Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

A Developmental Systems Investigation of Language Development in the Context of Preterm Birth

Thesis submitted to Trinity College Dublin, the University of Dublin, for the degree of Doctor of Philosophy in Psychology

2024

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Declaration

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Sarah Coughlan

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Summary

Preterm birth (< 37 weeks' gestation) affects approximately 10% of births worldwide and is a public health concern given the developmental risks that it poses (World Health Organisation, 2023). While preterm birth is associated with poor language development (van Noort-van der Spek et al., 2012), the manifestation of these difficulties varies widely. Through accounting for the dynamic interplay of the biopsychosocial factors associated with preterm birth, developmental systems views can help to explain this variability (Barra & Coo, 2023). From this theoretical perspective, this thesis characterised the language abilities of preterm-born children and investigated how preterm birth may shape language development through affecting the parent, child, and parent-child dyad.

Chapter 1 reviews the literature relating to preterm language development. Preterm birth is found to affect a range of language domains which are variously captured by disparate assessment approaches. In line with systems views, this chapter identifies child (e.g., non-linguistic abilities) and parent (e.g., wellbeing) factors which may mediate the effect of preterm birth on language development. This chapter also outlines how such child/parent factors shape parent-child conversations which form a critical setting for language learning.

Chapter 2 details how the studies comprising this thesis are presented in three parts across Chapters 3, 5, and 6. Chapter 3 used data from a nationally-representative cohort study (Growing Up in Ireland) to investigate the direct and indirect paths linking preterm birth to expressive language abilities at 3 and 5 years of age. Preterm birth was found to affect 3-year language abilities through negatively influencing cognitive and social-personal abilities at 9 months. Preterm birth also negatively affected parent-child relationships at 3 years through influencing infant temperament and parent wellbeing at 9

months. These findings indicate how preterm language difficulties may be rooted in non-linguistic difficulties, and how the impact of preterm birth can ripple beyond the child to affect the caregiving environment.

To examine the caregiving environment in depth, parent-infant free-play interactions involving 2-year-old preterm-born and term-born (i.e., non-preterm) infants were analysed. Chapter 4 details how these dyadic interactions were recorded in the Infant and Child Research Lab (Trinity College Dublin), and later transcribed to quantify the linguistic (e.g., amount/complexity of parent speech) and dyadic (e.g., responsiveness, turn-taking) features of parent-child conversations. With this observational data, Chapter 5 examined the parent-child conversations of preterm- and term-born groups and analysed how they concurrently associate with development. Few differences were found between the conversations of preterm- and term-born groups. The majority of differences were found in mother-child conversations, and this may suggest that preterm birth differentially affects mothers and fathers. The association between parent-child conversation and language/non-language development varied according to birth status (preterm/term) and parent gender (mother/father). This may point to preterm-term differences in developmental processes and needs, as well as differences in how mothers and fathers support these needs.

Chapter 6 used the same observational data to holistically profile the language abilities of 2-year-old preterm-born infants and to provide evidence-based guidance for the use of language assessments with this group. This chapter found that standardised testing can help to identify preterm language difficulties and that inspecting spontaneous infant speech via language sample analysis can aid the setting/monitoring of functional treatment goals.

Chapter 7 concludes this thesis through discussing its theoretical/practical implications, its strengths/weaknesses, and future directions for research. In sum, this chapter outlines how this thesis found preterm-born children to be characterised by a constellation of language difficulties which are underpinned by the reciprocal interplay of factors relating to the parent, child, and parent-child dyad. By beginning to unravel this web of effects, this thesis has the potential to advance the evidence-based care of preterm-born children.

Acknowledgements

I would like to extend my sincere gratitude to my supervisors, Dr. Elizabeth Nixon and Dr. Jean Quigley, for giving me the opportunity to complete a PhD at the Infant and Child Research Lab. Despite being a trove of knowledge on developmental topics and methods, you always demonstrated an incredible level of receptiveness to my research ideas. Thank you for your patience and guidance as I clumsily attempted to untangle these ideas. Your steadfast support and insight throughout this PhD process has made it a truly fulfilling and enjoyable experience.

Thank you also to the final-year students, postgraduate students, and research assistants who have worked at the Infant and Child Research Lab. In particular, thank you to Merve and Chelo. Merve, I can't think of a better companion for those many early-morning weekend testing sessions. And, Chelo, thank you for always being so willing to lend a helping hand with our fieldwork.

I would also like extend my thanks to our medical collaborators. Thank you to Professor Eleanor Molloy and her research team for their expert guidance. My heartfelt thanks to the staff at the Coombe Women and Infants University Hospital – especially Catherine Barnes who helped Merve and I to access patient contact details (even amidst a hospital cyber-attack).

Thank you to Dr. Conor McGuckin in the School of Education and to all members of the *Inclusion in Education and Society/Universal Design Think-Tank*. Whenever I got stuck in the mud thinking about the operationalisation of temporally contingent turn-taking, you gave me a gentle nudge to remind me not to lose sight of the issues that matter most to the families at the heart of this research topic.

This brings me to the mums, dads, and children who generously gave their time and energy to take part in this research. Thank you. It was a joy and privilege to be able to spend time with you during this research process. This research could not have been completed without your contributions.

Finally, to my own family and friends – thank you for being such gems. In particular, thank you to my sister, Emily, for being so enthusiastic (case in point: when you exclaimed "Oh wow that's so cool!!" after seeing a photo of me standing next to a scientific poster). I hope that my next career steps will be able to engender as much (if not more!) excitement in you. And to my mother, ありがとう for sticking by me through all of the ups and downs of the past three years (thank you also for the chocolate croissants while I was in the throes of writing this thesis – they really helped too). Dad, I wish you could have been here for this. I hope I've made you proud.

