as the findings produced in these studies highlighted the necessity of separating aspects of both screen use and developmental domains to produce more accurate statements on the influence of early screen use. They also provide empirical evidence on what role screens have in the under-researched areas of internalised and prosocial behaviour.

This is a note-worthy research contribution as internalised behaviour was the only developmental measure that screen time had a longitudinal influence on in the final regression models. This has implications for future research as it suggests the association between early screen use and internalised behaviour may be an important area that requires further research. This is particularly of interest given the rise in internalising problems reported in young children since the onset of Covid-19 (e.g., Adegboye et al., 2021). It should also be noted that research has found that young children are spending more time on screens since the international lockdowns resulting from the global Covid-19 pandemic (Nagata et al., 2020; Egan & Beatty, 2021; Sultana et al., 2021). This increase and change in screen use for many children may be a contributor to some of the increase in psychological issues reported. This increased screen use may also have various longitudinal influences on their psychological development that vary from the current findings, and so further research in this area is warranted to keep the discourse in this field of research current.

With the exception of internalised behaviour, screen time at age 3 years was ultimately not found to be a significant causal factor in the children's development age 5 in Study 2 and 4. As researchers have noted the absence of causal direction testing in screen time research (e.g., Orben & Przybylski, 2019; Hollenstein & Colasante, 2020), this suggests a further research implication of the findings in the current studies. Research with older children that have controlled for directionality have found that pre-existing developmental risks influence problematic media use, with screen time not being a causing factor of developmental outcomes (Heffer et al., 2019; Coyne et al., 2020). The few studies discussed throughout the thesis that have considered causality with younger cohorts have reported similar results (e.g., Wright et al., 2001; Ebenegger et al., 2012; Ansari & Crosnoe, 2016), however none to date have done so with multiple measures of development and influencing ecological factors, within the same prospective sample. More robust longitudinal research using prospective cohorts is therefore encouraged to further investigate the directionality of early screen use and psychological development.

Research has also discussed the importance of both significance testing and reporting of effect size in screen time research to avoid misleading interpretations of the findings (Ferguson & Colwell, 2017; Kardefelt-Winther, 2017). This is also consistent with the views of Ferguson (2015) and Etchells et al. (2016), who suggested the need for transparent communication of effect sizes and the role of mediating factors such as environmental factors in screen time research. It is therefore important to note the various effect sizes related to the influence of early screen use in the current research. As mentioned in the summary of the main findings, the R^2 values reported in Study 1 to 4 show that screen use accounted for very little of the variance in the developmental scores despite being significant contributors to the regression models. Furthermore, their contribution to the developmental scores were much smaller than that seen for the environmental factors. By statistical standards, the results show that the 5-year-olds' screen use is associated with their concurrent developmental scores, yet these effects are modest in comparison to other ecological factors. Given this, it is recommended that future screen time researchers also conservatively interpret their results as the current research shows that reporting p values alone may suggest a stronger effect than that shown by the coefficients. This also has implications for policymakers and children's advocacy organisations.

While Foster and Watkins (2010) highlighted that much research has been done on ecological correlates of screen time within the macrosystem (e.g., neighbourhood safety, and family ethnicity or socio-economic status), further research has shown factors within the microsystem such as parental factors have been less explored (e.g., Duch et al., 2013a; John et al., 2021). Tarasuik et al. (2017) also noted that historically, studies on screen use outside of TV viewing have not been conducted with children under 5 years of age due to the required cognitive and motor skill prerequisites needed for traditional computer use. The exploration of these factors in Study 5 and 6 therefore contributes novel empirical findings on the frequency of parental engagement during screen time in the home, and the associations between this and parental screen beliefs and early screen use. This further highlights the importance of including expansive measures of early screen use in future research to gain a more in-depth empirical understanding of the influence that various screen uses have on early development. The inclusion of the variables explored in both Study 5 and 6 is in line with past research, and the latest suggestions in the field (e.g., Straker et al., 2023), that call for the consideration of screen activity and content in screen time analyses, along with the connections being encouraged during screen time. As a result, the final implication of these findings for future research is to consider adopting a research model that is informed by these suggestions, such as the bioecological model.

Based on the varying findings on the role of early screen use across the studies in this thesis, screen use does seem to have an influence on the measures of development used in the current research, although to varying degrees. For example, screen activity had more of an influence on the cognitive measures than screen time, while screen time and activity both had significant influences on the socio-emotional measures but mostly only cross-sectionally. Therefore, the current research shows that the mixed findings on screen use currently reported in the literature may be due to researchers measuring various developmental domains and elements of screen use across various samples. Additionally, while some studies have controlled for contextual factors that may mediate this screen use's influence, others have not. The various study designs used across the past research also make it difficult to filter out other influences or show causation. As a result, the inconclusive findings reported in the previous research are of no surprise.

The current research shows that there are many different moving parts that need to be accounted for when considering the role of early screen use in psychological development, as screen time does not occur in a vacuum void of other influencing ecological factors. However, the use of a bioecological model to frame the research approach and design was successful in capturing some of the various cogs at work in the analyses. It is therefore suggested that future screen time and development researchers adopt an ecological perspective in their research design to create more robust and holistic inferences on the role of early screen use in child development.

Theoretical implications

An important aspect of the current research is that it contextualises screen use within a bioecological theory, namely Bronfenbrenner's bioecological model, in a way that has not been demonstrated in the literature to date. Utilising this theoretical framework to understand the role of early screen use in psychology development was important in accounting for contextual effects. The use of the Process-Person-Context-Time (PPCT; Bronfenbrenner & Evans, 2000) research model also provided an analytical framework for this to be achieved.

As mentioned in Chapters 3 and 4, the bioecological model includes elements of foundational frameworks of children's psychological development, such as those proposed by Piaget and Vygotsky. However, it additionally overcomes some of the limitations of these frameworks by including the child's ecology and developmental abilities at the core of the theory. As discussed in previous chapters, focusing on young children's developmental outcomes without controlling for ecological factors is also a noted limitation in contemporary screen use research. For that reason, the current research was framed by a bioecological theoretical framework. This allowed for an exploration of various screen use factors, baseline developmental differences, contextual factors, and time, and the mediating effect that they had on development scores in addition to the predictor variable of screen time.

A key element of the bioecological theory in structuring the current research was the employment of the PPCT model. As screen use was considered a Process in the current research, the findings showed that the other three elements of the PPCT model did meditate its influence on early development, to some extent. In relation to the Context element of the research model, the environmental variables seemed to mediate the influence of screen use both cross-sectionally and longitudinally. These contextual factors were also correlates for later screen time, specifically educational attainment, which was the only significant contextual predictor of screen time in the reverse-causal longitudinal regressions. The contextual factors additionally accounted for more variance in all developmental scores, in comparison to screen use, in the studies using the GUI data. This reflects the research showing family SES to mediate children's level of screen use (e.g., Schmiedeler et al., 2014; Lauricella et al., 2015). Study 6 also showed parental screen beliefs to be associated with parental engagement during screen time. These parental factors were associated with further contextual factors such as the screen activity and the child's age. This highlights the interaction between ecological factors and various aspects of screen use. Given this, it can be seen that these factors were important to control for and explore in the current research, which provides the first illustration of the benefits of considering the bioecological model in screen use research.

The element of Time was also an important aspect of the PPCT model to control for in the current research. Researchers have suggested that the influence of screen use may not be evident by measuring concurrent effects (e.g., Levelink et al., 2020). Bronfenbrenner (1989) also stated that developmental change takes place over time and does not happen instantaneously. The truth of this statement is evident in past screen time research, with

Ferguson (2015) noting that some of the more in-depth and reliable findings on the role of screen use in the development of older children and adolescents have been presented using longitudinal datasets. Controlling for the element of Time in the current research showed that screen use's cross-sectional influence on the various aspects of development measured in the current studies was not necessarily found longitudinally. This was similar to the findings of Levelink et al. (2020) who found TV watching at age 2 years to influence externalised behaviour, but this had no lasting influence at age 3 years.

Including two time-points in Study 2 and 4 at age 3 and age 5 years also allowed for reverse-causal associations to be explored. These analyses showed individual factors (the Person element of the PPCT model) such as baseline developmental scores, and contextual differences from early childhood, may be predictors of later screen time, rather than screen time being an initial causal factor of development. Study 5 and 6 explored the Person element further by separating the children by age and showing that this individual difference was also associated with the children's screen use and the frequency of parental engagement during screen time. A possible reason for the differences in these factors based on the child's age may relate to parents' scaffolding behaviours.

Scaffolding occurs when a more knowledgeable other (parent, teacher, or older sibling) uses specific behaviours to guide the child through a challenging task until they can independently master the skills or complete the tasks themselves (Wood et al., 1978). This term relates heavily to the Zone of Proximal Development (ZPD), which was described in Vygotsky's (1978) socio-cultural theory as the space between the child's ability to complete tasks with and without assistance. Developmental research exploring this aspect of the socio-cultural theory has historically been more concerned with scaffolding behaviours during non-digital activities. However, as highlighted by Pempek et al. (2011) and Lavigne et al. (2015), co-viewing educational screen content with an infant allows for opportunity to ask focused questions using the vocabulary and content on screen. Digital devices also now include in-built features that provide on-screen cognitive, affective, and technical scaffolding (Yelland & Master, 2007; Neumann & Neumann, 2016). Neumann (2018b) additionally noted that little is known about either on-screen scaffolding or parental scaffolding approaches with young children during screen time. This therefore suggests Vygotsky's socio-cultural theory as a further theoretical framework that may be useful to consider in future early screen time research.

The above findings highlighted the importance of considering the various elements of the PPCT model to provide a broader understanding of the varying factors that both mediate screen times' influence on development and predict later screen time. However, while the current research used the PPCT model to include factors from the micro, macro, and chronosystem, there was little exploration on how screen use fits within the paradigms of the meso and exosystems. The meso and the exosystem have been noted in previous research as elements within Bronfenbrenner's theory that have been less explored and tested in developmental research (Ashiabi & O'Neal, 2015).

Previous research by Hammed (2014) has explored early technology use from a meso-level perspective however, specifically the integration of ICT into early childhood education (ECE). While the ECE practitioners in this research had positive attitudes towards the use of technology in ECE, barriers to this integration included macro-level factors, such as the lack of national ICT policy for ECE settings, and meso-level factors, such as support from local schools and colleagues in leadership positions. However, Ashiabi and O'Neal (2015) note that due to the quantity of elements to be tested within Bronfenbrenner's theory, that it is not often that all ecological systems are considered together. Nonetheless, no studies to date have considered the three elements of Person, Context, and Time together when measuring the influence of the Process of screen use on early psychological development. While screen use was considered a process within the microsystem throughout the current thesis, whether it could, or should, be considered a proximal process in and of itself still remains an area for further exploration in the screen use literature.

Researchers have noted that although technology use is ubiquitous in children's immediate and broader environments, there is a paucity in the literature testing Bronfenbrenner's framework in contemporary times (Merçon-Vargas et al., 2020; Navarro & Tudge, 2022). Therefore, little research has incorporated screen use as a factor in the PPCT research model, despite it being an omnipresent activity. Children's screen use also fits within the description of a proximal process proposed by Bronfenbrenner, that being an activity that is engaged in on a regular basis, not unidirectional, becomes increasingly complex over time, and invites attention and involves interaction (Bronfenbrenner & Morris, 1998). The current research would support the idea of screen use as a proximal process as the findings in both Study 1 and 5 showed screen use is an activity that the vast majority of children engaged in on a daily basis. Study 5 also shows that the children's screen use invited attention and interaction, with some children engaging in digital games and educational content every day. Study 5 additionally highlighted that screen use changes with age, as older children were more likely to engage in digital games, showing screen use may become more involved and more complex over time.

However, Bronfenbrenner also described proximal processes as essential for development to occur and should therefore account for most of the variance in developmental outcomes. In contrast to this, other factors within the micro, macro, and chronosystem were overall shown to have greater influence on early development in the current research. However, with contextual factors being documented to play such a large role on early development, recent developmental research has debated whether proximal processes should still be viewed as the greatest contributors to development within the PPCT research model (e.g., Ashiabi & O'Neal, 2015). Therefore, more research is needed to determine the nature of screen use as a proximal process.

While a small amount of research using the PPCT model with technology use has looked at its influence from an environmental perspective (e.g., Navarro & Tudge, 2022), none have outlined it as a proximal process in and of itself. A possible reason for this might relate to the fact that screen time in the past did not allow for such interaction, complexity, or exploration. Traditional screen time, such as TV viewing, was a relatively passive activity that did not conform to the description of a proximal process. A further reason for screen use not being considered as a proximal process in previous research could relate to Bronfenbrenner and Evans' (2000) description of the function of processes. In their writing, these processes or activities were related to positive outcomes, where higher levels of proximal processes related to improved competence while also buffering developmental difficulties or dysfunctions. With past screen time research showing negative influences on children's development, it may be the case that researchers did not consider screens as a proximal process, but rather a moderating factor in the child's environment. However, this idea of proximal processes having to conform to being positive in nature was challenged by Merçon-Vargas et al. (2020) with their introduction of Inverse Proximal Processes.

The authors of this paper highlighted that the bi-directional interactions that happen on a daily basis, and become more complex over time, could be of a positive or negative nature. Abusive parent-child relationships were provided as an example of how proximal processes, at least as described by Bronfenbrenner, could have a negative influence on development and therefore not lead to higher competence or buffer dysfunctional development. This led to their development of the term Inverse Proximal Processes where it is possible for certain processes to increase developmental difficulties, and decrease competence, based on the child's context. Merçon-Vargas et al. (2020) also applied this sentiment to adolescents' social media use, where reference was made to various studies showing the negative influence of social media on developmental outcomes (e.g., Batzer et al., 2018; Charalampous et al., 2018).

As the current research found screen time to have a negative influence on concurrent development scores if engaged in for more than 2 hours per day, this may suggest that screen time could be considered a proximal process in future research, albeit an inverse one. Given the limited research that has contextualised technology use within the PPCT research model, it is important for future research to explore the influence of technology use as a proximal process further. This could additionally be used in conjunction with various aspects of screen use given that screen activities were shown to also influence early development in the current research, particularly digital games.

However, more generally, the use of the PPCT model provides a framework for overcoming some of the methodological and research design issues noted in the screen time research, such as the lack of directional testing, and the interpretation of findings without considering the wider ecological context (e.g., Bell et al., 2015; Elson & Ferguson, 2015). Furthermore, studies have reported the influence of media exposure on children's developmental outcomes to be highly dependent on social factors (e.g., family relations and environment; Valkenburg & Peter, 2013), and the child's psychological predisposition (e.g., aggressive children may be more susceptible to the effects of violent video games; Kronenberger et al., 2005). The findings reported in the current research are consistent with findings from past screen use research that has controlled for various elements in the PPCT (e.g., Breuer et al., 2015; Etchells et al., 2016), where ecological elements mediated the influence of screen use on well-being. Given that screen use researchers are already working towards controlling for elements such as Context and Time in their research, it is suggested based on the research findings from the studies reported in this thesis that the PPCT model be considered in future screen use research design.

The current research therefore adds to the literature on the uses and applications of the bioecological theory in contemporary research. The findings also encourage future screen use researchers to consider technology use as a proximal process moving forward, and to consider the other PPCT elements of Person, Context, and Time, when measuring the influence of this Process on development. Doing so would provide an improved methodological approach to assessing the role of screen use, while also providing a theoretical framework for guiding new screen use studies. There has been a call for such a framework by screen use researchers over the previous years (e.g., Nikkelen et al, 2014; Granic et al., 2020), who have noted the lack of theory testing and frameworks that examine the complex interplay between environment and screen use in the literature. The current research therefore bridges the gap between screen time research and developmental research to create a robust, high-quality research design for exploring the role of contemporary screen use in early development. In doing this, evidence-based statements on the place of screen use in children's ecological systems, and the influence it has on developmental outcomes, can be created. Such statements also have various applied practical implications.

Practical implications

As noted throughout the thesis, the variety of screen devices available to young children has grown vastly over the past two decades, but scientific research has not always kept pace. Despite the ubiquitous nature of screens in the home, few studies have explored young children's incidental screen use in this setting. Study 1 and 2 showed that less than 3% of the children in the GUI study had no screen time in the home. Similarly, Study 5 showed that only 8% of children aged 3 and over had no screen access, with the figure for children aged under 3 years being 23%. In addition to these high levels of screen access in early childhood, the findings of Study 5 also showed that 17% of children owned their own screen device.

With such a high rate of screen use in the early home environment, it is understandable how this has led to parental concerns about its contribution to early development, especially as early screen use has also become a discussion topic of interest in the media. However, the media headlines might not always be rooted in scientific evidence. For example, Courage and Setliff (2009) stated that the research showing associations between screen time and cognitive development at a young age is weak, despite it being a prominent message in the media. Nikkelen et al. (2014) also noted a problem in the literature and media to be the theorising of how screen time contributes to socio-emotional difficulties, with few studies empirically testing these claims. Therefore, the below discussion aims to consider the implications of the current research for parents, educators, ECE practitioners, child advocacy and health organisations, and policymakers, by drawing on the related evidence-based findings.

Implications at a microsystem level for parents

As seen across Study 1, 3, and 5, screen use had a varying role in developmental outcomes depending on the area of development being measured, the activity mostly engaged in, and the mediating influence of wider environmental factors. Screen activity was also noted to perhaps play more of a role in cognitive development than screen time itself. However, across these three studies, screen time did make a unique independent contribution to all measures of development, with the exception of language scores. Engaging in screen time for 3 or more hours a day had a negative influence on reasoning scores, while engaging in more than 2 hours of screen time had a negative influence on attentional ability, and on all measures of socio-emotional development. These findings closely align with the screen time recommendations set out by children's advocacy organisation and national health organisations.

For example, the American Academy of Paediatrics (AAP) recommend that children aged 2 to 5 years engage in no more than an hour of screen time on weekdays, and 3 hours of screen time on weekend days. This was founded on research that reported associations between early screen time and health risks such as obesity, sleep issues, and attentional deficit (Chassiakos et al., 2016). These guidelines were also adopted by other organisations concerned with health and development in early childhood, such as the Australian Department of Health, the Canadian Paediatric Society, the Irish Health Services Executive (HSE), and the World Health Organisation, all of which also encourage early screen use to remain under 2 hours per day. The current findings show that modest negative effects of screen time appear after 2 hours, and so, the first practical implication of this research for parents is to keep screen time in the home under 2 hours a day for children in this age bracket. It is positive that the majority of children in both the GUI and PLEY data were already engaging in the recommended amount of screen time outlined in the AAP guidelines. Therefore, encouraging screen time rules in the home may be a recommendation that is easy for Irish families to implement.

However, there was a shift from time-based guidelines in more recent years with the AAP providing practical suggestions in 2018 on how to engage in screen use to maximise beneficial outcomes. Here, the AAP emphasised the importance of parental co-viewing and co-playing during screen use to create bonds and conversations. Similarly, in the following year, the Royal College of Paediatrics and Child Health (RCPCH) released the first official screen use recommendations in the UK. In these guidelines it is noted that more, and better, research is needed before conclusions are drawn on screen time's role in early development. The RCPCH therefore proposed that guidelines on screen use should suggest parent-child interactions and educational content during screen time, rather than setting limits on amount of screen time.