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List of Abbreviations

Bayley-III: Bayley Scales of Infant and Toddler Development (3rd edition)

BRIEF-P: Behavior Rating Inventory of Executive Function Preschool

CELF: Clinical Evaluation of Language Fundamentals

CHAT: Codes for the Human Analysis of Transcripts

CLAN: Computerised Language Analysis program

DWLS: Diagonally Weighted Least Squares

EFCNI: European Foundation for the Care of Newborn Infants

GUI: Growing Up in Ireland

LENA: Language ENvironment Analysis system

LSA: Language Sample Analysis

MB-CDI: MacArthur-Bates Communicative Development Inventories

MLT: Mean Length of Turn

MLU: Mean Length of Utterance

MLUm: Mean Length of Utterance in Morphemes

MLUw: Mean Length of Utterance in Words

MTCE: Multiturn Conversational Episode

RMSEA: Root Mean Square Error of Approximation

SRMR: Standardised Root Mean Square Residual

WEIRD: Western, Educated, Industrialised, Rich, and Democratic

Publications to Date

Published

Study 3.1

Coughlan, S., Quigley, J., & Nixon, E. (2023). Preterm birth and expressive language development across the first 5 years of life: A nationally-representative longitudinal path analysis. *Early Childhood Research Quarterly, 65*. https://doi.org/10.1016/j.ecresq.2023.08.004

Study 5.3

Coughlan, S., Quigley, J., & Nixon, E. (2024). Parent-infant conversations are differentially associated with the development of preterm- and term-born infants. *Journal of Experimental Child Psychology, 239*, 105809. https://doi.org/10.1016/j.jecp.2023.105809 .

In-press

Study 5.2

Coughlan, S., Quigley, J., & Nixon, E. (n.d.). The synergistic effects of preterm birth and parent gender on the linguistic and interactive features of parent-infant conversations. *Journal of Speech, Language, and Hearing Research.*

Revised and Resubmitted

Study 6.1

Coughlan, S., Quigley, J., & Nixon, E. (n.d.). Assessing the language abilities of preterm-born infants: An examination of standardised testing and language sample analysis. *American Journal of Speech-Language Pathology.*

Chapter 1: Introduction

1.1 Introduction to Preterm Birth and Development

In 2020, preterm birth (birth before the 37th week of pregnancy) affected approximately 1 in 10 births worldwide (World Health Organisation, 2023). Although the prevalence of preterm birth varies considerably across regions (global range of 4.1%-16.2% in 2020; World Health Organisation, 2023), similar proportions of extremely (< 28 weeks' gestation; approximately 5% of preterm births), very (28 to < 32 weeks' gestation; approximately 10% of preterm births), and moderate-to-late (32 to < 37 weeks' gestation; > 80% of preterm births) preterm births have been found across the world (Blencowe et al., 2012; World Health Organisation, 2012). Preterm birth is the leading cause of death among children under 5 years of age (Perin et al., 2022), and those children who do survive are at heightened risk of experiencing wide-ranging developmental difficulties across respiratory, neural (e.g., cerebral palsy), sensory (e.g., vision, hearing), and cognitive (e.g., language) domains (see Saigal & Doyle, 2008 for a comprehensive review of the medical and developmental sequelae associated with preterm birth). These difficulties make the development of preterm-born children a research priority.

As medical advances are continually altering the survival rates and developmental profiles of preterm-born children, developmental research with contemporary preterm-born cohorts is essential. Changes in medical practices (e.g., introduction of pulmonary surfactants and the operation of neonatal intensive care units; Baron & Rey-Casserly, 2010) have coincided with the increased survival of preterm-born infants as well as a reduction in the incidence of severe neurodevelopmental difficulties (e.g., cerebral palsy; Aylward, 2014; Blencowe et al., 2012; Platt et al., 2007). Despite these positive outcomes, there has been a persistence of what have been termed "high prevalence-low severity" difficulties which can affect a range of developmental domains (e.g., language, cognitive, social-emotional, motor, domain-general processing; Aylward, 2014). As indicated by the term "high prevalence", such neurodevelopmental difficulties have not been limited to extremely/very preterm-born children, and have instead been observed to affect children of all degrees of prematurity (i.e., including moderate-to-late preterm births; Johnson, Evans, et al., 2015). Furthermore, the "low severity" term underscores how preterm-born children can perform at the low-end of average, and thereby experience developmental difficulties which may not be formally identified as being of clinical significance (e.g., Lacalle et al., 2023).

This combination of the increasing survival of preterm-born infants and the persistence of neurodevelopmental difficulties makes preterm birth a considerable public health concern. These concerns are amplified by the inconsistencies both within and across nations in the care provided to preterm-born infants and their families. To resolve this fractionation in the provision of care, organisations such as the European Foundation for the Care of Newborn Infants (EFCNI) are actively working to develop standardised guidelines for the perinatal and follow-up care of medically-vulnerable infants. To support the development of such evidence-based guidelines, research must continue to investigate contemporary preterm-born cohorts to develop a deeper understanding of the factors which may optimise their developmental outcomes. In the process, it is imperative to advance ecologically-valid studies which can produce practicable insights that effectively bridge the research-to-clinic divide.

Theoretical Perspectives on Preterm Development

A strong motivation for the development of standardised care guidelines is to optimise the developmental outcomes of preterm-born children. To inform such efforts, contemporary research is needed on the developmental pathways linking preterm birth to development. Given the great deal of variability in the developmental outcomes of preterm-born children (e.g., Sansavini et al., 2011), these pathways are likely to be complex. Furthermore, the persistence of high prevalence-low severity difficulties in spite of medical advances suggest that medical factors alone are unlikely to fully account for this variability. In recognition of the limitations of a purely biomedical perspective, there is an increasing impetus to adopt a broader developmental systems perspective which can accommodate the interplay of biopsychosocial factors operating within the developmental ecologies of preterm-born children (e.g., Barra & Coo, 2023).