Study 1, 3, and 5 again add to this sentiment by showing that the screen activity mostly engaged in does have an influence on developmental outcomes, and in some cases more so than screen time itself. Video games were shown to have a statistically significant negative influence on language development, along with internalised and externalised behaviour, in comparison to the other screen activities in Study 1 and 3. Additionally, Study 5 showed playing educational games to have a significant positive influence on attentional ability in comparison to the other screen activities. The current findings would therefore suggest that screen activity and content both play a role in early development, with these factors having more of role in cognitive development than amount of time spent on a screen. Thus, the type of screen use in the home, in addition to amount of screen time, should be monitored. This is a further practical implication of the findings and a recommendation for families to implement in their homes, especially if parents are primarily concerned about the amount of screen time their children have.

The Canadian Paediatric Society (2017) has also incorporated the move from time-based guidelines into their Digital Health Task Force, which suggests that parents can have a positive influence on their children's social skills by being involved during their child's screen time. While the current research did not explore the influence of this engagement on development, it did explore the factors associated with the frequency of parental engagement during screen time. Study 6 found that parents were less likely to engage with their children during screen time if their child was over 3 years of age, if the screen activity being engaged in was digital games, and if the parent had negative screen use beliefs. Given the extensive amount of research showing parental engagement to have various developmental benefits, it is important for parents to consider engaging more with older children and during all screen activities, not just while watching TV.

Additionally, Study 6 showed positive screen beliefs to be related to higher engagement with educational screen content. This was also found by Egan and Beatty (2021) where children were more likely to engage with educational TV programmes and digital games during the Covid-19 lockdowns if their parents had positive screen use beliefs. Therefore, it may be beneficial for parents to reflect on whether their screen use beliefs may be influencing their rate of engagement during screen time, and also their children's type of screen use. This is a further practical implication of the findings for parents as well as practitioners working with families with young children.

Implications at a micro and mesosystem level for parents and early educators

Returning to the importance of educational content, while the current research focused on naturalistic screen use in the home, there are various studies that explored the targeted use of educational apps and digital games in schools and ECE settings. Such research, including that by Cubelic and Larwin (2014), Russo-Johnson et al. (2017) and Neumann (2018a), has found educational apps to produce higher learning outcomes than traditional teaching methods. The findings in Study 5 also showed educational games to benefit attentional abilities. Such findings are important to discuss with parents and ECE practitioners to provide education on the potential benefits of early screen use.

As found in the aforementioned study by Hammed (2014), ECE practitioners' willingness to integrate technology into the ECE setting is often impacted by mesosystem level factors, inclusive to the support of local schools or those in leadership roles. The discussions on beneficial screen use are therefore important to continue within children's mesosystem, so that young children can continue to have the opportunity to benefit from the types of screen-based learning shown by previous research. These mesosystem level conversations, particularly between ECE practitioners, educators, and parents may positively influence the use and level of educational screen-based activities being supported in the home, therefore reinforcing children's learning across the ecological systems.

The use of screen-based activities in schools and in the home is also being encouraged in contemporary screen use research, with researchers calling for more guidance from health organisations on how screens can benefit learning (Straker et al., 2023). There is a particular push towards the presence of technology in early learning settings so that parents and educators can teach digital literacy from an early age (e.g., Levido & Rodriquez, 2022). These researchers discussed how children can learn ideas from imaginative toys, and a screen device may be no different in this regard. Bird (2020) also commented on how children's imaginative play spaces should include technology for the purpose of digital literacy learning.

By using screen devices as imaginative role-playing toys, parents and educators can engage with the child during screen time and act out real and imagined situations related to online safety, media literacy, and can support the development of digital skills needed for children's future education and careers. This highlights a further implication for parents, ECE practitioners, and educators that can help foster children's development from a micro, meso, and chronosystem perspective. It is therefore important that conversations on the learning benefits of early screen use continue to happen at a mesosystem level so that children can engage in learning and developing the necessary digital skills for their future across their microsystems. It is also important that these implications are being communicated at a macrosystem level to ensure all families, from all economic backgrounds, are included in the conversation.

The above discussion shows that, in a time where screen devices are omnipresent in the typical household, it may be useful for practitioners, child advocacy and health organisations, and policymakers to advise families on how to engage with screens in a way that supports the most beneficial developmental outcomes. Based on the current findings, such advice should have more of a focus on screen activities, content, and parental engagement, and move beyond screen time alone as a measure of healthy screen use. Certain national screen use policies have already accounted for such nuances, such as the RCPCH and the Canadian Paediatric Society, as previously mentioned.

While the AAP still provide time-based recommendation, their guidelines over the years have also begun to encompass recommendations related to the type of screen use and the context in which screens are engaged with. The latest early screen use research also encourages the consideration of aspects of screen use other than time when creating health policy guidelines, along with the necessity of providing guidance on how screens can be used to achieve best developmental outcomes (e.g., Straker et al., 2023). These recommendations are based on research conducted by the ARC Centre of Excellence for the Digital Child, which is undertaking a world-first longitudinal investigation of 3,000 Australian children's digital experiences from birth to eight years of age. The current research therefore adds to the literature informing such recommendations, with the findings also being in line with the emphasis on content, context, and connections in national policies such as the RCPCH.

As the current studies have been conducted on Irish children, these findings can be used to inform the national guidelines and campaigns currently being created in Ireland, such as those developed by the HSE and the START campaign, an initiative of the Department of Health. Both of these resources currently mostly focus on time-based recommendations. While the HSE's website does include more information on the importance of content and parental engagement, further reference to other important influencing factors such as the type of screen activity being engaged in, the children's age, and parents' screen use beliefs should also be noted in future statements. This may create more understanding around the ecological factors influencing screen use and its related developmental outcomes.

In the Irish ‘First 5’ strategy, a nurturing and playful home environment and time together with parents are noted as the key areas of focus for improving the lives of young children. Screen use, while present in the home environment, is just one part of this environment. The current research shows that other aspects of the developing child’s environment should also be focused on more when considering early development. Contemporary research also shows that a number of these factors, such as maternal education levels (Veena et al., 2010; Carr & Pike, 2012), the socio-economic status of the family (Neitzel & Dopkins-Stright, 2004; Mackey et al., 2011), and the parent-child relationship (Glaser, 2000; Bernier et al., 2012), are important predictors of development. This was also shown to be the case in the current research with these factors contributing to psychological development scores more so than screen use factors. For example, in Study 1 and 3, SES variables and parent-child closeness were significant in all regression models indicating that children from families with lower educated parents, income, and parent-child closeness levels had lower developmental scores. The Australian ‘First Five Years’ strategy’s website also notes that while it is important to understand how to make the most out of children’s screen time, research extending back throughout the last century (inclusive of Bronfenbrenner’s bioecological model) provides rich evidence of how children grow, learn, and develop (Nagel, 2019).

Importantly, however, the influence of screen use on the developmental scores (albeit small) remained significant in the final models. This highlights screen use to be a factor within the children’s ecological systems that parents can potentially control in comparison to wider factors such as their economic or educational background. This is of particular importance to communicate with families of lower SES, as researchers have found screen time to be the highest for children from disadvantaged backgrounds (Lauricella et al., 2015; Kostyrka-Allchorne et al., 2017). The current findings therefore are in line with the goals of the ‘First 5’ national strategy, where an emphasis is placed on working with Irish families of all socio-economic backgrounds to improve the home learning and play environment. The findings from Study 5 also add to the national findings by Early Childhood Ireland (2016) and Murray et al. (2019), as well as the international figures such as those reported by Ofcom (2018) and OECD (2020), that have shown the changing nature of screen use habits over time as digital devices evolve. This is necessary knowledge for policymakers so that policies on early screen time can reflect contemporary screen use and remain current in their recommendations.

Taken together, the above content suggests how the current research could be considered in discussions and decision-making processes around early childhood and family initiatives, and policies in an Irish context. This would also provide more clarity around the role of screen use in early development, as it is evident from the current research that not all screen use is equal and therefore there is no one-size-fits-all approach to creating guidelines or recommendations on best screen time practices. Ultimately, when considered within developmental theory, parents should work towards providing children with a balance of screen time and other cognitively stimulating and meaningful activities in the home environment for best developmental outcomes. When considered within a bioecological theory, screen use has been shown to fit within the child’s ecological systems as a part of their environment as opposed to being a driving contributor to later development.

Unlike what is seen in the many prominent media headlines, the current research therefore shows that screen time does not single-handedly cause developmental delays but is instead one of many potential influencing factors within children’s ecological systems. As a result, the current research provides an evidence-based and theory-driven perspective for parents and practitioners to view screen time, with recommendations for policymakers on best screen use practices to support children's psychological development. While many initiatives and policy approaches for screen time stem from a concern for physical health risks (Kuta, 2017), rather than a psychological perspective, the implications that the current research offers highlight the importance of adopting a psychological perspective also for young children.

This is especially the case as screen time has become even more prevalent in the home since the Covid-19 lockdowns, with children shifting to using screens more for schoolwork and educational purposes (Egan & Beatty, 2021; Sultana et al., 2021). Recent research has also shown this rise in children's screen use during the pandemic to persist long after lockdowns were lifted (Sefton-Green et al., 2022). However, Sefton-Green et al. (2022) also showed that parents are now more concerned about what their child is doing during this screen time rather than trying to enforce their pre-pandemic screen time restrictions. This is potentially a positive attitude change resulting from the pandemic, which is also in line with the findings and overall practical implications and recommendations from the current research.

Further considerations

Throughout the above discussion on the overall findings and implications, some of the strengths and limitations have already been briefly highlighted. Further strengths and limitations relate to the research design, the measures, and the analyses that could and could not be conducted based on the data available. The advantages and drawbacks of using the data from the GUI study and the primary data collection reported in Chapter 5 will be discussed below, along with the research design strengths and flaws. The use of the PPCT model in screen time research and whether this was beneficial to the current study will also be discussed, followed by the areas that future research should consider.

Strengths and limitations of the research

The main strength of this research is the number of novel findings that the research contributes to the field of early screen use research. These findings and their implications have been previously discussed and overall they show that individual, contextual, and temporal factors all play a role in screen time's influence on early psychological development. Assessing early screen use and development from a bioecological perspective allowed for robust, high-quality findings to be reported in each study, where other mediating factors were accounted for throughout. The current study provides a holistic, ecological view on screen use's concurrent and longitudinal influence on various domains of psychological development.

A further key strength of the current research was the use of the GUI dataset where data from two Waves, at ages 3 and 5 years, could be examined. As the GUI Study provides a large, nationally representative sample, accessing these data was important for gaining a snapshot of Irish 5-year-olds' screen use and the factors associated with it. The GUI Study included a heterogenous representative sample, which allowed for generalisable findings to be produced on the role of early screen use in psychological development. However, it is also important to note that as the research used a representative sample, the current findings may not apply to all children, especially those with varying developmental abilities. Findings concerning the influence of screen use may therefore differ in samples that consist of children with specific developmental abilities.

For instance, while the current research found screen time to have little influence on socio-emotional ability in comparison to wider environmental variables, research with neurodiverse children has shown technology use to be an important factor in supporting self-regulation and social skills (e.g., Reed et al., 2011; Cibrian et al., 2022). Similarly, screen time in the current research had less of an influence on cognitive development than ecological factors, but research with gifted and talented children has shown screen activities to be important in developing knowledge and skills (e.g., Siegle, 2013; Ali & Alrayes, 2019). Activities that develop and challenge skills and talents have been noted as important for gifted children to engage in within the home and early years settings (Sutherland, 2012). Therefore, future research should also explore the role of screen use in the psychological development of children with differing developmental abilities.

The GUI additionally collected data at various ages providing the opportunity for longitudinal analyses to be conducted on the influence of screen time on later developmental outcomes. This data also allowed for cross-sectional analyses to be carried out with variables and measures that otherwise would not have been feasible to examine experimentally. This allowed for valuable research findings on the role of early screen use to be produced using an existing dataset with reliable and validated measures of both cognitive and socio-emotional development. The benefits of this lie in the various research and practical implications and recommendation that could be inferred from these findings. However, a limitation to using this dataset relates to certain variables of interest such as parental engagement during screen time, or broader measures of early screen use at various ages, not being available. A further limitation is that screen activity was not measured at multiple timeframes in the GUI Study. This limitation meant that the longitudinal influence of screen activities on development could not be assessed and as a result remains an area that should be explored in future research. Despite this, the use of a prospective cohort study allowed for differences across types of screen activities, and time, to be analysed cross-sectionally within the same sample, providing an important foundation in understanding the role of early screen use in Irish children's psychological development.

The research reported in Chapter 5 built upon the GUI findings, where screen time measures were more fine-grained to additionally measure screen content, device use and parental engagement and screen beliefs. A further strength to collecting this primary data was that it allowed for the measurement of incidental screen use in the home by children under the age of 3 years, which was not measured in the GUI Study, nor has it been explored widely in the literature. This allowed for comparisons to be made on children's screen use across developmental stages, and for analyses to be conducted on the influence of screen activity, device, and content, from the earliest years. Although the sample size was smaller than the GUI Study, and the findings not as generalisable to the population due to the nature of the sample, the data in these studies provided useful insights into multiple aspects of, and factors associated with, young children's screen use in the home.

A further limitation of the research reported across the various chapters relates to the number of parental report measures used in relation to child development. While the measures of cognitive development in the GUI Study were individually administered by trained interviewers in the child's home (i.e., the children completed the BAS II tasks), the other measures of development reported in the thesis were parental report measures (e.g., the SDQ, the Attentional Focus Scale, and the Alberta Language and Development Questionnaire). While these scales are standardised measures of socio-emotional development, attention, and language, and have good reported validity and reliability in previous research, this difference between direct measures of child development and parental report measures of child development is something that should be considered in future research.

Studies using parental report often note this as a limitation due to the possibility of social desirability bias and issues around their ability to accurately assess their own child's development. For example, parents have been found to inflate their level of interaction with their children in parental report measures and under-report children's media consumption, although this may be more related to recall bias as opposed to social desirability bias (Anderson et al., 1985; Hofferth, 1999; Vandewater & Lee, 2009). Conversely, studies have shown parents to be adequate assessors of their children's development, with parental reports of early development strongly correlating with their children's developmental outcomes measured at a later age (e.g., Schonhaut et al., 2017; Squires, 2017). Additionally, the parents who participated in the PLEY survey were mostly highly educated and middle-aged, resulting in a quite a homogenous participant group. This may be true of other smaller screen-based research studies where the participants self-select to participate and give freely of their time. This is worth keeping in mind when interpreting findings, and highlights the value of drawing on data in nationally representative samples, where such data is available.

It has also been documented in the research that parents may underestimate their children's daily time spent on screens and so more comprehensive screen time measures such as daily dairies may be more accurate in assessing what activities the children are engaging in and for how long (e.g., Vandewater & Lee, 2009). However, these diaries also rely on parents' dedication to record all screen time and activities throughout the day for often a week or a fortnight at a time. This may also produce errors and inaccuracies. Due to this, researchers have found that data from parents' reports of screen time and diary methods are substantially consistent (Özmert et al., 2002; Anderson et al., 1985). In recent years however, there have been strides in this area with the creation of passive sensing (Yuan et al., 2019) and sensor bands (Fletcher et al., 2019; Willis et al., 2022), which provide even more accurate measures of children's sedentary and screen time. It is therefore suggested that future researchers consider the use of these for screen time measurement in addition to parental reports.

A final strength of the study relates to the reporting of results beyond significance testing. By doing so, it continues to emphasise the importance of practicing good scientific integrity by highlighting the importance of thorough statistical reporting, the use of robust and conceptually appropriate analyses, and appropriate interpretations of the findings. Many screen time studies have been criticised for focusing on statistical significance alone (Foster & Watkins, 2010), with small effect sizes and the lack of inclusion of environmental factors being highlighted as methodological issues in the literature (Elson & Ferguson, 2015; Bell et al., 2015). The reporting of effect sizes in psychological research was not a common or recommended practice until relatively recently and is a welcome advance for screen use research as well as for the discipline, and is therefore a strength of the current research. The small effect sizes reported throughout the current research show screen use to have a modest effect on the various developmental measures. Nevertheless, when dealing with developmental outcomes such as those in the current studies, “even small effect sizes can translate into important social costs when projected over a lifespan and across an entire population” (Pagani et al., 2013, p. 4), and are therefore important contributions to report.

Directions for future research

While an extensive exploration of screen use’s role in early psychological development was conducted in the current research, there are still areas that should be considered by future researchers interested in carrying out studies on early screen use. This research was one of the first to examine how screen use, including activity, content, and device, rather than just screen time, influences early psychological development. Although there were several measures of psychological development included in the current research, future screen use research is still warranted on further cognitive and socio-emotional measures. As stated by Bronfenbrenner and Evans (2000), it is necessary to assess multiple developmental outcomes to gain an accurate picture on the influence a process may have on an individual.

Additionally, an area that this research did not explore is parental screen use and the influence that this has on early development. This is an area that is increasingly considered to be an important factor in the home environment, with studies highlighting technoference to result in poorer parent-child interactions (McDaniel & Radesky, 2018; Mackay et al., 2022). It has been demonstrated that children's amount of screen time is associated with the daily amount of parental screen time, but it is not widely researched in what ways these distractions can influence early development. In their review of the related literature, Livingstone and Franklin (2018) reported that the research suggestions on screen time mostly state that parents should be positive role models in demonstrating healthy screen use, while encouraging parent-child interactions during screen time to achieve this. In addition to this, in a series of interviews with healthcare professionals about the use of digital devices in the home, Franklin (2018) found that most practitioners encouraged parents to evaluate their own screen use while with their child as this may lead to decreased levels of engagement.

Voort (2020) also found that increased screen use by parents resulted in fewer parent-child interactions, which was also reported to be a mediator for the children's internalised and externalised difficulties. With screens and screen use being omnipresent in the home for all family members, the influence of others' screen use on early child development is therefore another possible avenue for future researchers to explore. This also further encourages future screen time researchers to view the influence of screen use from a bioecological perspective, where technoference may significantly interact with proximal processes in the home.

Lastly, as expanded on in previous sections, researchers have encouraged the use of longitudinal design in screen time research to better understand the lasting implications of early screen use. While the current study found little evidence for a longitudinal causal influence in the screen use and developmental variables measured, further longitudinal analyses is needed with various cohorts to assess whether these findings are also true for children outside of Ireland. For example, American children have been shown to engage in more screen time than some other European countries (Obel et al., 2004). As negative, although small, effects of screen use were seen after engaging in more than 2 hours of daily screen time in the current research, perhaps longitudinal studies with children who engage in excessive daily screen time would show lasting effects.

This has been noted by researchers such as Przybylski and Weinstein (2019) who found screen time to only have an influence on children's well-being if engaged in for over 7 hours a day, and Przybylski (2014) where negative association between playing video games and socio-emotional outcomes were only seen when engaged in for over half of every day. Therefore, whether excessive screen use has a longitudinal causal influence (or little causal influence as seen in this research) could be an avenue for future research to explore. Importantly however, while the current study showed little evidence for lasting causal effects, the longitudinal regressions in Study 2 and 4 showed screen time to be autoregressive across the two age brackets, illustrating cross-sectional findings to still be valid and reliable where longitudinal analyses are not possible. This should be noted as a strength of cross-sectional research for researchers who wish to join the discourse on screen use and development but do not have access to longitudinal data.

Conclusion

As stated by George and Odgers (2015), the question is no longer if children are using digital technology, but how, why, and with what effects. Concerns around new technologies and their influence on children are not a recent phenomenon, and so it is not surprising that fears around early screen use may have developed. However, much of the literature on the effects of screen time may be somewhat inconclusive, as few researchers have focused on separating the influence of early screen use from the various ecological factors known to influence early development. In addition to this, screen time studies to date have been largely atheoretical with little research exploring screen use from a developmental or psychological perspective. The current research addressed these issues by critically appraising the existing literature and contributing theory-led empirical-based findings to this field.

The findings in this thesis show that the influence of early screen use in the home on psychological development is relatively time- and domain-specific. Furthermore, they highlight the importance of considering multiple aspects of screen use and multiple ecological factors for producing robust and high-quality findings on the role of screen use in development. Therefore, the use of the bioecological model was beneficial in framing the research design and analyses to provide a more nuanced understanding on the unique contribution of early screen use in early psychological development. By using Bronfenbrenner's bioecological model to frame the analytical approach, the current research also marries this framework with screen use research in a way that has not been done in the literature to date. The aspects of screen use outlined as important in the research, such as time, activity, content, and parental engagement, largely complement the work of Bronfenbrenner who also outlines the importance of considering wider environmental factors in studies concerned with development.

As a part of the microsystem, the current findings show that screens do have an independent influence on early development, although the effect sizes are small, and wider environmental factors such as socio-economic status were more likely to influence development than screen use. However, in comparison to these factors, screen use is an ecological factor within the home that parents can have control over, and so it is recommended that young children engage with mostly educational screen content, and engage in non-structured screen time for no more than 2 hours a day. It is important for future research to continue to explore the role of screen use in development with different child cohorts to ensure that such findings are replicated across different abilities, ages, and cultures.

In relation to the macro, meso, and chronosystem, the current findings can be used to inform national policies and statements on the influence of early screen use when it is considered in tandem with other influencing ecological factors. As screens are now a common part of family life it is important for further evidence-based information to reach families from a governmental level. Conversations between those in the mesosystem, specifically between parents, educators, and ECE practitioners, around the beneficial applications of screen use are also necessary for children to have the opportunities to learn from technology and learn necessary skills for their future. This will work towards improving the relationships between children and the screen activities that are in their early play and learning environments so that they can continue healthy screen engagement over time.

Now more than ever, psychology and developmental researchers have a responsibility to lead early screen use research so that the expertise and related theoretical frameworks in this field can guide inquiries into the role of screen use in psychological development. As stated by Nagel (2019), there is a vast amount of research extending back over the last century that highlights frameworks for best understanding early development and the factors that support it; and these should not be ignored in screen use research. The current findings support this statement by showing the importance of considering the existing bioecological framework when assessing the influence of screen use on early child development. In doing so, this honours the aim of Bronfenbrenner’s theory in not just exploring “the forces that have shaped human development in the past, but . . . those that may already be operating today to influence what human beings may become tomorrow" (Bronfenbrenner & Evans, 2000, p. 117).

References

Acevedo–Polakovich, I. D., Lorch, E. P., & Milich, R. (2005). TV or not TV: Questions and answers regarding television and ADHD. *The ADHD Report: Special Issue—Focus on Assessment*, *13*(6), 6-11.

Adegboye, D., Williams, F., Collishaw, S., Shelton, K., Langley, K., Hobson, C., ... & van Goozen, S. (2021). Understanding why the COVID-19 pandemic-related lockdown increases mental health difficulties in vulnerable young children. *JCPP advances*, *1*(1), e12005.

Aladé, F., Lauricella, A. R., Beaudoin-Ryan, L., & Wartella, E. (2016). Measuring with Murray: Touchscreen technology and preschoolers' STEM learning. *Computers in Human Behavior*, *62,* 433-441.

Ali, H., & Alrayes, A. (2019). The role of technology in gifted and talented education: A review of descriptive and empirical research. *KnE Social Sciences*, 26-38.

Anderson, C. A., & Bushman, B. J. (2001). Effects of Violent Video Games on Aggressive Behavior, Aggressive Cognition, Aggressive Affect, Physiological Arousal, and Prosocial Behavior: A Meta-Analytic Review of the Scientific Literature. *Psychological Science, 12*(5), 353–359.

Anderson, D. R., & Pempek, T. A. (2005). Television and very young children. *American Behavioral Scientist*, *48*(5), 505-522.

Anderson, D. R., Bryant, J., Wilder, A., Santomero, A., Williams, M., & Crawley, A. M. (2000). Researching Blue's Clues: Viewing behavior and impact. *Media psychology*, *2*(2), 179-194.

Anderson, D. R., Field, D. E., Collins, P. A., Lorch, E. P., & Nathan, J. G. (1985). Estimates of young children's time with television: a methodological comparison of parent reports with time-lapse video home observation. *Child development*, 1345-1357.

Anderson, D. R., Lorch, E. P., Collins, P. A., Field, D. E., & Nathan, J. G. (1986). Television viewing at home: Age trends in visual attention and time with TV. *Child Development, 57*, 1024-1033.

Anderson, S. E., Economos, C. D., & Must, A. (2008). Active play and screen time in US children aged 4 to 11 years in relation to sociodemographic and weight status characteristics: a nationally representative cross-sectional analysis. *BioMed Central Public Health, 8*(1), 366.

Ansari, A., & Crosnoe, R. (2016). Children's hyperactivity, television viewing, and the potential for child effects. *Children and Youth Services Review*, *61*, 135-140.

Ashiabi, G. S., & O'Neal, K. K. (2015). Child social development in context: An examination of some propositions in Bronfenbrenner's bioecological theory. *Sage Open*, *5*(2), 2158244015590840.

Australian Government Department of Health and Ageing (2011). *Get Up and Grow: Healthy Eating and Physical Activity for Early Childhood*. Family Book.

Barr, R., & Hayne, H. (1999). Developmental changes in imitation from television during infancy. *Child development*, *70*(5), 1067-1081.

Barr, R., Lauricella, A., Zack, E., & Calvert, S. L. (2010). Infant and early childhood exposure to adult-directed and child-directed television programming: Relations with cognitive skills at age four. *Merrill-Palmer Quarterly, 56*(1), 21-48.

Barr, R., Zack, E., Garcia, A., & Muentener, P. (2008). Infants' attention and responsiveness to television increases with prior exposure and parental interaction. *Infancy, 13,* 30–56.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and brain sciences*, *22*(4), 577-660.

Batzer, S., Berg, T., Godinet, M. T., & Stotzer, R. L. (2018). Efficacy or chaos? Parent–child interaction therapy in maltreating populations: A review of research. *Trauma, Violence, & Abuse*, *19*(1), 3-19.

Baumeister, R. F., & Vohs, K. D. (2007). Self‐Regulation, ego depletion, and motivation. *Social and personality psychology compass*, *1*(1), 115-128.

Bavelier, D., Green, C. S., Han, D. H., Renshaw, P. F., Merzenich, M. M., & Gentile, D. A. (2011). Brains on video games. *Nature reviews neuroscience*, *12*(12), 763-768.

Beatty, C., & Egan, S. M. (2018). Screen-time and vocabulary development: Evidence from the Growing Up in Ireland study. *ChildLinks-Children and the Digital Environment*, *3*, 18-22.

Beatty, C., & Egan, S. M. (2020a). Screen-time and non-verbal reasoning in early childhood: Evidence from the Growing Up in Ireland Study. *Children's Research Digest*, *6*(1) 32-39.

Beatty, C., & Egan, S. M. (2020b). The role of screen time and screen activity in the nonverbal reasoning of 5-year-olds: cross-sectional findings from a large birth cohort study. *Cyberpsychology, Behavior, and Social Networking*, *23*(6), 406-411.

Beatty, C., & Egan, S. M. (2020c). Screen time in early childhood: A review of prevalence, evidence and guidelines. *An Leanbh Óg*, *13*(1), 17-31.

Bedford, R., Saez de Urabain, I. R., Cheung, C. H., Karmiloff-Smith, A., & Smith, T. J. (2017). Toddlers' Fine Motor Milestone Achievement Is Associated with Early Touchscreen Scrolling. *Frontiers in Psychology*, *7*, 1108.

Bell, V., Bishop, D. V., & Przybylski, A. K. (2015). The debate over digital technology and young people. *Bio Medical Journal (Clinical research ed.)*, *351*, 3064.

Benson, J. B. (2020). *Encyclopedia of infant and early childhood development*. Elsevier.

Bergin, D. A., Ford, M. E., & Hess, R. D. (1993). Patterns of motivation and social behavior associated with microcomputer use of young children. *Journal of Educational Psychology, 85*(3), 437.

Bernier, A., Carlson, S. M., Deschênes, M., & Matte‐Gagné, C. (2012). Social factors in the development of early executive functioning: A closer look at the caregiving environment. *Developmental science, 15*(1), 12-24.

Bhargava, A., & Escobedo, T. (1997). What the Children Said: An Analysis of the Children's Language during Computer Lessons. *ERIC*, 1-19.

Bickham, D. S., & Rich, M. (2006). Is television viewing associated with social isolation?: roles of exposure time, viewing context, and violent content. *Archives of pediatrics & adolescent medicine*, *160*(4), 387-392.

Bird, J. (2020). “You need a phone and camera in your bag before you go out!”: Children’s play with imaginative technologies. *British Journal of Educational Technology, 51*(1), 166-176.

Blumberg, F. C., & Randall, J. D. (2013). What do children and adolescents say they do during video game play? *Journal of Applied Developmental Psychology, 34*(2), 82-88.

Blum-Ross, A. & Livingstone, S. (2016). *Families and screen time: Current advice and emerging research.* Media Policy Brief 17. London School of Economics and Political Science.

Bornstein, M. H., Putnick, D. L., & Suwalsky, J. T. (2012). A longitudinal process analysis of mother–child emotional relationships in a rural Appalachian European American community. *American Journal of Community Psychology*, *50*, 89-100.

Bowlby, J. (1958). The nature of the child’s tie to his mother. *International Journal of Psychoanalysis, 39*, 350-371.

Bowlby, J. (1980). *Attachment and Loss.* New York Basic Books.

Breuer, J., Vogelgesang, J., Quandt, T., & Festl, R. (2015). *Violent video games and physical aggression: Evidence for a selection effect among adolescents (Vol. 4).* Educational Publishing Foundation.

Bronfenbrenner, U. (1974). Developmental research, public policy, and the ecology of childhood. *Child development*, *45*(1), 1-5.

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American psychologist*, *32*(7), 513.

Bronfenbrenner, U. (1979). *The Ecology of Human Development: Experiments by Nature and Design.* Cambridge: Harvard University Press.

Bronfenbrenner, U. (1989). Ecological systems theory. In R. Vasta (Ed.), *Annals of child development (Vol. 6).* JAI Press.

Bronfenbrenner, U. (1993). The ecology of cognitive development: Research models and fugitive findings. *Development in context: Acting and thinking in specific environments*, *3*(46), 568-586.

Bronfenbrenner, U. (1995). Developmental ecology through space and time: A future perspective. In Moen, P., Elder, G.H., Luscher, K. (Eds.), *Examining Lives in Context: Perspectives on the Ecology of Human Development.* American Psychological Association.

Bronfenbrenner, U., & Evans, G. W. (2000). Developmental science in the 21st century: Emerging questions, theoretical models, research designs and empirical findings. *Social development*, *9*(1), 115-125.

Bronfenbrenner, U., & Morris, P. A. (1998). The ecology of developmental processes. In W. Damon & R. M. Lerner (Eds.), *Handbook of Child Psychology, Vol. 1: Theoretical models of human development (5th ed.).* John Wiley.

Bronfenbrenner, U., & Morris, P. A. (2007). The bioecological model of human development. *Handbook of child psychology*, 1.

Burns, T., & Gottschalk, F. (2020). *Education in the Digital Age: Healthy and Happy Children.* OECD Publishing.

Burns, T., & Gottschalk, F. (2019). *Educating 21st century children: Emotional well-being in the digital age.* OECD Publishing.

Burman, E. (2017). *Deconstructing Developmental Psychology*. Routledge.

Bus, A. G., Takacs, Z. K., & Kegel, C. A. (2015). Affordances and limitations of electronic storybooks for young children's emergent literacy. *Developmental Review*, *35*, 79-97.

Byeon, H., & Hong, S. (2015). Relationship between Television Viewing and Language Delay in Toddlers: Evidence from a Korea National Cross-Sectional Survey. *PloS one, 10(*3).

Canadian Paediatric Society. (2017). Screen time and young children: Promoting health and development in a digital world. *Paediatrics & child health*, *22*(8), 461–477.

Carew, J. V. (1980). Experience and the development of intelligence in young children at home and in day care. *Monographs for the Society for Research in Child Development, 45*(6), 187.

Carr, A., & Pike, A. (2012). Maternal scaffolding behavior: links with parenting style and maternal education. *Developmental psychology*, *48*(2), 543.

Carson, V., Kuzik, N., Hunter, S., Wiebe, S. A., Spence, J. C., Friedman, A., ... & Hinkley, T. (2015). Systematic review of sedentary behavior and cognitive development in early childhood. *Preventive medicine, 78*, 115-122.

Cattell, R. B. (1987). *Intelligence: Its structure, growth and action*. Elsevier.

Charalampous, K., Demetriou, C., Tricha, L., Ioannou, M., Georgiou, S., Nikiforou, M., & Stavrinides, P. (2018). The effect of parental style on bullying and cyber bullying behaviors and the mediating role of peer attachment relationships: A longitudinal study. *Journal of adolescence*, *64*, 109-123.

Chassiakos, Y. L. R., Radesky, J., Christakis, D., Moreno, M. A., & Cross, C. (2016). Children and adolescents and digital media. *Pediatrics, 138*(5), e20162593.

Cheng, S., Maeda, T., Yoichi, S., & Yamagata, Z. (2010). Early Television Exposure and Children's Behavioral and Social Outcomes at Age 30 Months. *Journal of Epidemiology*, *20*(2), S482-S489.

Chonchaiya, W., & Pruksananonda, C. (2008). Television viewing associates with delayed language development. *Acta Paediatrica, 97*(7), 977-982.

Chonchaiya, W., Sirachairat, C., Vijakkhana, N., Wilaisakditipakorn, T., & Pruksananonda, C. (2015). Elevated background TV exposure over time increases behavioural scores of 18-month-old toddlers. *Acta Paediatrica*, *104*(10), 1039-1046.

Christakis, D. A., & Zimmerman, F. J. (2007). Violent television viewing during preschool is associated with antisocial behavior during school age. *Pediatrics*, *120*(5), 993-999.

Christakis, D. A., Garrison, M. M., Herrenkohl, T., Haggerty, K., Rivara, F. P., Zhou, C., & Liekweg, K. (2013). Modifying media content for preschool children: a randomized controlled trial. *Pediatrics*, *131*(3), 431-438.

Christakis, D. A., Lowry, S. J., Goldberg, G., Violette, H., & Garrison, M. M. (2019). Assessment of a parent-child interaction intervention for language development in children. *JAMA network open*, *2*(6), 195738-195738.

Christakis, D. A., Zimmerman, F. J., DiGiuseppe, D. L., & McCarty, C. A. (2004). Early television exposure and subsequent attentional problems in children. *Pediatrics, 113*(4), 708-713.

Christian, K., Morrison, F. J., & Bryant, F. B. (1998). Predicting kindergarten academic skills, interactions among child care, maternal education, and family literacy environments. *Early Childhood Research Quarterly, 13*(3), 501-521.

Cibrian, F. L., Lakes, K. D., Schuck, S. E., & Hayes, G. R. (2022). The potential for emerging technologies to support self-regulation in children with ADHD: A literature review. *International Journal of Child-Computer Interaction, 31*, 100421.

Clements, D. H., & Sarama, J. (2003). Strip mining for gold: Research and policy in educational technology—A response to "Fool's Gold". *AACE Review, 11*(1), 7-69.

Cone, J. & Foster, S. (2006). *Dissertations and theses from start to finish (2nd ed).* American Psychological Association.

Conners-Burrow, N. A., McKelvey, L. M., & Fussell, J. J. (2011). Social outcomes associated with media viewing habits of low-income preschool children. *Early Education and Development*, *22*(2), 256-273.

Cost, K. T., Unternaehrer, E., Tsujimoto, K., Vanderloo, L. L., Birken, C. S., Maguire, J. L., ... & Charach, A. (2021). Patterns of parent screen use, child screen time, and child socioemotional problems at 5 years. *Journal of Neuroendocrinology*, e13246.

Courage, M. L., & Setliff, A. E. (2009). Debating the impact of television and video material on very young children: Attention, learning, and the developing brain. *Child Development Perspectives*, *3*(1), 72-78.

Coyne, S. M., Padilla-Walker, L. M., Holmgren, H. G., Davis, E. J., Collier, K. M., Memmott-Elison, M. K., & Hawkins, A. J. (2018). A meta-analysis of prosocial media on prosocial behavior, aggression, and empathic concern: A multidimensional approach. *Developmental psychology*, *54*(2), 331.

Coyne, S. M., Rogers, A. A., Zurcher, J. D., Stockdale, L., & Booth, M. (2020). Does time spent using social media impact mental health? An eight year longitudinal study. *Computers in Human Behavior, 104*, 106160.

Crawley, A. M., Anderson, D. R., Wilder, A., Williams, M., & Santomero, A. (1999). Effects of repeated exposures to a single episode of the television program Blue's Clues on the viewing behaviors and comprehension of preschool children. *Journal of Educational Psychology, 91*(4), 630–637

Crescenzi, L., Jewitt, C., & Price, S. (2014). The role of touch in preschool children's learning using iPad versus paper interaction. *Australian Journal of Language and Literacy, 37*(2), 86–96.

Cristia, A., & Seidl, A. (2015). Parental reports on touch screen use in early childhood. *PLoS One, 10*(6).

Cubelic, C. C., & Larwin, K. H. (2014). The use of iPad technology in the kindergarten classroom: A quasi-experimental investigation of the impact on early literacy skills. *Comprehensive Journal of Educational Research, 2*(4), 47-59.

De Decker, E., De Craemer, M., De Bourdeaudhuij, I., Wijndaele, K., Duvinage, K., Koletzko, B., ... & Zych, K. (2012). Influencing factors of screen time in preschool children: an exploration of parents' perceptions through focus groups in six European countries. *Obesity Reviews, 13*(1), 75-84.

De Leeuw, R. N., Kleemans, M., Rozendaal, E., Anschütz, D. J., & Buijzen, M. (2015). The impact of prosocial television news on children's prosocial behavior: An experimental study in the Netherlands. *Journal of children and media, 9*(4), 419-434.

DeLoache, J. S., Chiong, C., Sherman, K., Islam, N., Vanderborght, M., Troseth, G. L., ... & O'Doherty, K. (2010). Do babies learn from baby media? *Psychological science, 21*(11), 1570-1574.

Demir-Lira, Ö. E., Prado, J., & Booth, J. R. (2021). Neurocognitive basis of deductive reasoning in children varies with parental education. *Human brain mapping*, *42*(11), 3396-3410.

Dinleyici, M., Carman, K. B., Ozturk, E., & Sahin-Dagli, F. (2016). Media Use by Children, and Parents' Views on Children's Media Usage. *Interactive Journal of Medical Research*, *5*(2), e18.