These “systems” perspectives conceptualise developmental abilities (and their underlying neural substrates) as the probabilistic outcome of dynamic interactions between factors characterising the child and his/her environment (genetics, cognitive abilities, behaviour, social/physical environment; Ibbotson, 2020; Karmiloff-Smith, 2009; Spencer et al., 2011). In such a system, the influence of any one constituent factor cannot be understood in isolation, and small discrepancies in one or more factors can trigger a cascade of developmental sequelae (Barra & Coo, 2023; Karmiloff-Smith, 2009). These sequelae can involve the interplay of factors internal to the child (e.g., Ibbotson, 2020). For instance, the neuropsychological processing abilities of an infant might affect their language development through shaping their ability to learn from the speech that they hear in daily life. The cascades can also extend beyond the child through engendering transactional effects involving proximal social partners (Fiese & Sameroff, 1989; Sameroff & Mackenzie, 2003). For example, infant behavioural difficulties could affect parental wellbeing and behaviours which may consequently affect the infant’s developmental outcomes. Importantly, these two cascading effects respectively reflect the embodied and contextually-embedded nature of child development (Tamis-LeMonda & Masek, 2023).

Through capturing the equifinality of developmental outcomes in this way, developmental and dynamic systems perspectives underscore how a comprehensive understanding of preterm development hinges upon advancing a holistic view of the child within their broader developmental ecology. This dynamic and cascading model of development can importantly help to identify the many biopsychosocial factors which could be modified to improve the developmental outcomes of preterm-born children.

Current Thesis

The preceding introductory paragraphs highlight how the effects of preterm birth cannot be wholly understood through a medical lens alone. The experience of preterm birth (for both the child and parent) is imbued by a complex network of biopsychosocial forces which have considerable potential to shape developmental outcomes. While this broader developmental system could aggravate pre-existing biological vulnerabilities, these ecological factors may also buffer their influence. Hence, a deeper understanding of this developmental system may be essential to effectively identify developmentally at-risk preterm-born populations and to locate targets for intervention. In this way, the developmental systems perspective can be understood to be essential for the development of evidence-based guidelines for the care of preterm-born children.

In line with this view, the current thesis adopts a developmental systems view to advance a practicable understanding of preterm development. With a particular focus on language development, the included studies explore how preterm development may be shaped by parental factors, child factors, and their interplay. Through focusing on modifiable risk/protective factors and through pursuing novel research questions and methods, this thesis provides insights which are of relevance to policymakers, practitioners, and researchers alike.

Prior to presenting these original empirical investigations, the remaining three sections of this chapter review the existing literature on the language development of preterm-born children. Section 1.2 characterises the language difficulties associated with preterm birth and the various approaches to measuring language skills. Section 1.3 discusses the child and parent factors which could underpin preterm-term differences in language skills.

Finally, Section 1.4 considers the contribution that parent-child conversations can make to language development, and how such conversations may serve as a conduit for the developmental influence of the aforementioned child/parent factors.

1.2 Preterm Birth and Language Development

Preterm-born children have been observed to exhibit poor language skills when compared to their term-born peers. These language difficulties have been found among preterm-born children of varying degrees of prematurity (extremely, very, and moderate-to-late preterm; Månsson & Stjernqvist, 2014; Putnick et al., 2016) and at a variety of ages (from infancy to adolescence; Cattani et al., 2010; Luu et al., 2011). Importantly, these preterm language difficulties do not appear to reflect a simple developmental lag originating from the biological immaturity of the preterm-born child.

Specifically, maturational perspectives of preterm development propose that differences between the developmental abilities of age-matched preterm- and term-born children are rooted in the biological immaturity of the preterm-born child. This perspective thereby suggests that preterm-term differences in such abilities should disappear after controlling for this between-group difference in biological maturity. This is typically achieved through "adjusting" or "correcting" the age of the preterm-born child for their degree of prematurity (e.g., a child born 4 weeks early could have a chronological age of 26 months but a corrected age of 25 months; see Gattis, 2019 for a more detailed discussion). The observation that preterm-term differences in language abilities persist after adjusting for biological maturity (i.e., using corrected age; e.g., Loi et al., 2016) suggests that preterm-born children may not be exhibiting a simple maturational lag. Instead, such findings suggest that the language abilities of preterm- and term-born children may be underpinned by distinct developmental processes (Gattis, 2019).

Since poor language development can have negative ramifications for both proximal (e.g., school performance) and distal (e.g., occupation) life outcomes (Bleses et al., 2016; Johnson et al., 2010), it is imperative to develop a deeper understanding of the potentially unique developmental processes underlying the language abilities of preterm-born children. To facilitate an informed investigation of such mechanisms, the following subsections first seek to characterise the language difficulties experienced by preterm-born children. In particular, the findings of studies which have compared preterm- and term-born children's language abilities are reviewed. Following this, a developmental perspective is adopted to explore how such preterm-term contrasts may change with age.

Language Abilities of Preterm-Born Children

In the literature to date, preterm-term language abilities have been compared on a range of language domains and using a variety of assessment approaches. The findings of studies using the following three assessment approaches are presented in turn: standardised assessments, discourse-based assessments (language sample analysis), and experimental methods.

Standardised Assessment

Standardised language assessments include examiner-administered tests (e.g., Bayley Scales of Infant and Toddler Development 3rd edition; Bayley-III) and parent-report measures (e.g., MacArthur-Bates Communicative Development Inventories; MB-CDI) which allow for the calculation of norm-referenced developmental scores. These norm-referenced scores can be used to ascertain whether a child's language abilities are above, below, or commensurate with that expected for their age-range. While standardised assessments can provide broad indications of language abilities through "composite" language scores, they can additionally generate scores corresponding to more specific language domains. In the following sections, preterm-term comparisons on composite language scores are presented first. Following this, the findings pertaining to receptive language and expressive language scores, and more specifically to lexical skills (reflecting vocabulary development) and morphosyntactic skills (reflecting grammatical development), are presented in separate sections.

Further, within each section, the findings of meta-analyses and individual studies are discussed. As three meta-analyses are repeatedly referenced, their methodological details are outlined here for information:

van Noort-van der Spek et al. (2012) conducted a meta-analysis on studies published between 1995 and 2011 which compared the language abilities of 3- to 12-year-old preterm- (< 37 weeks' gestation) and term-born children. All 17 studies reviewed by van Noort-van der Spek et al. (2012) used standardised assessments.