Domingues-Montanari, S. (2017). Clinical and psychological effects of excessive screen time on children. *Journal of paediatrics and child health*, *53*(4), 333-338.

Duch, H., Fisher, E. M., Ensari, I., & Harrington, A. (2013a). Screen time use in children under 3 years old: a systematic review of correlates. *International journal of behavioral nutrition and physical activity*, *10*(1), 102.

Duch, H., Fisher, E. M., Ensari, I., Font, M., Harrington, A., Taromino, C., ... & Rodriguez, C. (2013b). Association of screen time use and language development in Hispanic toddlers: a cross-sectional and longitudinal study. *Clinical pediatrics*, *52*(9), 857-865.

Durkin, K., & Barber, B. (2002). Not so doomed: Computer game play and positive adolescent development. *Journal of applied developmental psychology*, *23*(4), 373-392.

Early Childhood Ireland (2016). *Children's Use of Technology*. Early Childhood Ireland Annual Report.

Ebenegger, V., Marques-Vidal, P. M., Munsch, S., Quartier, V., Nydegger, A., Barral, J., ... & Puder, J. J. (2012). Relationship of hyperactivity/inattention with adiposity and lifestyle characteristics in preschool children. *Journal of child neurology*, *27*(7), 852-858.

Edwards, C. P., Sheridan, S. M., & Knoche, L. L. (2010). Parent-child relationships in early learning. *International Encyclopedia of Education*, 438-443.

Egan, S. M., & Beatty, C. (2021). To school through the screens: the use of screen devices to support young children's education and learning during the COVID-19 pandemic. *Irish Educational Studies*, *40*(2), 275-283.

Egan, S. M., & Murray, A. (2014). Does time spent watching television in early childhood affect socio-emotional development? *Growing Up in Ireland Annual Conference*, Dublin, Ireland. Retrieved from: https://dspace.mic.ul.ie/handle/10395/2543

Elliott, C. D., Smith, P., & McCulloch, K. (1997). *British ability scales second edition (BAS II): Technical manual*. Windsor: NFER-Nelson.

Ellis, D. A. (2019). Are smartphones really that bad? Improving the psychological measurement of technology-related behaviors. *Computers in Human Behavior*, *97*, 60-66.

Elson, M., & Ferguson, C. J. (2015). Twenty-five years of research on violence in digital games and aggression: Empirical evidence, perspectives, and a debate gone astray. *European Psychologist*, *19*(1), 33.

Etchells, P. J., Gage, S. H., Rutherford, A. D., & Munafò, M. R. (2016). Prospective investigation of video game use in children and subsequent conduct disorder and depression using data from the Avon longitudinal study of parents and children. *PloS one, 11*(1), e0147732.

Ferguson, C. J. (2011). Video games and youth violence: A prospective analysis in adolescents. *Journal of youth and adolescence, 40*, 377-391.

Ferguson, C. J. (2015). Do angry birds make for angry children? A meta-analysis of video game influences on children’s and adolescents’ aggression, mental health, prosocial behavior, and academic performance. *Perspectives on Psychological Science, 10*(5), 646-666.

Ferguson, C. J., & Colwell, J. (2017). Understanding why scholars hold different views on the influences of video games on public health. *Journal of Communication*, *67*(3), 305-327.

Ferrer, E., & McArdle, J. J. (2004). An experimental analysis of dynamic hypotheses about cognitive abilities and achievement from childhood to early adulthood. *Developmental psychology*, *40*(6), 935.

Ferrer, E., McArdle, J. J., Shaywitz, B. A., Holahan, J. M., Marchione, K., & Shaywitz, S. E. (2007). Longitudinal models of developmental dynamics between reading and cognition from childhood to adolescence. *Developmental psychology*, *43*(6), 1460.

Fessakis, G., Gouli, E., & Mavroudi, E. (2013). Problem solving by 5–6 years old kindergarten children in a computer programming environment: A case study. *Computers & Education*, *63*, 87-97.

Fiorini, M. (2010). The effect of home computer use on children’s cognitive and non-cognitive skills. *Economics of Education review*, *29*(1), 55-72.

Fisch, S. M., Lesh, R., Motoki, E., Crespo, S., & Melfi, V. (2011). Children’s mathematical reasoning in online games: Can data mining reveal strategic thinking? *Child Development Perspectives*, *5*(2), 88-92.

Fisch, S. M., Lesh, R., Motoki, E., Crespo, S., & Melfi, V. (2014). Cross-platform learning: How do children learn from multiple media. *Learning by playing: Video gaming in education*, 207-219.

Fletcher, R. R., Chamberlain, D., Richman, D., Oreskovic, N., & Taveras, E. (2016). Wearable sensor and algorithm for automated measurement of screen time. In *2016 IEEE Wireless Health (pp. 1-8).* IEEE.

Floyd, R. G., Evans, J. J., & McGrew, K. S. (2003). Relations between measures of Cattell-Horn-Carroll (CHC) cognitive abilities and mathematics achievement across the school-age years. *Psychology in the Schools*, *40*(2), 155-171.

Fogle, L. M., & Mendez, J. L. (2006). Assessing the play beliefs of African American mothers with preschool children. *Early Childhood Research Quarterly*, *21*(4), 507-518.

Foster, E. M., & Watkins, S. (2010). The value of reanalysis: TV viewing and attention problems. *Child Development, 81*(1), 368-375.

Franklin, K. (2018). *Healthcare professionals' opinions on the use of handheld devices in the development of two-year-olds at the two-year review.* (MSc thesis, Buckinghamshire New University).

Friedrich, L. K., & Stein, A. H. (1973). Aggressive and prosocial television programs and the natural behavior of preschool children. *Monographs of the Society for Research in Child Development*, 1-64.

Fry, A. F., & Hale, S. (1996). Processing speed, working memory, and fluid intelligence: Evidence for a developmental cascade. *Psychological science*, *7*(4), 237-241.

Gentile, D. A., Reimer, R. A., Nathanson, A. I., Walsh, D. A., & Eisenmann, J. C. (2014). Protective effects of parental monitoring of children's media use: A prospective study. *JAMA pediatrics*, *168*(5), 479-484.

George, M. J., & Odgers, C. L. (2015). Seven fears and the science of how mobile technologies may be influencing adolescents in the digital age. *Perspectives on psychological science*, *10*(6), 832-851.

Gerber, B. L., Cavallo, A. M., & Marek, E. A. (2001). Relationships among informal learning environments, teaching procedures and scientific reasoning ability. *International Journal of Science Education*, *23*(5), 535-549.

Ghanizadeh, A., & Shams, F. (2007). Children's perceived parent-child relationships and family functioning in attention-deficit/hyperactivity disorder. *Child & Family Behavior Therapy*, *29*(3), 1-11.

Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: a guide for non-statisticians. *International journal of endocrinology and metabolism*, *10*(2), 486.

Ginsburg, K. R. (2007). The importance of play in promoting healthy child development and maintaining strong parent-child bonds. *Pediatrics*, *119*(1), 182-191.

Gioia, D. A., & Brass, D. J. (1986). Teaching the TV generation: The case for observational learning. *Organizational Behavior Teaching Review*, *10*(2), 11-18.

Glaser, D. (2000). Child abuse and neglect and the brain—a review. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *41*(1), 97-116.

Goodman, A., Lamping, D. L., & Ploubidis, G. B. (2010). When to use broader internalising and externalising subscales instead of the hypothesised five subscales on the Strengths and Difficulties Questionnaire (SDQ): data from British parents, teachers and children. *Journal of abnormal child psychology*, *38*, 1179-1191.

Goodman, R. (1997). The Strengths and Difficulties Questionnaire: a research note. *Journal of child psychology and psychiatry*, *38*(5), 581-586.

Gortmaker, S. L., Must, A., Sobol, A. M., Peterson, K., Colditz, G. A., & Dietz, W. H. (1996). Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Archives of Pediatrics & Adolescent Medicine*, *150*(4), 356-362.

Granic, I., Morita, H., & Scholten, H. (2020). Beyond screen time: Identity development in the digital age. *Psychological Inquiry*, *31*(3), 195-223.

Green, C. S., & Seitz, A. R. (2015). The impacts of video games on cognition (and how the government can guide the industry). *Policy Insights from the Behavioral and Brain Sciences, 2*(1), 101-110.

Greitemeyer, T., Osswald, S., & Brauer, M. (2010). Playing prosocial video games increases empathy and decreases schadenfreude. *Emotion*, *10*(6), 796.

Griffiths, L. J., Dowda, M., Dezateux, C., & Pate, R. (2010). Associations between sport and screen-entertainment with mental health problems in 5-year-old children. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(1), 1-11.

Haddad, A., Doherty, R., & Purtilo, R. (2019). Respectful interaction: Working with new-borns, infants, and children in the early years. In *Health professional and patient interaction (9th ed.).* Saunders Elsevier.

Hammed, N. M. A. (2014). *Information and communication technology in early childhood education: challenges for effective implementation and integration*. (Doctoral dissertation, University of Glasgow).

Haughton, C., Aiken, M., & Cheevers, C. (2015). Cyber babies: The impact of emerging technology on the developing infant. *Psychology*, *5*(9), 504-518.

Haveman, R., & Wolfe, B. (1995). The determinants of children's attainments: A review of methods and findings. *Journal of economic literature*, *33*(4), 1829-1878.

Hawes, D. J., & Dadds, M. R. (2004). Australian data and psychometric properties of the Strengths and Difficulties Questionnaire. *Australian & New Zealand Journal of Psychiatry, 38*(8), 644-651.

Heffer, T., Good, M., Daly, O., MacDonell, E., & Willoughby, T. (2019). The longitudinal association between social-media use and depressive symptoms among adolescents and young adults: An empirical reply to Twenge et al. (2018). *Clinical Psychological Science*, *7*(3), 462-470.

Heft, T. M., & Swaminathan, S. (2002). The effects of computers on the social behavior of preschoolers. *Journal of Research in Childhood Education, 16*(2), 162-174.

Herodotou, C. (2018). Young children and tablets: A systematic review of effects on learning and development. *Journal of Computer Assisted Learning*, *34*(1), 1-9.

High, P. C. (2008). School readiness. *Pediatrics*, *121*(4), e1008-e1015.

Hill, D., Ameenuddin, N., Reid Chassiakos, Y. L., Cross, C., Hutchinson, J., Levine, A., ... & Swanson, W. S. (2016). Media and young minds. *Pediatrics*, *138*(5).

Hill, M. M., Gangi, D., Miller, M., Rafi, S. M., & Ozonoff, S. (2020). Screen time in 36-month-olds at increased likelihood for ASD and ADHD. *Infant Behavior and Development, 61*, 101484.

Hinkley, T., Brown, H., Carson, V., & Teychenne, M. (2018). Cross sectional associations of screen time and outdoor play with social skills in preschool children. *PloS one, 13*(4), e0193700.

Hinkley, T., Verbestel, V., Ahrens, W., Lissner, L., Molnar, D., Moreno, L. A., ... & De Bourdeaudhuij, I. (2014). Early childhood electronic media use as a predictor of poorer well-being: a prospective cohort study. *JAMA pediatrics*, *168*(5), 485-492.

Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps: Lessons from the science of learning. *Psychological Science in the Public Interest*, *16*(1), 3-34.

Hofferth, S. L. (1999). Family reading to young children: Social desirability and cultural biases in reporting. In *Workshop on the Measurement of and Research on Time Use, National Research Council, Committee on National Statistics.* National Research Council.

Hollenstein, T., & Colasante, T. (2020). Socioemotional development in the digital age. *Psychological Inquiry*, *31*(3), 250-257.

Horn, J. L., & Cattell, R. B. (1967). Age differences in fluid and crystallized intelligence. *Acta psychologica*, *26*, 107-129.

Hoza, B. (2007). Peer functioning in children with ADHD. *Journal of pediatric psychology*, *32*(6), 655-663.

Huang, C. (2010). Internet use and psychological well-being: A meta-analysis. *Cyberpsychology, behavior, and social networking*, *13*(3), 241-249.

Huber, B., Tarasuik, J., Antoniou, M. N., Garrett, C., Bowe, S. J., Kaufman, J., & Team, S. B. (2016). Young children's transfer of learning from a touchscreen device. *Computers in Human Behavior*, *56*, 56-64.

Huber, B., Yeates, M., Meyer, D., Fleckhammer, L., & Kaufman, J. (2018). The effects of screen media content on young children's executive functioning. *Journal of experimental child psychology*, *170*, 72-85.

Hudon, T. M., Fennell, C. T., & Hoftyzer, M. (2013). Quality not quantity of television viewing is associated with bilingual toddlers' vocabulary scores. *Infant Behavior and Development*, *36*(2), 245-254.

John, J. J., Joseph, R., David, A., Bejoy, A., George, K. V., & George, L. (2021). Association of screen time with parent-reported cognitive delay in preschool children of Kerala, India. *BMC pediatrics*, *21*, 1-8.

Johnson-Laird, P. N. (2006). *How we reason.* Oxford University Press.

Kabali, H. K., Irigoyen, M. M., Nunez-Davis, R., Budacki, J. G., Mohanty, S. H., Leister, K.P., & Bonner, R. L. (2015). Exposure and use of mobile media devices by young children. *Pediatrics*, *136*(6), 1044-1050.

Kail, R. V. (2007). Longitudinal evidence that increases in processing speed and working memory enhance children's reasoning. *Psychological science*, *18*(4), 312.

Kail, R. V. (2021). *Children and Their Development (7th Edition).* Pearson.

Kano, A., Takahashi, K., Kataoka, N., & Seino, Y. (2007). Relation of television and video watching time to development of children aged three and a half years. *The Journal of the Japan Pediatric Society*, *111*, 454-461.

Karani, N. F., Sher, J., & Mophosho, M. (2022). The influence of screen time on children's language development: A scoping review. *South African Journal of Communication Disorders*, *69*(1), 825.

Kardefelt-Winther, D. (2017). *How Does the Time Children Spend Using Digital Technology Impact Their Mental Well-being, Social Relationships and Physical Activity? An Evidence-Focused Literature Review*. UNICEF Office of Research.

Kirkorian, H. L., & Pempek, T. A. (2013). Toddlers and Touch Screens: Potential for Early Learning? *Zero to Three, 33*(4), 32-37.

Kirkorian, H. L., Wartella, E. A., & Anderson, D. R. (2008). Media and young children's learning. *The Future of children*, 39-61.

Konok, V., Liszkai-Peres, K., Bunford, N., Ferdinandy, B., Jurányi, Z., Ujfalussy, D. J., ... & Miklósi, Á. (2021). Mobile use induces local attentional precedence and is associated with limited socio-cognitive skills in preschoolers. *Computers in Human Behavior*, *120*, 106758.

Kostyrka-Allchorne, K., Cooper, N. R., & Simpson, A. (2017). The relationship between television exposure and children's cognition and behaviour: A systematic review. *Developmental Review, 44*, 19-58.

Kostyrka-Allchorne, K., Cooper, N. R., Wass, S. V., Fenner, B., Gooding, P., Hussain, S., ... & Sonuga-Barke, E. J. (2020). Future preferences and prospection of future of outcomes: Independent yet specific associations with attention-deficit/hyperactivity disorder. *Journal of Adolescence*, *83*, 31-41.

Kovess-Masfety, V., Keyes, K., Hamilton, A., Hanson, G., Bitfoi, A., Golitz, D., ... & Pez, O. (2016). Is time spent playing video games associated with mental health, cognitive and social skills in young children? *Social psychiatry and psychiatric epidemiology*, *51*(3), 349-357.

Kronenberger, W. G., Mathews, V. P., Dunn, D. W., Wang, Y., Wood, E. A., Larsen, J. J., ... & Lurito, J. T. (2005). Media violence exposure in aggressive and control adolescents: differences in self-and parent-reported exposure to violence on television and in video games. *Aggressive behavior*, *31*(3), 201-216.

Kühhirt, M., & Klein, M. (2020). Parental education, television exposure, and children's early cognitive, language and behavioral development. *Social science research*, *86*, 102391.

Kuta, C. (2017). *The negative impact of excessive screen time on language development in children under 6-years-old: An integrative review with screen time reduction toolkit and presentation for outpatient pediatric and family health providers.* Doctors and Nurses Practice (DNP) Projects.

Kwak, S. G., & Kim, J. H. (2017). Central limit theorem: the cornerstone of modern statistics. *Korean journal of anesthesiology*, *70*(2), 144-156.

Lamb, M. E., & Lerner, R. M. (2015). *Handbook of child psychology and developmental science: Socioemotional processes (Vol. 3)*. John Wiley & Sons, Inc.

Lauricella, A. R., Blackwell, C. K., & Wartella, E. (2016). The “New” technology environment: The role of content and context on learning and development from mobile media. In R. Barr & D. N. Linebarger (Eds.), *Media exposure during infancy and early childhood: The effects of content and context on learning and development*. Springer.

Lauricella, A. R., Wartella, E., & Rideout, V. J. (2015). Young children's screen time: The complex role of parent and child factors. *Journal of Applied Developmental Psychology, 36*, 11-17.

Lavigne, H. J., Hanson, K. G., & Anderson, D. R. (2015). The influence of television coviewing on parent language directed at toddlers. *Journal of Applied Developmental Psychology, 36*, 1-10.

Lerner, R. M., Liben, L. S., & Mueller, U. (2015). *Handbook of child psychology and developmental science, cognitive processes (Vol. 2)*. John Wiley & Sons.

Levelink, B., van der Vlegel, M., Mommers, M., Gubbels, J., Dompeling, E., Feron, F. J., ... & Thijs, C. (2021). The longitudinal relationship between screen time, sleep and a diagnosis of attention-deficit/hyperactivity disorder in childhood. *Journal of attention disorders*, *25*(14), 2003-2013.

Levido, A., & Rodriquez, A. (2022). *Relax, it's just a ring light for kids. Toys like the 'vlogger set' prepare them for a digital world.* The Conversation.

Li, C., Cheng, G., Sha, T., Cheng, W., & Yan, Y. (2020). The relationships between screen use and health indicators among infants, toddlers, and preschoolers: A meta-analysis and systematic review. *International journal of environmental research and public health*, *17*(19), 7324.

Li, X., & Atkins, M. S. (2004). Early childhood computer experience and cognitive and motor development. *Pediatrics, 113*(6), 1715-1722.

Lieberman, D. A. (2012). What can we learn from playing interactive games? In *Playing video games* (pp. 447-469). Routledge.

Lieberman, D. A., Fisk, M. C., & Biely, E. (2009). Digital games for young children ages three to six: From research to design. *Computers in the Schools, 26*(4), 299-313.

Lin, L. Y. (2019). Differences between preschool children using tablets and non-tablets in visual perception and fine motor skills. *Hong Kong Journal of Occupational Therapy*, *32*(2), 118-126.

Linebarger, D. L., & Vaala, S. E. (2010). Screen media and language development in infants and toddlers: An ecological perspective. *Developmental Review*, *30*(2), 176-202.

Linebarger, D. L., & Walker, D. (2005). Infants' and toddlers' television viewing and language outcomes. *American behavioral scientist*, *48*(5), 624-645.

Lingineni, R. K., Biswas, S., Ahmad, N., Jackson, B. E., Bae, S., & Singh, K. P. (2012). Factors associated with attention deficit/hyperactivity disorder among US children: results from a national survey. *BioMed Central Pediatrics*, *12*(1), 50.