Zimmerman (2018) conducted a meta-analysis which compared the language abilities of 5- to 8-year-old preterm- (< 37 weeks' gestation and/or < 2,500g birth weight) and term-born children (born after 1990). Standardised language assessments were used by 15 of the 16 studies reviewed by Zimmerman (2018; the exception being one study which used language sample analysis). Note that while this meta-analysis specified the inclusion of studies with preterm-born children who had gestational ages < 37 weeks and/or birth weights < 2,500g, the preterm-born participants in the final 16 studies had gestational ages ≤ 33 weeks (i.e., extremely/very preterm birth) and/or had birth weights ≤ 1,500g.

Barre et al. (2011) carried out a meta-analysis on studies published between 1990 and 2009 which compared the language abilities of 2- to 12-year-old extremely/very preterm- (< 32 weeks' gestation and/or < 1,500g birth weight) and term-born children. Standardised assessments were used by 10 of the 12 studies reviewed by Barre et al. (2011; the exception being two studies which used category fluency tasks).

When presenting the findings of individual studies, examiner-administered and parent-report measures are differentiated through explicitly identifying the latter measures as "parent-report" (with the exception of MB-CDI which has already been identified in this chapter as being a parent-report measure). Thus, all other measurement tools can be assumed to be examiner-administered.

Composite Language Scores. Two of the three meta-analyses investigated the effect of birth status (preterm/term) on composite language scores. The meta-analysis by van Noort-van der Spek et al. (2012) found preterm-born groups to obtain significantly poorer composite scores than term-born groups (Cohen's d = -0.62; medium-to-large effect size). Furthermore, this meta-analysis observed an age-related increase in the magnitude of this preterm-term difference. The meta-analysis by Zimmerman (2018) similarly found preterm-born groups to obtain lower composite scores than term-born groups (no standardised effect size reported). However, Zimmerman's (2018) findings should be interpreted with caution as only two of the 16 studies in this meta-analysis had reported composite language scores.

Additional studies (not included in these meta-analyses) have also compared the composite language scores of preterm- and term-born groups. Using the Bayley-III assessment, Loi et al. (2016) found 18-month-old very preterm-born infants (gestational age: ≤ 32 weeks, birth weight: < 1,800g; corrected age) to obtain composite scores significantly lower than those of their term-born peers. Furthermore, using a selection of items from the communication subscale of the parent-report Ages and Stages Questionnaire, Stene-Larsen et al. (2014) found late preterm-born infants (gestational age between 34 and ≤ 37 weeks) to exhibit poorer language skills when compared to their term-born peers at both 18 and 36 months of age. Furthermore, at 18 months (but not 36 months of age), the late preterm-born infants exhibited significantly higher odds of impaired communication when compared to their term-born peers (communication impairment defined as a score > 2 standard deviations above the sample mean; higher scores signifying poorer communication abilities).

Receptive Language Scores. Two of the three meta-analyses examined the effect of birth status (preterm/term) on receptive language scores. Barre et al. (2011) found that preterm-born groups obtained significantly lower receptive language scores than term-born groups (Hedge's g = -0.77; large effect size). Zimmerman (2018) similarly found extremely/very preterm-born groups to obtain significantly poorer receptive language scores than their term-born peers (no standardised effect size reported). Studies which have not been included in these meta-analyses have found converging results with participant samples who are younger and of differing degrees of prematurity. Månsson and Stjernqvist (2014) found significantly poorer receptive communication scores (Bayley-III) among extremely preterm- (< 27 weeks' gestation) as compared to term-born infants at 2.5 years of age. Using the same assessment tool, Snijders et al. (2020) found a significant association between gestational age and test scores among a sample of moderate-to-late preterm- (32-37 weeks' gestation) and term-born infants at 2 years of age (corrected age for preterm-born infants).

Lexical. Mixed findings have been recorded regarding the effect of birth status on receptive lexical skills. In the meta-analysis by Barre et al. (2011), two studies of school-aged children found the receptive semantic ability of preterm-born children to be significantly lower than that of their term-born counterparts (Hedge's g = -0.59; medium-to-large effect size). Similarly, the meta-analysis by van Noort-van der Spek et al. (2012) found preterm-born groups to obtain significantly lower receptive vocabulary scores than term-born groups (Cohen's $d = -0.45$; medium effect size). This pattern of poorer lexical abilities has also been observed among younger cohorts not covered by these meta-analyses. Cattani et al. (2010) found that 12-, 15-, and 18-month-old preterm-born infants (gestational age: 26-34 weeks; birth weight: 840-2,790g) obtained lower scores than a normative sample on the word comprehension subscale of the parent-report PVB ("Primo Vocabolario del Bambino" – Italian MB-CDI).

Nonetheless, several studies (published after the meta-analyses) found no significant association between birth status and receptive lexical skills. De Stefano et al. (2019) found no significant differences between the lexical comprehension scores of extremely preterm- (< 28 weeks' gestation) and term-born groups at 4 and 5 years of age (using the Preschool Neuropsychological Test for Italian speakers). Furthermore, Pérez-Pereira et al. (2014) observed no significant differences between the word comprehension scores of low-risk preterm- (< 37 weeks' gestational age) and term-born infants at 10, 12, and 30 months of age (corrected age for preterm-born group; using the IDHD, the Galician version of the MB-CDI). This study additionally found no significant between-group differences when conducting finer-grained comparisons through segmenting the sample into four smaller groups according to gestational age (≤ 31 weeks, 32-33 weeks, 34-36 weeks, ≥ 37 weeks).

Morphosyntactic. Few studies have compared the receptive morphosyntactic skills of preterm- and term-born children. The meta-analysis by Barre et al. (2011) identified only one such study (Pritchard et al., 2009), with this study finding significantly poorer scores among very preterm/very low birth weight children (gestational age ≤ 33 weeks and/or birth weight < 1,500g) at 6 years of age (using the Woodcock Johnson III Tests of Achievement). In contrast, De Stefano et al. (2019) found no significant differences between the morphosyntactic comprehension scores of extremely preterm- (gestational age < 28 weeks) and term-born children at 4 and 5 years of age (Preschool Neuropsychological Test for Italian speakers).