Liu, J., Chen, X., & Lewis, G. (2011). Childhood internalizing behaviour: analysis and implications. *Journal of psychiatric and mental health nursing*, *18*(10), 884-894.

Liu, W., Wu, X., Huang, K., Yan, S., Ma, L., Cao, H., ... & Tao, F. (2021). Early childhood screen time as a predictor of emotional and behavioral problems in children at 4 years: a birth cohort study in China. *Environmental health and preventive medicine*, *26*(1), 1-9.

Livingstone, S., & Franklin, K. (2018). Families with young children and 'screen time'. *Journal of Health Visiting*, *6*(9), 434-439.

Mackay, L. J., Komanchuk, J., Hayden, K. A., & Letourneau, N. (2022). Impacts of parental technoference on parent-child relationships and child health and developmental outcomes: a scoping review protocol. *Systematic reviews*, *11*(1), 1-7.

Mackey, A. P., Hill, S. S., Stone, S. I., & Bunge, S. A. (2011). Differential effects of reasoning and speed training in children. *Developmental science*, *14*(3), 582-590.

Madigan, S., Browne, D., Racine, N., Mori, C., & Tough, S. (2019). Association between screen time and children's performance on a developmental screening test. *JAMA pediatrics*, *173*(3), 244-250.

Madigan, S., McArthur, B. A., Anhorn, C., Eirich, R., & Christakis, D. A. (2020). Associations between screen use and child language skills: a systematic review and meta-analysis. *JAMA pediatrics*, *174*(7), 665-675.

Mares, M. L., & Pan, Z. (2013). Effects of Sesame Street: A meta-analysis of children's learning in 15 countries. *Journal of Applied Developmental Psychology*, *34*(3), 140-151.

Mares, M. L., & Woodard, E. (2012). Effects of prosocial media content on children's social interactions. In D. G. Singer & J. L. Singer (Eds.), *Handbook of children and the media* (2nd ed., pp. 197–214). Sage.

Marsh, J., Plowman, L., Yamada-Rice, D., Bishop, J. C., Lahmar, J., Scott, F., ... & Thornhill, S. (2015). *Exploring play and creativity in pre-schoolers' use of apps: Final project report*. Technology and Play.

McArthur, B. A., Tough, S., & Madigan, S. (2022). Screen time and developmental and behavioral outcomes for preschool children. *Pediatric Research*, *91*(6), 1616-1621.

McCarrick, K., & Li, X. (2004). Buried treasure: The impact of computer use on young children's social, cognitive, language development and motivation. *American Association of Clinical Endocrinologists Journal*, *15*(1), 73-95.

McClure, E. R., Chentsova-Dutton, Y. E., Barr, R. F., Holochwost, S. J., & Parrott, W. G. (2015). "Facetime doesn't count": Video chat as an exception to media restrictions for infants and toddlers. *International Journal of Child-Computer Interaction, 6*, 1-6.

McDaniel, B. T., & Radesky, J. S. (2018). Technoference: Parent distraction with technology and associations with child behavior problems. *Child development, 89*(1), 100-109.

McFadden, K. E., & Tamis-Lemonda, C. S. (2013). Maternal responsiveness, intrusiveness, and negativity during play with infants: Contextual associations and infant cognitive status in a low-income sample. *Infant Mental Health Journal*, *34*(1), 80-92.

Mendelsohn, A. L., Brockmeyer, C. A., Dreyer, B. P., Fierman, A. H., Berkule-Silberman, S. B., & Tomopoulos, S. (2010). Do verbal interactions with infants during electronic media exposure mitigate adverse impacts on their language development as toddlers? *Infant and Child Development, 19*(6), 577-593.

Merçon-Vargas, E. A., Lima, R. F. F., Rosa, E. M., & Tudge, J. (2020). Processing proximal processes: What Bronfenbrenner meant, what he didn't mean, and what he should have meant. *Journal of Family Theory & Review*, *12*(3), 321-334.

Mieloo, C., Raat, H., van Oort, F., Bevaart, F., Vogel, I., Donker, M., & Jansen, W. (2012). Validity and reliability of the strengths and difficulties questionnaire in 5–6 year olds: differences by gender or by parental education? *PloS one, 7*(5), e36805.

Miguel-Berges, M. L., Santaliestra-Pasias, A. M., Mouratidou, T., Flores-Barrantes, P., Androutsos, O., De Craemer, M., ... & Moreno, L. A. (2020). Parental perceptions, attitudes and knowledge on European preschool children’s total screen time: the ToyBox-study. *European journal of public health*, *30*(1), 105-111.

Milich, R., Lorch, E. P., & Berthiaume, K. (2005). Story comprehension in children with ADHD: Research findings and treatment implications. *Attention deficit hyperactivity disorder research*, 111-137.

Miller, C. J., Marks, D. J., Miller, S. R., Berwid, O. G., Kera, E. C., Santra, A., & Halperin, J. M. (2007). Brief report: Television viewing and risk for attention problems in preschool children. *Journal of pediatric psychology*, *32*(4), 448-452.

Mistry, K. B., Minkovitz, C. S., Strobino, D. M., & Borzekowski, D. L. (2007). Children's television exposure and behavioral and social outcomes at 5.5 years: does timing of exposure matter? *Pediatrics*, *120*(4), 762-769.

Mordkoff, T. (2016). *The assumption(s) of normality*. Retrieved from: http://www2.psychology.uiowa.edu/faculty/mordkoff/GradStats/part%201/I.07%20normal.pdf

Mumme, D. L., & Fernald, A. (2003). The infant as onlooker: Learning from emotional reactions observed in a television scenario. *Child development*, *74*(1), 221-237.

Murray, A., & Egan, S. M. (2014). Does reading to infants benefit their cognitive development at 9-months-old? An investigation using a large birth cohort survey. *Child Language Teaching and Therapy*, *30*(3), 303-315.

Murray, A., McNamara, E., Williams, J. & Smyth, E. (2019). *Growing Up in Ireland: The Lives of Five-Year Olds.* The Stationery Office.

Nagata, J. M., Magid, H. S. A., & Gabriel, K. P. (2020). Screen time for children and adolescents during the coronavirus disease 2019 pandemic. *Obesity*, *28*(9), 1582.

Nagel, M. (2019). *Screen time and the science of learning.* First Five Years. Retrieved from: https://www.firstfiveyears.org.au/child-development/screen-time-and-the-science-of-learning

Naigles, L. G., & Kako, E. T. (1993). First contact in verb acquisition: Defining a role for syntax. *Child development*, *64*(6), 1665-1687.

National Research Council. (2015). *Transforming the workforce for children birth through age 8: A unifying foundation.* Institute of Medicine and National Research Council of the National Academies.

Navarro, J. L., & Tudge, J. R. (2022). Technologizing bronfenbrenner: neo-ecological theory. *Current Psychology*, 1-17.

Neitzel, C., & Dopkins Stright, A. (2004). Parenting behaviours during child problem solving: The roles of child temperament, mother education and personality, and the problem-solving context. *International Journal of Behavioral Development*, *28*(2), 166-179.

Nelson, K. (1973). Structure and strategy in learning to talk. *Monographs of the society for research in child development*, 1-135.

Neumann, M. M. (2018a). Using tablets and apps to enhance emergent literacy skills in young children. *Early Childhood Research Quarterly*, *42*, 239-246.

Neumann, M. M. (2018b). Parent scaffolding of young children's use of touch screen tablets. *Early Child Development and Care*, *188*(12), 1654-1664.

Neumann, M. M., & Neumann, D. L. (2014). Touch screen tablets and emergent literacy. *Early Childhood Education Journal, 42*(4), 231–239.

Neumann, M. M., & Neumann, D. L. (2016). An analysis of mother-child interactions during an iPad activity. In K. Alvarez (Ed.), *Parent-child interactions and relationships: Perceptions, practices, and developmental outcomes* (pp. 133–148). Nova Science.

Niedenthal, P. M. (2007). Embodying emotion. *Science, 316*(5827), 1002-1005.

Nikkelen, S. W., Valkenburg, P. M., Huizinga, M., & Bushman, B. J. (2014). Media use and ADHD-related behaviors in children and adolescents: A meta-analysis. *Developmental psychology*, *50*(9), 2228.

Obel, C., Henriksen, T. B., Dalsgaard, S., Linnet, K. M., Skajaa, E., Thomsen, P. H., & Olsen, J. (2004). Does children's watching of television cause attention problems? Retesting the hypothesis in a Danish cohort. *Pediatrics, 114*(5), 1372-1373.

O'Connor, T. G., Hetherington, E. M., & Clingempeel, W. G. (1997). Systems and bidirectional influences in families. *Journal of Social and Personal Relationships*, *14*(4), 491-504.

OECD (2020). *Early Learning and Child Well-being: A Study of Five-year-Olds in England, Estonia, and the United States.* OECD Publishing.

Ofcom. (2018). *Children and parents: Media use and attitudes report*. Office of Communications.

Oliver, B. R. (2015). Unpacking externalising problems: negative parenting associations for conduct problems and irritability. *BJPsych open*, *1*(1), 42-47.

Operto, F. F., Pastorino, G. M. G., Marciano, J., de Simone, V., Volini, A. P., Olivieri, M., ... & Coppola, G. (2020). Digital devices use and language skills in children between 8 and 36 month. *Brain Sciences*, *10*(9), 656.

Orben, A., & Przybylski, A. K. (2019). The association between adolescent well-being and digital technology use. *Nature Human Behaviour*, *3*(2), 173-182.

Özmert, E., Toyran, M., & Yurdakök, K. (2002). Behavioral correlates of television viewing in primary school children evaluated by the child behaviour checklist. *Archives of pediatrics & adolescent medicine*, *156*(9), 910-914.

Pagani, L. S., Fitzpatrick, C., & Barnett, T. A. (2013). Early childhood television viewing and kindergarten entry readiness. *Pediatric research*, *74*(3), 350-355.

Paik, H., & Comstock, G. (1994). The effects of television violence on antisocial behavior: a meta-analysis. *Communication research*, *21*(4), 516-546.

Paradis, J., Emmerzael, K., & Duncan, T. S. (2010). Assessment of English language learners: Using parent report on first language development. *Journal of communication disorders*, *43*(6), 474-497.

Parkes, A., Sweeting, H., Wight, D., & Henderson, M. (2013). Do television and electronic games predict children's psychosocial adjustment? Longitudinal research using the UK Millennium Cohort Study. *Archives of disease in childhood*, *98*(5), 341-348.

Passmore, H. A., & Holder, M. D. (2014). Gaming for good: Video games and enhancing prosocial behavior. *Journal of Communications Research*, *6*(2), 199-224.

Peck, T., Scharf, R. J., Conaway, M. R., & DeBoer, M. D. (2015). Viewing as little as 1 hour of TV daily is associated with higher change in BMI between kindergarten and first grade. *Obesity, 23*(8), 1680-1686.

Pempek, T. A., Demers, L. B., Hanson, K. G., Kirkorian, H. L., & Anderson, D. R. (2011). The impact of infant-directed videos on parent–child interaction. *Journal of Applied Developmental Psychology, 32*(1), 10-19.

Piaget, J. (1936). *Origins of intelligence in the child.* Routledge & Kegan Paul.

Pianta, R. (1992). *Child Parent Relationship Scale.* University of Virginia.

Plowman, L., & McPake, J. (2013). Seven myths about young children and technology. *Childhood Education*, *89*(1), 27-33.

Plowman, L., McPake, J., & Stephen, C. (2012). Extending opportunities for learning: the role of digital media in early education. In *Contemporary debates in childhood education and development* (pp. 109-118). Routledge.

Poulain, T., Vogel, M., Neef, M., Abicht, F., Hilbert, A., Genuneit, J., ... & Kiess, W. (2018). Reciprocal associations between electronic media use and behavioral difficulties in preschoolers. *International journal of environmental research and public health*, *15*(4), 814.

Powers, K. L., Brooks, P. J., Aldrich, N. J., Palladino, M. A., & Alfieri, L. (2013). Effects of video-game play on information processing: a meta-analytic investigation. *Psychonomic bulletin & review, 20*(6), 1055-1079.

Przybylski, A. K. (2014). Electronic gaming and psychosocial adjustment. *Pediatrics*, *134*(3), e716-e722.

Przybylski, A. K. (2019). Digital screen time and pediatric sleep: evidence from a preregistered cohort study. *The Journal of pediatrics*, *205*, 218-223.

Przybylski, A. K., & Weinstein, N. (2017). A large-scale test of the goldilocks hypothesis: quantifying the relations between digital-screen use and the mental well-being of adolescents. *Psychological Science*, *28*(2), 204-215.

Przybylski, A. K., & Weinstein, N. (2019). Digital Screen Time Limits and Young Children's Psychological Well-Being: Evidence from a Population-Based Study. *Child Development*, *90*(1), e56-e65.

PSI. (2010). *Code of Professional Ethics.* Psychological Society of Ireland.

Qualtrics. (2019). *Qualtrics Research Suite*. Provo, UT, USA,

Quisenberry, N. I. and Klasek, C. B. (1977). Can watching TV be good for children? *Audio-visual Instruction*, *22*(3), 56-57.

Radesky, J. S., Schumacher, J., & Zuckerman, B. (2015). Mobile and interactive media us by young children: the good, the bad, and the unknown. *Pediatrics, 135*(1), 1-3.

Radesky, J. S., Silverstein, M., Zuckerman, B., & Christakis, D. A. (2014). Infant self-regulation and early childhood media exposure. *Pediatrics*, *133*(5), e1172-e1178.

Rice, M. L., & Woodsmall, L. (1988). Lessons from television: Children's word learning when viewing. *Child development*, 420-429.

Rice, M. L., Huston, A. C., Truglio, R., & Wright, J. C. (1990). Words from" Sesame Street": Learning vocabulary while viewing. *Developmental psychology*, *26*(3), 421.

Richert, R. A., & Abrego, T. (2007). *Preschooler's transfer from fantasy through books and video.* University of California.

Rideout, V. J. (2011). *Zero to eight: Children's media use in America.* Common Sense Media.

Rideout, V. J. (2013). *Zero to eight: Children's media use in America.* Common Sense Media.

Rideout, V. J., & Hamel, E. (2006). *The media family: Electronic media in the lives of infants, toddlers, preschoolers and their parents*. Kaiser Family Foundation.

Rideout, V. J., Vandewater, E. A., & Wartella, E. A. (2003). *Zero to six: Electronic media in the lives of infants, toddlers and preschoolers.* Kaiser Family Foundation.

Reed, F. D. D., Hyman, S. R., & Hirst, J. M. (2011). Applications of technology to teach social skills to children with autism. *Research in Autism Spectrum Disorders*, *5*(3), 1003-1010.

Roseberry, S., Hirsh-Pasek, K., & Golinkoff, R. M. (2014). Skype me! Socially contingent interactions help toddlers learn language. *Child development*, *85*(3), 956-970.

Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development*, *72*(5), 1394-1408.

Rowe, M. L., & Zuckerman, B. (2016). Word gap redux: Developmental sequence and quality. *JAMA pediatrics*, *170*(9), 827-828.

Ruangdaraganon, N., Chuthapisith, J., Mo-suwan, L., Kriweradechachai, S., Udomsubpayakul, U., & Choprapawon, C. (2009). Television viewing in Thai infants and toddlers: impacts to language development and parental perceptions. *BMC pediatrics*, *9*(1), 1-6.

Russo-Johnson, C., Troseth, G., Duncan, C., & Mesghina, A. (2017). All tapped out: Touchscreen interactivity and young children's word learning. *Frontiers in psychology*, *8*, 578.

Sachs, J., Bard, B., & Johnson, M. L. (1981). Language learning with restricted input: Case studies of two hearing children of deaf parents. *Applied Psycholinguistics*, *2*(1), 33-54.

Saleme, P., Pang, B., Dietrich, T., & Parkinson, J. (2020). Prosocial digital games for youth: A systematic review of interventions. *Computers in Human Behavior Reports*, *2*, 100039.

Sanders, T., Parker, P. D., del Pozo-Cruz, B., Noetel, M., & Lonsdale, C. (2019). Type of screen time moderates effects on outcomes in 4013 children: evidence from the Longitudinal Study of Australian Children. *International Journal of Behavioral Nutrition and Physical Activity*, *16,* 1-10.

Schmidt, M. E., & Vandewater, E. A. (2008). Media and attention, cognition, and school achievement. *The Future of children,* 63-85.

Schmidt, M. E., Rich, M., Rifas-Shiman, S. L., Oken, E., & Taveras, E. M. (2009). Television viewing in infancy and child cognition at 3 years of age in a US cohort. *Pediatrics, 123*(3), e370-e375.

Schmiedeler, S., Niklas, F., & Schneider, W. (2014). Symptoms of Attention-Deficit Hyperactivity Disorder (ADHD) and Home Learning Environment (HLE): Findings from a Longitudinal Study. *European Journal of Psychology of Education, 29*(3), 467-482.

Schonhaut, B. L., Pérez, R. M., Castilla, F. A., Castro, M. S., Salinas, A. P., & Armijo, R. I. (2017). Predictive value of Ages & Stages Questionnaires for cognitive performance at early years of schooling. *Revista Chilena de Pediatria*, *88*(1), 28-34.

Schwartz, R. N., & Plass, J. L. (2014). Click versus drag: User-performed tasks and the enactment effect in an interactive multimedia environment. *Computers in Human Behavior, 33,* 242-255.

Seefeldt, C., Denton, K., Galper, A., & Younoszai, T. (1999). The relation between Head Start parents' participation in a transition demonstration, education, efficacy and their children's academic abilities. *Early Childhood Research Quarterly*, *14*(1), 99-109.

Sefton-Green, J., Willett, R., Zhao, X., Jeong, H., Healy, S., Williams, J. L. (2022). *Digital Child Project 2022-09, Children, media and parenting in the COVID-19 pandemic.* ARC Centre of Excellence for the Digital Child, Brisbane, Australia.

Sevincok, D., Ozbay, H. C., Ozbek, M. M., Tunagur, M. T., & Aksu, H. (2020). ADHD symptoms in relation to internalizing and externalizing symptoms in children: The mediating role of sluggish cognitive tempo. *Nordic journal of psychiatry*, *74*(4), 265-272.

Shapiro, J. (2019). *The New Childhood: Raising kids to thrive in a digitally connected world*. Hachette.

Shirley, S. & Kumar, S. (2019). A study on screen time use in children between 24 to 60 months of age in Tamilnadu, India. *International Journal of Contemporary Pediatrics, 6*, 2582.

Shuler, C. (2012). *iLearn II: An Addendum an analysis of the games category of Apple's App Store.* The Joan Ganz Cooney Center.

Shute, R., & Miksad, J. (1997). Computer assisted instruction and cognitive development in preschoolers. *Child Study Journal, 27*(3), 237-53.

Siegle, D. (2013). iPads: Intuitive technology for 21st-century students. *Gifted Child Today, 36*(2), 146-150.

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of educational research*, *75*(3), 417-453.

Smith, G. G., & Olkun, S. (2005). Why interactivity works: Interactive priming of mental rotation. *Journal of Educational Computing Research, 32*(2), 93-111.

Spence, I., & Feng, J. (2010). Video games and spatial cognition. *Review of General Psychology, 14*(2), 92-104.

Squires, J. (2017). Use of parents and caregivers as accurate assessors of young childrens development. *Revista Chilena de Pediatría, 88*(1), 22-24.