Expressive Language Scores. Conflicting findings have been documented regarding preterm-term differences in expressive language scores. The meta-analyses by Barre et al. (2011; Hedge's g = -0.63; medium-to-large effect size) and Zimmerman (2018; no standardised effect size reported) found significantly poorer expressive language abilities among very preterm/low birth weight children when compared to term-born children.

Convergent results have been obtained from studies not included in these meta-analyses. Månsson and Stjernqvist (2014) found extremely preterm-born infants (< 27 weeks' gestational age) to obtain significantly poorer expressive communication scores than term-born infants at 2.5 years of age (Bayley-III; corrected age for the preterm-born group). Furthermore, Foster-Cohen et al. (2010) observed very preterm/very low birth weight children (gestational age ≤ 33 weeks or birth weight < 1,500g) to exhibit poorer expressive language skills than term-born children at 4 years of age (Clinical Evaluation of Language Fundamentals [CELF] Preschool; corrected age for the preterm-born group).

Notably, mild-to-moderate levels of heterogeneity were found across the studies synthesised by Barre et al.'s (2011) meta-analysis. In line with this variability, several studies (not included in the meta-analyses above) did not find significant preterm-term differences in expressive language skills. Importantly, these studies involved samples with demographic characteristics (age, degree of prematurity) which fall outside the inclusion criteria of the meta-analyses by Barre et al. (2011) and Zimmerman (2018). For instance, Snijders et al. (2020) found no significant differences between the expressive communication scores of moderate-to-late preterm- (32-37 weeks' gestational age) and term-born infants at 2 years of age (BSID-III-NL – Dutch adaptation of Bayley-III).

Lexical. The meta-analysis by Barre et al. (2011) found significantly poorer lexical scores among very preterm/very low birth weight children when compared to term-born children (Hedge's g = -0.38; small-to-medium effect size). However, subsequently published studies have reported more inconsistent results. For instance, Cattani et al. (2010) found that the word-production scores of 12-, 15-, 18-, 21-, and 24-month-old preterm-born infants (26-34 weeks' gestation) were lower than those recorded for a normative sample (Italian MB-CDI). Meanwhile, De Stefano et al. (2019) found no significant differences between the lexical production scores of extremely preterm- (< 28 weeks' gestation) and term-born infants at 4 and 5 years of age (Preschool Neuropsychological Test for Italian speakers). Similarly, among a less premature sample, Marchman et al. (2019) observed no significant differences between the expressive vocabulary scores of preterm- (≤ 32 weeks' gestation, < 1,800g birth weight) and term-born infants at 16, 18, or 22 months of age (MB-CDI; corrected age for the preterm-born group). Finally, Pérez-Pereira et al. (2014) found no significant differences between the word production scores of preterm- and term-born infants at 10, 12, or 30 months of age (Galician MB-CDI; corrected age for the preterm-born group).

Morphosyntactic. Few studies have compared the expressive morphosyntactic skills of preterm- and term-born children, with the meta-analysis by Barre et al. (2011) identifying only one such study. This study, by Foster-Cohen et al. (2007), found 2-year-old extremely/very preterm-born (< 33 weeks' gestation) or low birth weight (< 1,500g) infants to exhibit poorer expressive morphosyntactic skills when compared to their term-born peers (MB-CDI; corrected age for preterm-born group). These between-group differences were manifested in the preterm-born infants' difficulties with morphological endings and in fewer preterm-born infants producing multi-word utterances. Among the preterm-born infants who did combine words, their utterances were observed to be significantly shorter and less complex than those of their term-born counterparts. De Stefano et al. (2019) also found extremely preterm-born children (< 28 weeks' gestation) to obtain significantly poorer morphosyntactic production scores than term-born children at 4 and 5 years of age (Preschool Neuropsychological Test for Italian speakers).

Summary. The literature review above summarised the findings from studies which compared the language abilities of preterm- and term-born children using standardised assessments. The studies used a wide range of both examiner-administered and parent-report measures, with the range of assessment tools being widened even further when considering the use of translated measures (e.g., MB-CDI in English, Italian, and Galician). The review included three meta-analyses alongside additional studies which were not included in these three review articles as a result of falling outside of their inclusion criteria and/or from being published after their completion. In both the meta-analyses and individual studies, preterm-born children were observed to obtain poorer composite, receptive, and expressive language scores when compared to their term-born peers. Furthermore, within both the receptive and expressive domains, preterm-born groups were found to exhibit poorer lexical and morphosyntactic abilities when compared to the term-born groups.

This review importantly identified that the existing body of literature has disproportionately focused on describing the language abilities of extremely/very preterm-born (or low birth weight) children. Only a minority of studies focused specifically on moderate-to-late preterm-born children, and very few studies used sampling criteria which included preterm-born children of all degrees of prematurity (i.e., < 37 weeks' gestation; see Pérez-Pereira, 2021 for a discussion of the over-representation of extremely/very preterm-born children in this literature). As a result, it is unknown whether the above findings are representative of the preterm-born population.

Even among these samples of predominantly extremely/very preterm-born infants, mixed findings were observed with both significant and non-significant preterm-term differences being found across studies. The limited number of studies which have investigated each score domain precludes conclusions regarding what may be affecting the presence or absence of preterm-term differences. A later section of this literature review (Section 1.3) will seek to shed light on these variables through discussing the child and parent factors which may shape the language development of preterm-born children.

Language Sample Analysis

The majority of research comparing the language abilities of preterm- and term-born children have utilised standardised assessments (Barre et al., 2011). In comparison, only a small number of studies have adopted discourse-based measures to characterise the language abilities of preterm-born children. Language sample analysis assesses the expressive communicative competencies of children through analysing speech samples which can be recorded in a variety of settings. For instance, speech sample recordings have been obtained from caregiver-child or examiner-child conversations during unstructured free-play activities (e.g., Craig et al., 1991; Sanchez et al., 2020) and more structured activities like book-sharing (Suttora et al., 2020). Among older children, narrative retelling tasks have also been used to record a child's speech as they recount a story. With the recorded speech samples, the children's verbal productions can be scored on a variety of speech features which reflect their lexical abilities (e.g., type-token ratio reflecting the diversity of vocabulary used by the child) and morphosyntactic abilities (e.g., mean length of utterance [in words or morphemes] reflecting the morphosyntactic complexity of speech).

Through capturing naturalistic language use in settings which are often familiar to the child (e.g., free-play interaction), language sample analysis can provide ecologically valid insights into the functional communicative abilities of the child. The developmental information that is derived from language sample analysis can complement the insights obtained from standardised assessment scores. Specifically, while correlations exist between the scores obtained from language sample analyses and standardised assessments (Owens & Pavelko, 2017), these scores form separate factors in factor analyses (Mahurin-Smith et al., 2014). Such findings demonstrate how these assessment approaches capture conceptually-related yet distinct dimensions of language development. As a result, it can be understood that using standardised assessment and language sample analysis in tandem can offer a more comprehensive characterisation of preterm language development than could be achieved using either approach alone (Imgrund et al., 2019; Mahurin-Smith et al., 2014; Sanchez et al., 2020). In line with this understanding, the following section reviews the small number of studies, categorised by child age, which have compared preterm- and term-born children's language abilities using language sample analyses and standardised assessments.

Preschool-Aged Children. Grunau et al. (1990) examined the language abilities of 3-year-old extremely low birth weight (< 1,000g) preterm-born (corrected age) and term-born children using conversational speech samples (examiner-child play session) and two standardised assessments (Stanford-Binet Intelligence Scale [4th edition]; Peabody Picture Vocabulary Test-Form L). The preterm-born children performed more poorly than the term-born children on both the language sample analysis measures and the standardised assessments. In the language sample analysis, the preterm-born group obtained significantly lower scores than the term-born group on one of two measures of morphosyntactic skill (sentence complexity; no preterm-term differences were observed in mean length of utterance). With respect to the standardised measures, the preterm-born children obtained lower scores than their term-born peers on the Peabody Picture Vocabulary Test and on three of the four language/communication-related scales of the Stanford-Binet Intelligence Scale (verbal reasoning, comprehension, memory for sentences; there was no significant preterm-term difference on the vocabulary scale).

Among a slightly older sample of preschool-aged children, Imgrund et al. (2019) compared the language abilities of 4-year-old preterm- (23-34 weeks' gestation) and term-born children using conversational language samples (examiner-child free-play interaction) and the CELF-Preschool assessment (2nd edition). Preterm-term differences were primarily observed on measures obtained from the conversational speech samples rather than the CELF-Preschool scores. Specifically, no significant preterm-term differences were found on any CELF-Preschool subtest, with the exception of the sentence-recall task where the preterm-born group performed significantly more poorly than the term-born group. Meanwhile, the preterm-born group obtained significantly lower scores than the term-born group across all of the lexical (number of different words used; semantic analysis score) and morphosyntactic (mean length of utterance in morphemes; developmental sentence score; % correct use of finite verb morphology) speech features which were measured using language sample analysis.

School-Aged Children. Crosbie et al. (2011) compared the language abilities of 10-year-old preterm-born (< 33 weeks' gestation) and term-born children using a narrative speech sample and the CELF (4^{th} ed; CELF-4) assessment. In this study preterm-term differences were not observed on the narrative speech features, while significant between-group differences were observed on the standardised assessment scores. In particular, while the preterm-born children exhibited poorer narrative formulation abilities than the term-born group, there were no significant preterm-term differences in the productivity (number of words in T-units, number of T-units; T-units are defined as a main clause plus any dependent clauses), complexity (mean length of utterance in words in T-units, number of complex T-units), or quality (number of T-units with grammatical errors) of the children's speech. With respect to the CELF-4 assessment, the preterm-born group performed significantly more poorly than the term-born group on the expressive (but not the receptive) language subtest.

Stipdonk et al. (2020) assessed the performance of 10-year-old children born preterm (24-32 weeks' gestation) and at term (matched on age and sex) using a narrative speech sample and the CELF-4 assessment. The preterm-born group performed more poorly than the term-born group on measures from both the narrative speech sample and the standardised language assessment. With relation to the speech sample, the preterm-born group produced significantly less complex grammatical structures (lower mean length of five longest utterances [in words] and fewer embedded utterances) when compared to the term-born group (there were no significant preterm-term differences in lexical diversity [measured using VOCD] or the number of ungrammatical utterances produced). With relation to the CELF-4 assessment, the preterm-born children obtained significantly lower CELF-4 core language scores when compared to the term-born children.

Mahurin-Smith et al. (2014) investigated the language abilities of 10-year-old twins born preterm (≤ 32 weeks' gestation or < 1,500g birth weight) and at term (matched on age, gender, race, and parental education) using a narrative speech sample and standardised testing (CELF-4, Test of Narrative Language). While there was no significant effect of gestational age on measures taken from the narrative speech samples, gestational age significantly affected the standardised test scores. Specifically, gestational age was not found to significantly affect a composite measure of the lexical speech features (reflecting adverb density, metalinguistic verb density, morphologically complex word density, low-frequency word density, number of different words, and number of total words) or a composite measure of the syntactic speech features (reflecting conjunction density, complex conjunction density, elaborated noun phrase density, developmental sentence score, and mean length of utterance) obtained from the narrative samples. Meanwhile, gestational age was positively associated with the composite standardised assessment score. In a follow-up investigation of this sample, Mahurin-Smith et al. (2021) similarly found that gestational age did not significantly affect the narrative speech samples obtained at either 11 or 12 years of age. Although gestational age was positively associated with the composite standardised test score at 11 years of age, it was no longer a significant predictor of this standardised score at 12 years of age.