Stevens, T., & Mulsow, M. (2006). There is no meaningful relationship between television exposure and symptoms of attention-deficit/hyperactivity disorder. *Pediatrics*, *117*(3), 665-672.

Straker, L., Edwards, S., Kervin, L., Burley, J., Hendry, D., & Cliff, D. (2023). *Digital Child Working Paper 2023-01, Moving screen use guidelines: Nine reasons why screen use guidelines should be separated from public health 24-hour movement guidelines in Australia and internationally.* ARC Centre of Excellence for the Digital Child, Brisbane, Australia.

Strasburger, V. C., Hogan, M. J., Mulligan, D. A., Ameenuddin, N., Christakis, D. A., Cross, C., ... & Moreno, M. A. (2013). Children, adolescents, and the media. *Pediatrics, 132*(5), 958-961.

Strouse, G. A., Troseth, G. L., O'Doherty, K. D., & Saylor, M. M. (2018). Co-viewing supports toddlers' word learning from contingent and noncontingent video. *Journal of experimental child psychology*, *166*, 310-326.

Sugawara, M. (2010). *NHK.org.* NHK Broadcasting Culture Research Institute.

Sultana, A., Tasnim, S., Hossain, M. M., Bhattacharya, S., & Purohit, N. (2021). Digital screen time during the COVID-19 pandemic: a public health concern. *F1000Research*, *10*, 81.

Supanitayanon, S., Trairatvorakul, P., & Chonchaiya, W. (2020). Screen media exposure in the first 2 years of life and preschool cognitive development: a longitudinal study. *Pediatric Research*, *88*(6), 894-902.

Sutherland, M. (2012). *Gifted and talented in the early years: Practical activities for children aged 3 to 6*. Sage Publications.

Sweetser, P., Johnson, D. M., Ozdowska, A., & Wyeth, P. (2012). Active versus passive screen time for young children. *Australasian Journal of Early Childhood, 37*(4), 94-98.

Swing, E. L., Gentile, D. A., Anderson, C. A., & Walsh, D. A. (2010). Television and video game exposure and the development of attention problems. *Pediatrics*, *126*(2), 214-221.

Takeuchi, H., Taki, Y., Hashizume, H., Asano, K., Asano, M., Sassa, Y., ... & Kawashima, R. (2015). The impact of television viewing on brain structures: cross-sectional and longitudinal analyses. *Cerebral Cortex*, *25*(5), 1188-1197.

Takeuchi, L., & Stevens, R. (2011). *The new coviewing: Designing for learning through joint media engagement.* The Joan Ganz Cooney Centre.

Tamana, S. K., Ezeugwu, V., Chikuma, J., Lefebvre, D. L., Azad, M. B., Moraes, T. J., ... & Mandhane, P. J. (2019). Screen-time is associated with inattention problems in preschoolers: Results from the CHILD birth cohort study. *PloS one*, *14*(4), e0213995.

Tamir, P. (1990). Factors associated with the relationship between formal, informal, and nonformal science learning. *Journal of Environmental Education, 22,* 34-42.

Tanimura, M., Okuma, K., & Kyoshima, K. (2007). Television viewing, reduced parental utterance, and delayed speech development in infants and young children. *Archives of pediatrics & adolescent medicine*, *161*(6), 618-619.

Tanimura, M., Takahashi, K., & Kataoka, N. (2004) Heavy television and video viewing poses a risk for infants and young children. *Acta Paediatrica Japonica, 108*, 709-712.

Tansriratanawong, S., Louthrenoo, O., Chonchaiya, W., & Charnsil, C. (2017). Screen viewing time and externalising problems in pre-school children in Northern Thailand. *Journal of Child & Adolescent Mental Health*, *29*(3), 245-252.

Tarasuik, J., Demaria, A., & Kaufman, J. (2017). Transfer of problem solving skills from touchscreen to 3D model by 3-to 6-year-olds. *Frontiers in Psychology*, *8*, 1586.

Tenny, S., & Hoffman, M. R. (2020). *Odds Ratio*. StatPearls Publishing.

Thakkar, R. R., Garrison, M. M., & Christakis, D. A. (2006). A systematic review for the effects of television viewing by infants and preschoolers. *Pediatrics*, *118*(5), 2025-2031.

Thelen, E. (2000). Grounded in the world: Developmental origins of the embodied mind. *Infancy, 1*(1), 3-28.

Thompson, A. L., Adair, L. S., & Bentley, M. E. (2013). Maternal characteristics and perception of temperament associated with infant TV exposure. *Pediatrics*, *131*(2), e390-e397.

Tomopoulos, S., Dreyer, B. P., Berkule, S., Fierman, A. H., Brockmeyer, C., & Mendelsohn, A. L. (2010). Infant media exposure and toddler development. *Archives of pediatrics & adolescent medicine*, *164*(12), 1105-1111.

Tomopoulos, S., Dreyer, B. P., Valdez, P., Flynn, V., Foley, G., Berkule, S. B., & Mendelsohn, A. L. (2007). Media content and externalizing behaviors in Latino toddlers. *Ambulatory Pediatrics*, *7*(3), 232-238.

Troseth, G. L., & DeLoache, J. (1998). The medium can obscure the message: Young children's understanding of video. *Child Development, 69*, 950-965.

Troseth, G. L., Russo, C. E., & Strouse, G. A. (2016). What's next for research on young children's interactive media? *Journal of children and Media*, *10*(1), 54-62.

Twenge, J. M., & Campbell, W. K. (2018). Associations between screen time and lower psychological well-being among children and adolescents: Evidence from a population-based study. *Preventive medicine reports*, *12*, 271-283.

Valkenburg, P. M., & Peter, J. (2013). The differential susceptibility to media effects model. *Journal of communication*, *63*(2), 221-243.

van Egmond-Fröhlich, A. W., Weghuber, D., & de Zwaan, M. (2012). Association of symptoms of attention-deficit/hyperactivity disorder with physical activity, media time, and food intake in children and adolescents. *PloS one*, *7*(11), e49781.

van Evra, J. (2004). *Television and child development*. Routledge.

Vandewater, E. A., & Lee, S. J. (2009). Measuring children's media use in the digital age: issues and challenges. *American Behavioral Scientist*, *52*(8), 1152-1176.

Vandewater, E. A., Bickham, D. S., & Lee, J. H. (2006). Time well spent? Relating television use to children's free-time activities. *Pediatrics*, *117*(2), e181-e191.

Vandewater, E. A., Bickham, D. S., Lee, J. H., Cummings, H. M., Wartella, E. A., & Rideout, V. J. (2005). When the television is always on: Heavy television exposure and young children’s development. *American Behavioral Scientist*, *48*(5), 562-577.

Vandewater, E. A., Rideout, V. J., Wartella, E. A., Huang, X., Lee, J. H., & Shim, M. S. (2007). Digital childhood: electronic media and technology use among infants, toddlers, and preschoolers. *Pediatrics*, *119*(5), e1006-e1015.

Veena, S. R., Krishnaveni, G. V., Srinivasan, K., Kurpad, A. V., Muthayya, S., Hill, J. C., ... & Fall, C. H. D. (2010). Childhood cognitive ability: relationship to gestational diabetes mellitus in India. *Diabetologia*, *53*, 2134-2138.

Voort, J. L. V. (2020). Disentangling the pathways of parent screen time and child behavior. *The Journal of Pediatrics*, *226*, 1-4.

Vygotsky, L. S. (1967). Play and its role in the mental development of the child. *Soviet psychology*, *5*(3), 6-18.

Vygotsky, L.S. (1978). *Mind in Society: The development of higher psychological processes.* Harvard University Press.

Wang, X., & Cheng, Z. (2020). Cross-sectional studies: strengths, weaknesses, and recommendations. *Chest, 158*(1), 65-71.

Wartella, E., & Richert, R. A. (2009). Special Audience, Special Concerns. *Multimedia and literacy development: Improving achievement for young learners*, 15.

Wartella, E., Richert, R. A., & Robb, M. B. (2010). Babies, television and videos: How did we get here? *Developmental Review*, *30*(2), 116-127.

Watson, K. H., Dunbar, J. P., Thigpen, J., Reising, M. M., Hudson, K., McKee, L., ... & Compas, B. E. (2014). Observed parental responsiveness/warmth and children's coping: Cross-sectional and prospective relations in a family depression preventive intervention. *Journal of Family Psychology*, *28*(3), 278.

Whitaker, J. L., & Bushman, B. J. (2012). "Remain calm. Be kind." Effects of relaxing video games on aggressive and prosocial behavior. *Social Psychological and Personality Science*, *3*(1), 88-92.

Whitebread, D., Basilio, M., Kuvalja, M., & Verma, M. (2012). *The importance of play.* Toy Industries of Europe.

Wilkinson, C., Low, F., & Gluckman, P. (2021). *Screen time: The effects on children's emotional, social, and cognitive development.* The Centre for Informed Futures.

Williams, J., Thornton, M., Murray, A., & Quail, A. (2019). *Design, Instrumentation and Procedures for Cohort '08 at Wave 3 (5 Years). The* Stationery Office.

Williams, L., Degnan, K. A., Perez-Edgar, K. E., Henderson, H. A., Rubin, K. H., Pine, D. S., ... & Fox, N. A. (2009). Impact of behavioral inhibition and parenting style on internalizing and externalizing problems from early childhood through adolescence. *Journal of abnormal child psychology*, *37*, 1063-1075.

Willis, E. A., Hales, D., Smith, F. T., Burney, R., El-Zaatari, H. M., Rzepka, M. C., ... & Ward, D. S. (2022). Feasibility and Acceptability of Wearable Sensor Placement for Measuring Screen Time of Children. *Translational Journal of the American College of Sports Medicine*, *7*(4), e000214.

Willoughby, T., Adachi, P. J., & Good, M. (2012). A longitudinal study of the association between violent video game play and aggression among adolescents. *Developmental psychology*, *48*(4), 1044.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of child psychology and psychiatry*, *17*(2), 89-100.

Wood, W., Wong, F. Y., & Chachere, J. G. (1991). Effects of media violence on viewers' aggression in unconstrained social interaction. *Psychological bulletin*, *109*(3), 371.

Wright, J. C., Huston, A. C., Murphy, K. C., St. Peters, M., PiÃ±on, M., Scantlin, R., & Kotler, J. (2001). The relations of early television viewing to school readiness and vocabulary of children from low-income families: The early window project. *Child development*, *72*(5), 1347-1366.

Yang, Y. T. C. (2012). Building virtual cities, inspiring intelligent citizens: Digital games for developing students' problem solving and learning motivation. *Computers & Education*, *59*(2), 365-377.

Yelland, N., & Masters, J. (2007). Rethinking scaffolding in the information age. *Computers and Education*, *48*, 362–382.

Yousef, S., Eapen, V., Zoubeidi, T., & Mabrouk, A. (2014). Behavioral correlation with television watching and videogame playing among children in the United Arab Emirates. *International journal of psychiatry in clinical practice*, *18*(3), 203-207.

Yuan, N., Weeks, H. M., Ball, R., Newman, M. W., Chang, Y. J., & Radesky, J. S. (2019). How much do parents actually use their smartphones? Pilot study comparing self-report to passive sensing. *Pediatric research*, *86*(4), 416-418.

Zimmerman, F. J., & Christakis, D. A. (2005). Children's television viewing and cognitive outcomes: a longitudinal analysis of national data. *Archives of Pediatrics & Adolescent Medicine, 159*(7), 619-625.

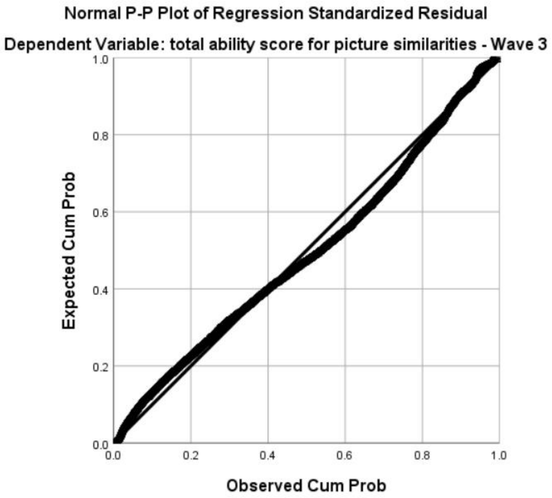
Zimmerman, F. J., & Christakis, D. A. (2007). Associations between content types of early media exposure and subsequent attentional problems. *Pediatrics, 120*(5), 986-992.

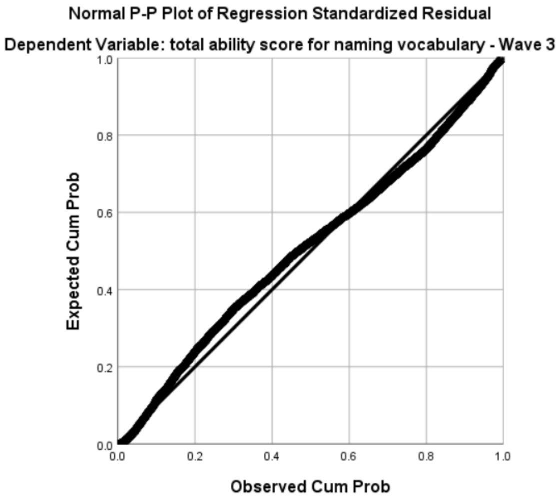
Zimmerman, F. J., Christakis, D. A., & Meltzoff, A. N. (2007a). Associations between media viewing and language development in children under age 2 years. *The Journal of Pediatrics*, *151*(4), 364-368.

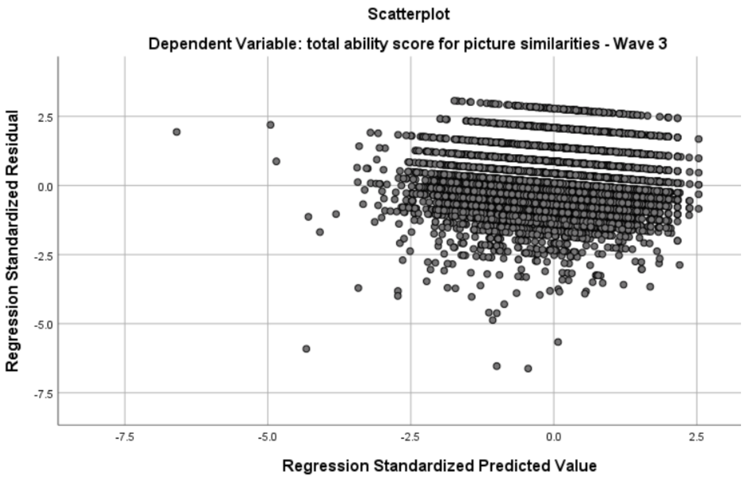
Zimmerman, F. J., Christakis, D. A., & Meltzoff, A. N. (2007b). Television and DVD/video viewing in children younger than 2 years. *Archives of pediatrics & adolescent medicine*, *161*(5), 473-479.

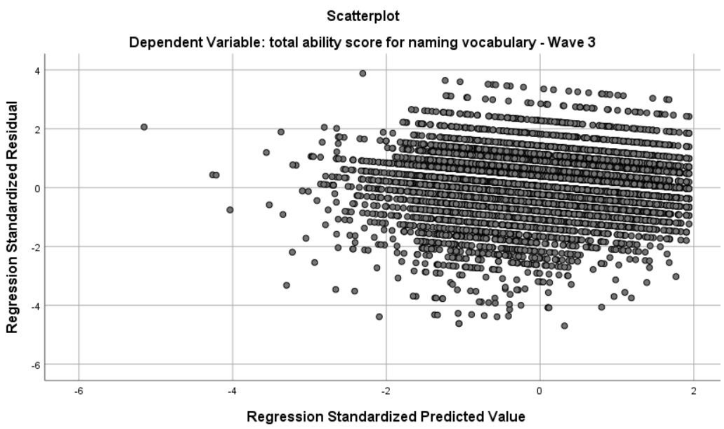
Appendices

Appendix A: P-P Plots and Scatterplots for Study 1



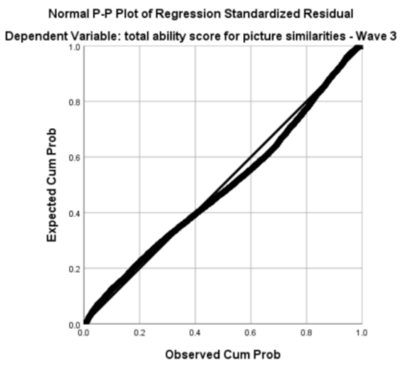


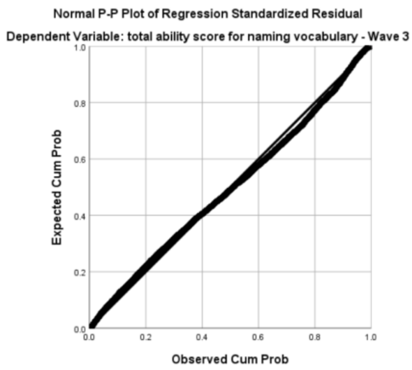


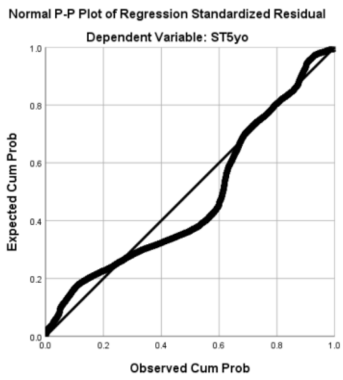


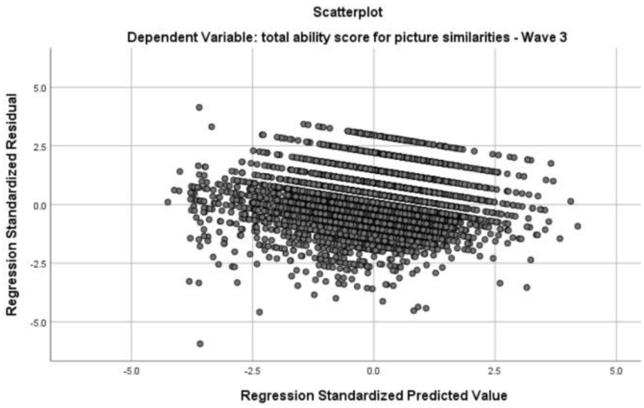
Appendix B: P-P Plots and Scatterplots for Study 2

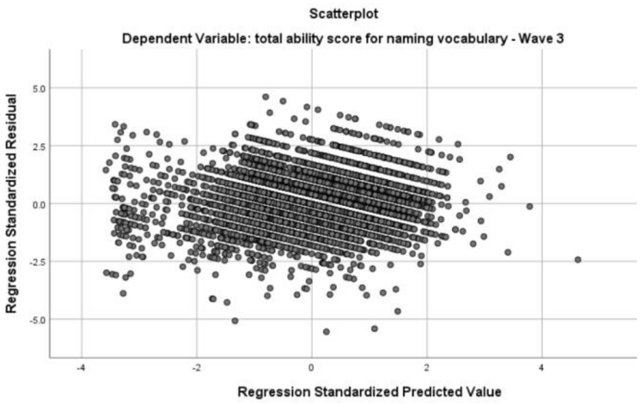
Reverse-causal model:



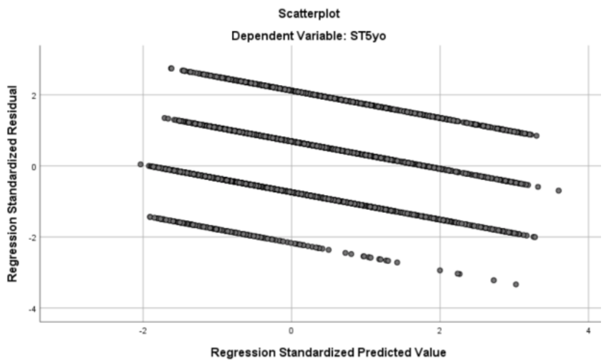




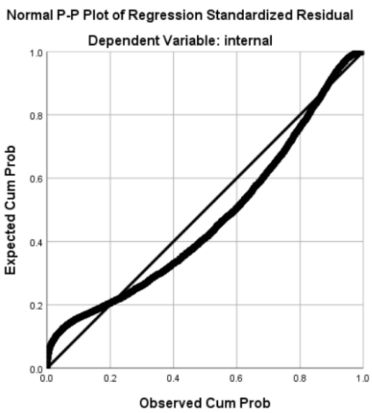


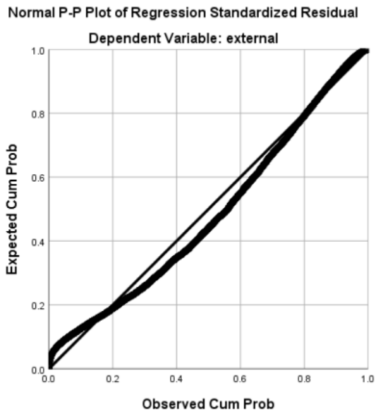


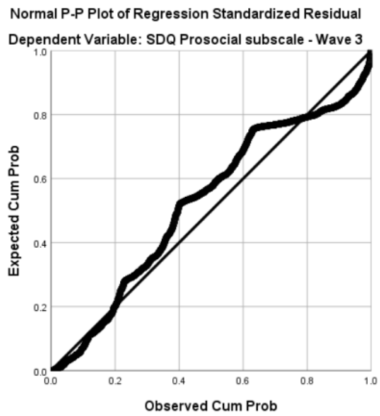
Reverse-causal model:

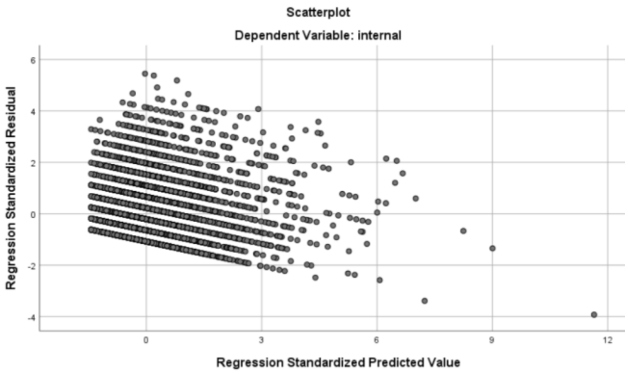


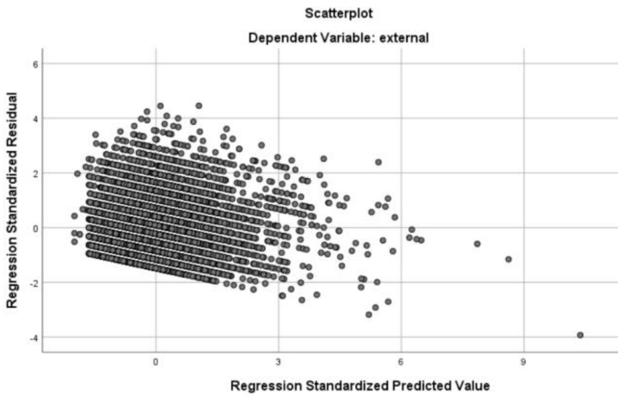
Appendix C: P-P Plots and Scatterplots for Study 3

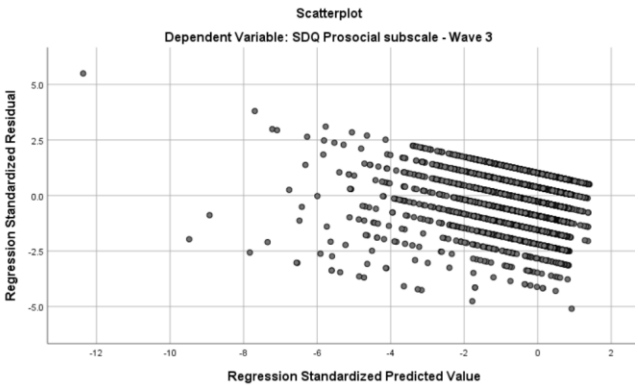




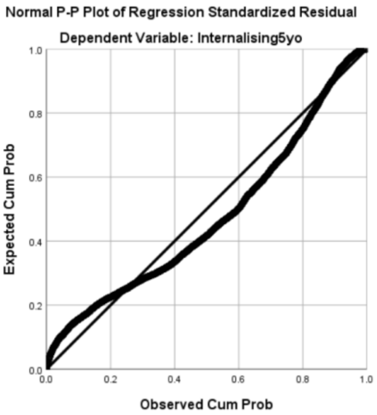


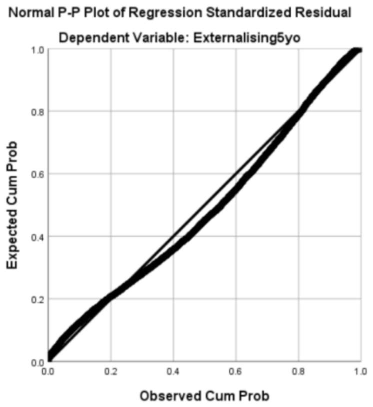


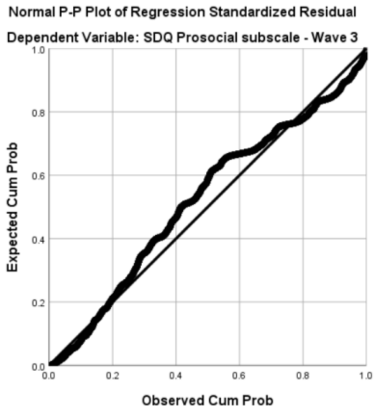


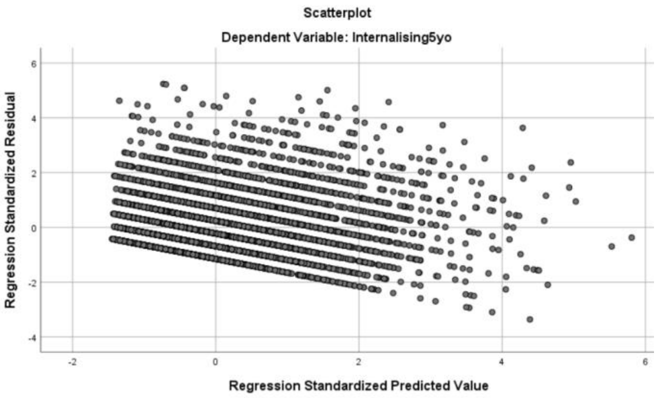


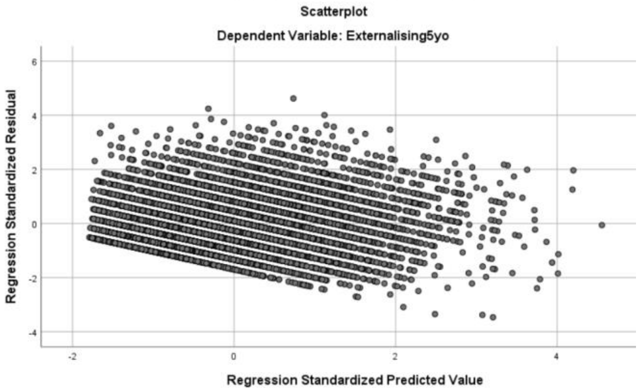
Appendix D: P-P Plots and Scatterplots for Study 4

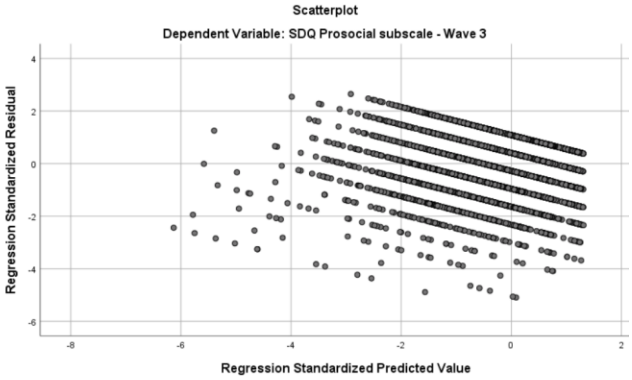












Appendix E: PLEY Study Letter to Principal

Dear Principal,

We wish to invite the parents of junior and senior infant pupils in your school to participate in a research study that is being undertaken by Dr Suzanne Egan and researchers in the Cognition, Development and Learning Research Lab in the Department of Psychology, Mary Immaculate College, Limerick. The survey is interested in the activities that young Irish children (aged 6 years and under) engage in at home, how parent(s) encourage their interest in play and learning and how this may affect child development. If parents wished to participate, they would be asked to respond anonymously to specific questions related to the following areas in a survey:

1. The family's demographics (information about the family)
2. Play and Learning Activities in the Home
3. Play and Learning Interests and Influences
4. Parent Playtime Experiences
5. Supports and Barriers to Play and Learning
6. Child's Attentional Ability
7. Child's Language ability
8. Child's Socio-Emotional development

Parents of pupils in junior and senior infants can volunteer to complete the survey, which will take approximately 20 minutes, in their own time. The Recruitment Letter and the Information Sheet contain additional information for parents about the study.

If you wish for the parents of your pupils to be invited to take part in this study, please contact the researchers to forward you information packs for the parents. This can be sent home to parents in their children's school bags. The information pack will include the Recruitment Letter and Information Sheet attached below, and a paper survey with a debriefing sheet. The pack can also be circulated electronically via email, newsletter, or website using the link below. If the parents wish to participate, they can then follow the link provided in the Recruitment Letter (same link provided below) or complete the paper survey and return it to the school where the researchers can collect the completed surveys.

This research study has received ethical approval from the Mary Immaculate College Research Ethics Committee (MIREC) (A19-027). If you have any queries relating to this study please contact us email via phone (000 123456) or email (xxx@mic.ul.ie; xxx@mic.ul.ie; xxx@mic.ul.ie).

Kind regards,
Dr Suzanne Egan, Chloé Beatty, and Clara Hoyne
Department of Psychology

Appendix F: PLEY Study Letter of Recruitment for Parents

Do you have a child aged 6 years or under?
Would you like to participate in a study that looks at your role in your child's learning and play?

Parents are their child's first caregivers and teachers, and therefore play a role in their child's learning and development – especially in the early stage of childhood. As part of the Cognition, Development and Learning Research Lab in the Department of Psychology, Mary Immaculate College, Limerick, we are interested in looking at the activities that young Irish children (aged 6 years and under) engage in at home, both with and without their parent(s), and how parent(s) engage with their children in play and learning.

We have put together a survey that will ask about the activities that you are doing with your child(ren) at home, and some of your own attitudes towards these activities. Ultimately, we are interested in whether these activities and other factors affect your child's thinking and social skills. The survey will take approximately 20 minutes to complete, and will include specific questions related to the following areas:

1. The family's demographics (information about the family)
2. Play and Learning Activities in the Home
3. Play and Learning Interests and Influences
4. Parent Playtime Experiences
5. Supports and Barriers to Play and Learning
6. Child's Attentional ability
7. Child's Language ability
8. Child's socio-emotional development

If you are interested in finding out more about the study please read the attached information sheet, which provides more details about the study and what is involved. If you decide to participate in the research you can complete the survey via an online link (see below), or a paper survey that is also attached. Please ensure to return all surveys, completed or not, back to your child's school to be collected by the researchers.

(Insert link)

This research study has received ethical approval from the Mary Immaculate College Research Ethics Committee (MIREC) (A19-027).
If you have any concerns about this study and wish to contact an independent authority, you may contact
Mary Collins (MIREC Administrator),
Mary Immaculate College.
Telephone: 061-204980, or e-mail: mirec@mic.ul.ie.

King regards,
Dr Suzanne M. Egan, Chloé Beatty, and Clara Hoyne

L A B
Ψ C D L

Appendix G: Recruitment Notice for Online Use

Short Recruitment Notice (e.g., for Twitter):

Do you have a child aged 6 years or under? Would you like to participate in a study that looks at your role in your child's learning and play? To find out more about the research please click on the link below:

(Insert link)

Longer Recruitment Notice (e.g., for webpage or Facebook)

Do you have a child aged 6 years or under? Would you like to participate in a study that looks at your role in your child's learning and play? Researchers in the Cognition, Development and Learning Research Lab in the Department of Psychology in Mary Immaculate College, Limerick, are interested in examining the activities that young Irish children (aged 6 years and under) engage in at home and how parent(s) engage with their children in play and learning. We are hoping to investigate the role of these activities (e.g., screen time, story time and outdoor play) in child development and the factors that support or hinder it.

To find out more about the research please click on the link below:

(Insert link)

Appendix H: PLEY Survey with Information Sheet, Consent Form and Debrief

Play and Learning in the Early Years (PLEY) Survey

Thank you for your interest in this study

Purpose of the Research: The current research aims to examine 1) children's activities and interests at home, 2) your opinions on these activities and the factors that act as barriers or supports to play and learning in the home, and 3) its contribution to child development. This project is being undertaken by Dr Suzanne Egan, Clara Hoyne, and Chloé Beatty from the Cognition, Development and Learning Research Lab in MIC. This study has been approved by the Mary Immaculate College Ethics Committee. Before you decide whether or not you wish to participate, it is important for you to understand why this research is being done and what it will involve. Please take the time to read this information carefully. Our contact information is also provided at the end of this information sheet. If you know of other parents that may be interested in taking part in the survey, please feel free to share the link.

Kind regards,
Dr Suzanne M. Egan, Clara Hoyne, and Chloé Beatty
Department of Psychology, Mary Immaculate College

Information Sheet

What is involved: If you decide to participate, the study will involve an anonymous survey that will ask questions about your family, your child's activities and interests in the home and your involvement in, and opinion of, these activities. This will be followed by questions about your child's development related to how focused they are on particular tasks, their language and how they get on with other people. It is anticipated that the survey will take approximately 15 minutes to complete.

Do I have to take part? You are free to decide whether you wish to take part in this research or not. If you do decide to partake in the survey, you will be asked to indicate your consent after reading through the following short Consent Form. You are free to withdraw from this study at any time and without giving reasons. Your decision to take part in this study will have no impact on your child's marks or assessments in school.

What are the benefits of this research? The aim of this study is to find out more about the home lives of young children and the factors that can support their development. This information can be very helpful for developmental researchers, policymakers and practitioners.

How will information about me and my family be used, and who will have access to it? The data collected on the surveys will be added to the other participants' data, so as to make inferences about general home practices (rather than any individual). Your responses on the survey will be anonymous and will remain confidential. The data will be stored on a password protected computer at all times.

Findings from the research may be presented at conferences or published in academic journals and the data may be archived for use in future studies by the Cognition Development and Learning Lab, to build upon the current questions we have asked in this study. This is to ensure that new knowledge gained from the data is shared with others.

What if I have a question? If you have a query about any aspect of the study or the information outlined here, please get in touch with the researchers:
Dr Suzanne Egan at 061 204333 or suzanne.egan@mic.ul.ie;
Clara Hoyne at clara.hoyne@mic.ul.ie;
Chloé Beatty at chloe.beatty@mic.ul.ie

This research study has received ethical approval from the Mary Immaculate College Research Ethics Committee (MIREC; approval number A19-027).
If you have any concerns about this study and wish to contact someone independent, you may contact:
Mary Collins (MIREC Administrator),
Mary Immaculate College.
Telephone: 061-204980, or e-mail: mirec@mic.ul.ie.

Consent Form

If you wish to participate in this study, please read the following statements:

- I agree to take part in this study

- I confirm that I have read and understand the information sheet for this study, and have had the opportunity to ask questions about the study

- I understand that my participation is voluntary and that I am free to withdraw, and request that my data be removed from the study, at any time

- I understand that data collected about me during this study will be stored anonymously

- I agree to allow the data collected to be used for presentation and publication purposes, and for future research projects.

PLEY Survey

Q1 Your age:

____

Q2 Your gender:

- ○ Male (1)
- ○ Female (2)
- ○ Other (3)

Q3 Your relationship to child:

- ○ Mother (1)
- ○ Father (2)
- ○ Other (Please State): (3) ____

Q4 Gender of child:

- ○ Male (1)
- ○ Female (2)
- ○ Other (3)

Q5 Age of child (In years <u>and</u> months, e.g., 4 years and 5 months):

____

Q6 Does your child have siblings?

- ○ Yes (1)
- ○ No (2)

Q7 What position is the child in the family?

- ○ Eldest (1)
- ○ Middle (2)
- ○ Youngest (3)
- ○ Only Child (4)

Q8 Was your child ever breastfed?

- ○ Yes (1)
- ○ No (2)
- ○ Unsure (3)

Q9 What is the child's primary caregiver's highest education attainment?

- ○ No formal education (1)
- ○ Primary education (2)
- ○ Lower secondary (3)
- ○ Upper secondary (4)
- ○ Technical/Vocational (5)
- ○ Certificate/Diploma (6)
- ○ Bachelor's degree (7)
- ○ Postgraduate degree (8)
- ○ Doctorate (9)

Q9a What is the child's secondary caregiver's highest education attainment (if secondary caregiver is living in the home)?

- ○ No formal education (1)
- ○ Primary education (2)
- ○ Lower secondary (3)
- ○ Upper secondary (4)
- ○ Technical/Vocational (5)
- ○ Certificate/Diploma (6)
- ○ Bachelor's degree (7)
- ○ Postgraduate degree (8)
- ○ Doctorate (9)

Q10 Which of these descriptions best describes the child primary caregiver's usual situation with regards to work?

- ○ Working full time (1)
- ○ Working part time (2)
- ○ Unemployed (3)
- ○ On Leave (4)
- ○ Home duties/looking after family (5)
- ○ Student/Training (6)
- ○ Other (7)

Q10a Which of these descriptions best describes the child's secondary caregiver's usual situation with regards to work (if secondary caregiver is living in the home)?

- ○ Working full time (1)
- ○ Working part time (2)
- ○ Unemployed (3)
- ○ On Leave (4)
- ○ Home duties/looking after family (5)
- ○ Student/Training (6)
- ○ Other (7)

Q11 In which country do you currently reside?