Summary. Across all of the studies reviewed above, preterm-born children were observed to exhibit poorer language skills than their term-born peers. While some studies identified difficulties on both language sample analysis and standardised assessment measures, other studies found difficulties to be primarily observable on only one assessment approach (either language sample analysis or standardised assessment scores). These latter findings in particular critically demonstrate the complementary utility of language sample analysis and standardised assessments in offering a more comprehensive profile of language ability than could be achieved through using either approach alone.

Nonetheless, further investigation is required to understand why preterm-term differences were observed on both language sample analysis and standardised assessments in some studies, while in others, between-group differences were observed when using one assessment approach but not the other. One potential contributing factor may be the age of the child at assessment. Among the studies reviewed here, preterm-term differences in language sample analysis measures were more consistently observed in the studies involving preschool-aged as compared to school-aged children. An important caveat to this age-related proposal is the potential confounding of such age-effects by methodological variations across studies. Specifically, in addition to the differences in the choice of standardised assessment tools, considerable procedural variations can be seen across the studies in the implementation of language sample analysis. Such procedural variations in language sample analysis (e.g., the speech sampling context) can substantially affect the insights that are obtained from the recorded speech samples (Ebert & Pham, 2017). Further cumulative evidence and targeted investigations of such methodological moderators will be required to elucidate the origins of these inconsistencies.

Experimental Paradigms

Standardised assessments and language sample analysis respectively offer insights into the child’s linguistic knowledge and their ability to use this knowledge in naturalistic communicative contexts. To complement these insights, experimental paradigms have been used to characterise the neuropsychological processing abilities which may underlie the acquisition and use of such linguistic knowledge. In particular, the “Looking While Listening” eye-tracking task has been used to understand the real-time speech processing ability of preterm- and term-born children. In this task, children view images of two familiar objects (e.g., a dog and a baby) while listening to a pre-recorded utterance commenting on one of the two images (e.g., “Where’s the doggy?”; Fernald et al., 2008; Marchman et al., 2019). The speed and accuracy with which the child orients their gaze to the image corresponding to the utterance are thought to reflect the efficiency of neuropsychological processes which are fundamental to language learning and communication. In line with this reasoning, it has been found that the speed and accuracy of performance on the Looking While Listening task at 18 months of age significantly predict the receptive and expressive language abilities of both preterm- (≤ 32 weeks’ gestation and < 1,800g birth weight) and term-born children at 4.5 years of age (corrected for the preterm-born group at the 18-month age-point; Marchman et al., 2023)

Nonetheless, inconsistent findings have been recorded among studies which have compared the performance of preterm- and term-born children on this task. While Marchman et al. (2019) found that 18-month-old preterm-born infants (corrected age; ≤ 32 weeks’ gestation and < 1,800g birth weight) performed significantly more slowly than term-born infants (accuracy was not investigated), the aforementioned study by Marchman et al. (2023) found no significant preterm-term differences in either speed or accuracy at 18 months (corrected age for the preterm-born group). In line with this latter finding, Loi et al. (2016) similarly found no significant differences between preterm- (corrected age; ≤ 32 weeks’ gestation and < 1,800g birth weight) and term-born children on either speed or accuracy at 16-, 18-, or 22-months of age (significantly slower and less accurate performance was recorded among the preterm-born group when using chronological age).

Developmental Changes

A consistent feature of this research is the mixed findings regarding the presence or absence of preterm-term differences in language skills. Given that the studies reviewed above have included both preschool-aged and school-aged children, it is important to consider how the presence and/or magnitude of preterm-term differences may be moderated by the child's age. In fact, the meta-analysis by van Noort-van der Spek et al. (2012) found significantly larger preterm-term differences in composite language scores among studies including older, as compared to younger, samples of children. Such findings may suggest an age-related change in the manifestation of preterm-term differences in language abilities. To facilitate a more direct examination of such developmental changes, the findings of longitudinal studies which have traced the receptive and expressive language abilities of preterm-born children are reviewed.

Longitudinal studies tracking receptive language abilities from 12 to 24 months of age have found evidence for preterm language difficulties of both consistent (i.e., persistent preterm difficulties; Cattani et al., 2010) and increasing (i.e., preterm-term divergence in language skills; Sansavini et al., 2011) magnitude. Among the longitudinal studies involving older samples, preterm-born children have been found to gradually approximate the receptive language abilities of their term-born peers between 3 and 12 years of age (Luu et al., 2009) and also between 8 and 16 years of age (Luu et al., 2011). Meanwhile, longitudinal studies tracking expressive language skills across infancy have found evidence for both age-related increases (between 12-24 months in Sansavini et al., 2011) and decreases (between 12-24 months in Cattani et al., 2010; between 18-36 months in Stene-Larsen et al., 2014) in the magnitude of preterm-term differences.

Summary

These longitudinal studies demonstrate how the manifestation of preterm-term differences in receptive and expressive language skills may change across development. However, there is disagreement across studies regarding the precise valence of this age effect – evidence has been found for stable, widening, and diminishing preterm-term differences across the infancy/toddlerhood period. Beyond this period of infancy/toddlerhood, there is evidence that preterm-term differences in receptive skills may diminish across later childhood. As no longitudinal study of expressive language skills covering this later childhood period could be found, future studies are needed to investigate whether such developmental catch-up may generalise beyond the receptive domain.

Conclusion

The literature review thus far has characterised preterm language development through reviewing studies which have compared the language abilities of preterm- and term-born children. The literature was found to contain evidence for both preterm-term similarities and differences in language skills, with a potential age-related change in the manifestation of these contrasts. When preterm-term differences were found, the preterm-born group exhibited poorer language skills than their term-born peers. Through drawing on studies utilising standardised assessments, language sample analysis, and experimental paradigms, these language difficulties were demonstrated in the children's linguistic knowledge, their ability to apply this knowledge in naturalistic communicative contexts, and also possibly in their real-time language processing capacities. Nonetheless, as many of the reviewed studies were found to focus on extremely/very preterm-born children, further research is required to examine whether these findings may generalise to the preterm-born population as a whole (i.e., including moderate-to-late preterm-born children).