____

Q12 Please indicate how often <u>your child engages</u> in the following activities:	Never (1)	Hardly Ever (2)	Occasionally (3)	1 - 2 days per week (4)	3-6 days per week (5)	Every day (6)
Play with toys and games (1)	○	○	○	○	○	○
Play with puzzles and jigsaws (2)	○	○	○	○	○	○
Play using blocks or Lego or building materials (3)	○	○	○	○	○	○
Play entertainment games on a screen device (PC/Xbox/Smartphones/iPads/TV) (4)	○	○	○	○	○	○
Play educational games on a screen device (PC/Xbox/Smartphones/iPads/TV) (5)	○	○	○	○	○	○
Watch entertainment TV/Videos on any screen device (6)	○	○	○	○	○	○
Watch educational TV/Videos on any screen device (7)	○	○	○	○	○	○
Video calls or messaging (e.g., Skype/WhatsApp) (8)	○	○	○	○	○	○
Use a screen device for any other activity (9)	○	○	○	○	○	○
Visit the library (10)	○	○	○	○	○	○
Read (11)	○	○	○	○	○	○
Play sports or physical activities (12)	○	○	○	○	○	○
Play "make believe" or pretend games (13)	○	○	○	○	○	○
Paint, draw, play with slime/play-doh/make models (14)	○	○	○	○	○	○

Enjoy dance, movement, listens to music (15)	◯	◯	◯	◯	◯	◯
Climb on trees/climbing frames/wall bars/etc. (16)	◯	◯	◯	◯	◯	◯
Play with a ball (17)	◯	◯	◯	◯	◯	◯
Play chasing or running games (18)	◯	◯	◯	◯	◯	◯
Ride a bike/tricycle/scooter (19)	◯	◯	◯	◯	◯	◯
Skate (20)	◯	◯	◯	◯	◯	◯
Play on a trampoline (21)	◯	◯	◯	◯	◯	◯
Play outside (22)	◯	◯	◯	◯	◯	◯
Visit a playground (23)	◯	◯	◯	◯	◯	◯
Do everyday activities (cooking/caring for a pet) (24)	◯	◯	◯	◯	◯	◯
Play letter or alphabet learning activities (25)	◯	◯	◯	◯	◯	◯
Play number and shape learning activities (26)	◯	◯	◯	◯	◯	◯
Go on a play date (27)	◯	◯	◯	◯	◯	◯

Q12a Now please indicate how often you engage with your child in the following activities:	Never (1)	Hardly Ever (2)	Occasionally (3)	1 - 2 days per week (4)	3-6 days per week (5)	Every day (6)
Play with toys and games (1)	○	○	○	○	○	○
Play with puzzles and jigsaws (2)	○	○	○	○	○	○
Play using blocks or Lego or building materials (3)	○	○	○	○	○	○
Play entertainment games on a screen device (PC/Xbox/Smartphones/iPads/ TV) (4)	○	○	○	○	○	○
Play educational games on a screen device (PC/Xbox/Smartphones/iPads/ TV) (5)	○	○	○	○	○	○
Watch entertainment TV/Videos on any screen device (6)	○	○	○	○	○	○
Watch educational TV/Videos on any screen device (7)	○	○	○	○	○	○
Video calls or messaging (e.g., Skype/WhatsApp) (8)	○	○	○	○	○	○
Use a screen device for any other activity (9)	○	○	○	○	○	○
Visit the library (10)	○	○	○	○	○	○
Read to your child (11)	○	○	○	○	○	○
Listen to your child read (if applicable) (12)	○	○	○	○	○	○
Play sports or physical activities (13)	○	○	○	○	○	○
Play "make believe" or pretend games (14)	○	○	○	○	○	○
Paint, draw, play with slime/play-doh/make models (15)	○	○	○	○	○	○

Enjoy dance, movement, listens to music (16)	○	○	○	○	○	○
Climb on trees/climbing frames/wall bars/etc. (17)	○	○	○	○	○	○
Play with a ball (18)	○	○	○	○	○	○
Play chasing or running games (19)	○	○	○	○	○	○
Ride a bike/tricycle/scooter (20)	○	○	○	○	○	○
Skate (21)	○	○	○	○	○	○
Play on a trampoline (22)	○	○	○	○	○	○
Play outside (23)	○	○	○	○	○	○
Visit a playground (24)	○	○	○	○	○	○
Do everyday activities (cooking/caring for a pet) (25)	○	○	○	○	○	○
Play letter or alphabet learning activities (26)	○	○	○	○	○	○
Play number and shape learning activities (27)	○	○	○	○	○	○
Go on a play date (28)	○	○	○	○	○	○

Q13 Overall, how much time would your child spend on the following activities on <u>an average weekday</u>?

	0 minutes (1)	1 - 30 minutes (2)	31 - 60 minutes (3)	61 - 90 minutes (4)	91 - 120 minutes (5)	2 to 3 hours (6)	More than 3 hours (7)
On screen time (Computer/TV/games/ tablets/smartphone) (1)	○	○	○	○	○	○	○
Playing outdoors (2)	○	○	○	○	○	○	○
Reading or story time (3)	○	○	○	○	○	○	○
Playing with games and toys (4)	○	○	○	○	○	○	○

Q13a Overall, how much time would your child spend on the following activities on <u>an average weekend day</u>?

	0 minutes (1)	1 - 30 minutes (2)	31 - 60 minutes (3)	61 - 90 minutes (4)	91 - 120 minutes (5)	2 to 3 hours (6)	More than 3 hours (7)
On screen time (Computer/TV/games/ tablets/smartphone) (1)	○	○	○	○	○	○	○
Playing outdoors (2)	○	○	○	○	○	○	○
Reading or story time (3)	○	○	○	○	○	○	○
Playing with games and toys (4)	○	○	○	○	○	○	○

Q14 How many children's books does your child have?

- ◯ 0-10 (1)
- ◯ 11-20 (2)
- ◯ 21-30 (3)
- ◯ More than 30 (4)

Q15 Does your child ever play with or use any of the following devices?

	Yes, they have their own (1)	Yes, they use a parent's or sibling's (2)	No (3)
TV (6)	◯	◯	◯
Computer/Laptop (1)	◯	◯	◯
Tablet (2)	◯	◯	◯
Smartphone (3)	◯	◯	◯
Handheld console (e.g. Nintendo DS/PSP) (5)	◯	◯	◯
Game console (e.g. PlayStation/Xbox) (4)	◯	◯	◯

Q16 What screen activity does your child mostly engage in?

- ◯ Entertainment games (e.g. video games) (1)
- ◯ Educational games (2)
- ◯ Watching entertainment TV/Videos on any screen device (3)
- ◯ Watching educational TV/Videos on any screen device (7)
- ◯ Video calls or messaging (e.g. Skype/WhatsApp) (6)
- ◯ E-books (8)
- ◯ Mix of all activities (4)
- ◯ Other (5)

Q16a What screen device do they mostly use for this screen activity?

- ◯ Computer/Laptop (1)
- ◯ Tablet/Smartphone (2)
- ◯ TV (3)
- ◯ Handheld/Game console (4)
- ◯ Mix of all devices (6)
- ◯ Other (5)

Q17 Regarding the child's interests and the types of games they like to play, books they like to read or programmes they like to watch - who, if anyone, is your child mostly influenced by for the following activities?

	Their own interest (1)	Your interests (2)	Other parent's interests (3)	Siblings (4)	School or preschool friends (5)	Neighbour hood children (6)	Other (7)	N/A (8)
Reading (1)	○	○	○	○	○	○	○	○
Special interest books (2)	○	○	○	○	○	○	○	○
Board games (3)	○	○	○	○	○	○	○	○
TV/Movies (4)	○	○	○	○	○	○	○	○
Outdoor games/play (5)	○	○	○	○	○	○	○	○
Computer or other screen games (6)	○	○	○	○	○	○	○	○

Q18 Please read the list of activities and for each one indicate <u>who mostly suggests or initiates the activities</u> (the child or an adult e.g. you or other caregivers). If your child never engages in the activity, please select 'Not Applicable (N/A)'.

	Mostly me or other adult (1)	Mostly child (2)	Both equally (3)	Part of routine (4)	N/A (5)
Suggests reading or story time (1)	○	○	○	○	○
Suggests learning about something new s/he has heard about (2)	○	○	○	○	○
Suggests games/toys to play with (3)	○	○	○	○	○
Suggests playing outdoors (4)	○	○	○	○	○
Watching educational TV/Videos (5)	○	○	○	○	○
Watching entertainment TV/Videos (6)	○	○	○	○	○
Playing educational on-screen games (PC/Xbox/tablet/smartphone) (7)	○	○	○	○	○
Playing entertainment on-screen games (PC/Xbox/tablet/smartphone) (8)	○	○	○	○	○
Any other activity on a screen (9)	○	○	○	○	○
Playing with arts and crafts material (10)	○	○	○	○	○
Playing with other children (siblings/friends) (11)	○	○	○	○	○

Q18a Please read the list of activities and for each one indicate <u>who normally stops the activity</u> or brings it to an end. If your child never engages in the activity, please select 'Not Applicable (N/A)'.

	Mostly me or another adult (1)	Mostly child (2)	Both equally (3)	Ends naturally (4)	N/A (5)
Reading or story time (1)	○	○	○	○	○
Learning about something new s/he has heard about (2)	○	○	○	○	○
Games/toys to play with (3)	○	○	○	○	○
Playing outdoors (4)	○	○	○	○	○
Watching educational TV/Videos (5)	○	○	○	○	○
Watching entertainment TV/Videos (6)	○	○	○	○	○
Playing educational on-screen games (PC/Xbox/tablet/smartphone) (7)	○	○	○	○	○
Playing entertainment on-screen games (PC/Xbox/tablet/smartphone) (8)	○	○	○	○	○
Any other activity on a screen (9)	○	○	○	○	○
Playing with arts and crafts material (10)	○	○	○	○	○
Playing with other children (siblings/friends) (11)	○	○	○	○	○

Q19 Please read each statement listed below and indicate how much you agree or disagree with each sentence about play for your child.	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Play can help my child develop social skills, such as cooperating and making friends. (1)	○	○	○	○	○
Play does not help my child learn academic skills like counting or recognising letters. (2)	○	○	○	○	○
It is important for me to participate in play with my child. (3)	○	○	○	○	○
I have a lot of fun with my child when we play together. (4)	○	○	○	○	○
Play can improve my child's language and communication abilities. (5)	○	○	○	○	○
I can teach my child social skills during play. (7)	○	○	○	○	○
Play does not influence my child's ability to solve problems. (8)	○	○	○	○	○
I can help my child learn to control his or her emotions during play. (9)	○	○	○	○	○
Playing at home will help/helped get my child get ready for school/preschool. (10)	○	○	○	○	○
My child will get more out of play if I play with him or her. (11)	○	○	○	○	○
Play can help my child develop better thinking abilities. (12)	○	○	○	○	○
It is more important for my child to have good academic skills than to play well with other children. (13)	○	○	○	○	○

Playtime is not a high priority in my home. (14)	○	○	○	○	○
Playing with my child is one of my favourite things to do. (15)	○	○	○	○	○
If I take time to play with my child, s/he will be better at playing with other children. (16)	○	○	○	○	○
Reading to my child is more worthwhile than playing with him or her. (17)	○	○	○	○	○
My child does not enjoy playing with me. (18)	○	○	○	○	○
I do not think it is very important for other family members to play with my child. (19)	○	○	○	○	○
My child will learn more if I allow him or her to play without me. (20)	○	○	○	○	○
Play helps my child learn how to express his or her feelings. (21)	○	○	○	○	○
Playing with my child is more useful than teaching letters and numbers. (22)	○	○	○	○	○
Play is a fun activity for my child. (23)	○	○	○	○	○
Playing together helps me build a good relationship with my child. (24)	○	○	○	○	○
I do not think my child learns important skills by playing. (25)	○	○	○	○	○
My child does not need my help to deal with his or her emotions during play. (26)	○	○	○	○	○
My child gets too excited during play. (27)	○	○	○	○	○
My child has a lot of fun when we play together. (28)	○	○	○	○	○
Through play, my child develops new skills and abilities. (29)	○	○	○	○	○
Playing at preschool did/will help	○	○	○	○	○

my child get ready for school. (30)					
Learning academic skills at preschool did/will help my child get ready for school (34)	◯	◯	◯	◯	◯
Watching TV supports my child’s learning. (31)	◯	◯	◯	◯	◯
Playing games on a screen device supports my child’s learning. (32)	◯	◯	◯	◯	◯
By playing outdoors my child develops new skills and abilities. (33)	◯	◯	◯	◯	◯

Q20 Please read each statement about your child's home environment and indicate how characteristic each statement is of your home.	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
There are lots of creative activities going on in our home. (1)	○	○	○	○	○
My screen time interferes with interactions with my child. (2)	○	○	○	○	○
Our home is an interesting place for my child. (3)	○	○	○	○	○
There are plenty of books for my child. (4)	○	○	○	○	○
There are plenty of toys, pictures, and music for my child. (5)	○	○	○	○	○
At home, there are rules about screen use for my child. (6)	○	○	○	○	○
At home, my child has many natural learning experiences. (7)	○	○	○	○	○
At home, activities are provided that are just right for my child. (8)	○	○	○	○	○
My child gets a lot of individual attention. (9)	○	○	○	○	○
I talk to my child about everyday activities. (10)	○	○	○	○	○
I use play activities as educational experiences. (11)	○	○	○	○	○

Q21 Please indicate how much you agree or disagree with the following statements about your neighbourhood and other factors that may support or limit your child's playtime:	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
This is a safe neighbourhood (1)	○	○	○	○	○
There are good parks, playgrounds and play spaces (2)	○	○	○	○	○
The state of footpaths, roads and street lighting is good (3)	○	○	○	○	○
There is heavy traffic on my street or road (4)	○	○	○	○	○
It is safe for children to play outside during the day (5)	○	○	○	○	○
Most people in my neighbourhood can be trusted (6)	○	○	○	○	○
There is rubbish and litter lying about (7)	○	○	○	○	○
Homes and gardens are in bad condition (8)	○	○	○	○	○
This is a good neighbourhood to bring up children (9)	○	○	○	○	○
Organised sports activities and clubs encourage my child outdoors (10)	○	○	○	○	○
Homework limits the amount of free play time my child has (11)	○	○	○	○	○
My child prefers to play indoors than outdoors (12)	○	○	○	○	○
There are other children outside to play with (13)	○	○	○	○	○
Scheduled lessons & clubs limit the amount of free play time my child has (14)	○	○	○	○	○
My child has access to outdoor play equipment (e.g., trampoline, bike, etc) (15)	○	○	○	○	○

Bad weather prevents my child from playing outdoors (16)	○	○	○	○	○
My child is in childcare and we get home very late (17)	○	○	○	○	○
My child prefers screen time or TV to other types of play (18)	○	○	○	○	○
My child has very little access to toys and games (19)	○	○	○	○	○
My child prefers to play with other children rather than alone (20)	○	○	○	○	○
My child does not like books or story time (21)	○	○	○	○	○
Our family enjoys books and reading (26)	○	○	○	○	○
TV programmes encourage my child to play particular games (22)	○	○	○	○	○
My child has a garden to play in (23)	○	○	○	○	○
Our family enjoys being outdoors (24)	○	○	○	○	○

Q22 The following are statements that describe children's reactions to a number of situations. We would like you to tell us what your child's reaction is likely to be in those situations. Please read each statement and decide whether it is a "true" or "untrue" description of your child's reaction within the past six months.	Extremely untrue (1)	Slightly untrue (2)	Neither untrue or true (3)	Slightly true (4)	Extremely true (5)
When picking up toys or other jobs, usually keeps at the task until it's done. (1)	○	○	○	○	○
When practicing an activity, has a hard time keeping her/his mind on it. (2)	○	○	○	○	○
Will move from one task to another without completing any of them. (3)	○	○	○	○	○
When drawing or colouring in a book, shows strong concentration. (4)	○	○	○	○	○
When building or putting something together, becomes very involved in what s/he is doing, and works for long periods. (5)	○	○	○	○	○
Has difficulty leaving a project s/he has begun. (6)	○	○	○	○	○
Is easily distracted when listening to a story. (7)	○	○	○	○	○
Sometimes becomes absorbed in a picture book and looks at it for a long time. (8)	○	○	○	○	○
Has a hard time concentrating on an activity when there are distracting noises. (9)	○	○	○	○	○

Q23 The following four questions ask about your child's use of language. There are no "correct" answers here as children learn language in the different ways. Please read the following questions and answer as best you can by ticking your response.

1. Compared with other children of the same age, how do you think that your child expresses him/herself?

- ○ Not very well (1)
- ○ A little less well (2)
- ○ The same (3)
- ○ Very good/better/one of the best (4)

2. Compared with other children of the same age, how do you think your child pronounces words?

- ○ Not very clearly (1)
- ○ Sometimes not clear (2)
- ○ Same (3)
- ○ Very clear, one of the best (4)

3. Compared with other children of the same age, does your child have difficulty producing correct sentences?

- ○ A lot of difficulties (1)
- ○ Some difficulties (2)
- ○ Same (3)
- ○ No difficulties, maybe better (4)

4. Is it easy for your family or friends to have a conversation with your child?

- ○ No, very hard (1)
- ○ Sometimes not easy (2)
- ○ Easy enough (3)
- ○ Very easy (4)

Q24 Listed below is a set of statements which could be used to describe your child's behaviour. For each item, please indicate how true the statement is of your child. It would help us if you answered all items as best you can even if you are not absolutely certain. Please give answers on the basis of the child's behaviour over the last six months.	Not True (1)	Somewhat True (2)	Certainly True (3)
Considerate of other people's feelings (1)	○	○	○
Restless, overactive, cannot stay still for long (2)	○	○	○
Often complains of headaches, stomach-aches or sickness (3)	○	○	○
Shares readily with other children (treats, toys, pencils etc.) (4)	○	○	○
Often has temper tantrums or hot tempers (5)	○	○	○
Rather solitary, tends to play alone (6)	○	○	○
Generally obedient, usually does what adults request (7)	○	○	○
Many worries, often seems worried (8)	○	○	○
Helpful if someone is hurt, upset or feeling ill (9)	○	○	○
Constantly fidgeting or squirming (10)	○	○	○
Has at least one good friend (11)	○	○	○
Often fights with other children or bullies them (12)	○	○	○
Often unhappy, down-hearted or tearful (13)	○	○	○
Generally liked by other children (14)	○	○	○
Easily distracted, concentration wanders (15)	○	○	○
Nervous or clingy in new situations, easily loses confidence (16)	○	○	○
Kind to younger children (17)	○	○	○

Often argumentative with adults (18)	○	○	○
Picked on or bullied by other children (19)	○	○	○
Often volunteers to help others (parents, teachers, other children) (20)	○	○	○
Can stop and think things out before acting (21)	○	○	○
Can be spiteful to others (22)	○	○	○
Gets on better with adults than with other children (23)	○	○	○
Many fears, easily scared (24)	○	○	○
Sees tasks through to the end, good attention span (25)	○	○	○

Debrief Sheet

Thank you for your participation in the study.

This study investigates the various family factors (e.g., education, attitudes, and employment) that influence the richness of the home environment and act as supports or barriers to play and learning in early childhood. Your contribution will also allow the researchers to explore the association between various types of play in the home and different aspects of child development.

Findings of this survey may help educate other parents on the importance of their role in home learning activities. We hope that the findings may play a role in developing policy and practice on play and learning in the home environment, such as the development of screen use guidelines for young children in Ireland or supports for the promotion of outdoor play.

Thank you again for giving your time to complete this survey.

Suzanne, Clara and Chloé.

Contact details:
Suzanne.Egan@mic.ul.ie (Ph: 061 204333)
Clara.Hoyne@mic.ul.ie
Chloe.Beatty@mic.ul.ie

Appendix I: P-P Plot and Scatterplot for Study 5