It was particularly apparent in studies using more than one assessment approach (e.g., standardised assessment and language sample analysis) that preterm-born children may experience difficulties in some but not all assessed language domains. These circumscribed language difficulties reflect a pattern of "peaks and valleys" (Guarini et al., 2016, p. 952) in the language abilities of preterm-born children and thereby indicate how the use of multiple assessment approaches in research and clinical settings may afford the most comprehensive understanding of preterm language development. The advancement of such evidence-based insights into the use of language assessments with preterm-born cohorts is pertinent given international clinical guidelines to monitor the development of preterm-born children through periodic developmental assessments (EFCNI, 2022a).

Nonetheless, the precise profile of peaks and valleys is as yet unclear owing to the aforementioned heterogeneity between study findings. In the following section of this literature review, a better understanding of the source of such inconsistencies is pursued through reviewing the child and parent factors which may shape the language development of preterm-born children.

1.3 Sources of Variation in Language Development

Preterm-born children are at elevated risk of experiencing language difficulties. Nonetheless, there is considerable inconsistency across studies in whether and how preterm-term differences in language abilities are found. This suggests that the association between preterm birth and language difficulties is complex and nuanced. An understanding of the factors that underlie this variable association would significantly advance the identification of developmentally "at-risk" preterm-born subgroups, as well as the prevention and mitigation of language difficulties.

The following literature review considers factors which may mediate the association between preterm birth and language development. Specifically, child (clinical and biomedical, developmental and behavioural) and parent (parenting experiences and behaviour) factors which have been found to differ between preterm- and term-born groups and to be associated with preterm language development are considered.

Clinical and Biomedical Factors

Preterm birth has been associated with a range of clinical experiences (e.g., extended hospitalisation; Manktelow et al., 2010), medical outcomes (e.g., bronchopulmonary dysplasia, sensory impairments; Saigal & Doyle, 2008), and neurobiological sequelae (e.g., intraventricular haemorrhage, gray/white matter atypicalities; Ment & Vohr, 2008) which may serve as risk factors for language development. As these experiences are relatively unique to preterm-born children, studies involving term-born samples are not discussed here.

With regards to the clinical experiences and medical outcomes of preterm-born children, the expressive language abilities of 2-year-old extremely preterm-born children (corrected age) have been found to be negatively associated with the length of hospitalisation following birth as well as the presence of a severe disability (clinically significant difficulties in neuromotor, visual, hearing, communication and/or physical domains; Marston et al., 2007). Furthermore, the receptive language abilities of preterm-born infants (3 years corrected age) have similarly been found to be negatively associated with the presence of medical conditions such as bronchopulmonary dysplasia (Luu et al., 2009).

With regard to the neurobiological sequelae, the severity of brain injury (either intraventricular haemorrhage [grade 3-4], periventricular leukomalacia, or moderate-to-severe ventriculomegaly) experienced by preterm-born children has been found to be associated with the developmental trajectory of receptive vocabulary. Between 3 and 12 years (corrected age), preterm-born children with more severe brain injuries were found to show a slower rate of growth in receptive vocabulary (Luu et al., 2009). Gray matter integrity has also been found to associate with language development among preterm-born children. At 2, 5, 7, and 13 years of age, preterm-born children with moderate-to-severe deep gray matter abnormalities were found to exhibit poorer overall language function when compared to their preterm-born peers with no/mild abnormalities (< 30 weeks gestational age or < 1,250g birth weight; Nguyen et al., 2019). Finally, white matter atypicalities have also been found to associate with language outcomes. Overall language functioning has been found to be negatively associated with the severity of white matter abnormalities among 4-year-old

(Foster-Cohen et al., 2010) and 5-year-old (Howard et al., 2011) preterm-born children (corrected age).

Developmental and Behavioural Factors

The developmental influence of the clinical and biomedical factors discussed above are not limited to the language domain as they have also been found to affect non-linguistic developmental and behavioural characteristics (e.g., the experience of undergoing painful medical procedures during the neonatal period has been linked to the temperamental characteristics of preterm-born cohorts; Valeri et al., 2015). Since these non-linguistic characteristics have the capacity to influence language learning and use, it is possible that these clinical/biomedical factors may affect language development in part through influencing these non-linguistic developmental domains. Such associations between language development and non-language development can be understood through considering how non-linguistic skills can shape the domain-general learning capacities of children and the nature of their engagements with their physical and social environments. These ideas, which have been outlined through Ibbotson's (2020) developmental cognitive linguistic view, critically align with neuroconstructivist ideas which highlight the importance of recognising the inter-relations between developmental domains when understanding the development of biologically vulnerable children (Guarini et al., 2016; Guarini et al., 2009; Karmiloff-Smith, 2009).

In line with these views, the following sections review the studies which have examined the associations between non-linguistic developmental/behavioural factors (cognitive, motor, social-emotional and behavioural) and language development among preterm- and term-born cohorts.

Cognitive

Preterm-born children have been found to exhibit poorer performance than their term-born peers across a range of cognitive measures (e.g., intelligence quotient, executive function; Lacalle et al., 2023; Sandoval et al., 2022). Critically, such cognitive abilities have been found to associate with the language development of both preterm- and term-born groups.

For example, cognitive scores on the Bayley-III assessment have been found to be concurrently associated with the receptive and expressive communication scores of 18-month-old preterm-born infants (corrected age; Ross et al., 2018). Furthermore, intelligence quotients have been found to be both concurrently (Foster-Cohen et al., 2010) and longitudinally (Sansavini et al., 2010) associated with the language abilities of preterm-born children. Associations have also been found between more specific neuropsychological processing abilities and language development. Among a sample of preterm- and term-born children, Snijders et al. (2020) investigated how gestational age may directly and indirectly (via alerting, executive, or orienting attention at 18 months of age) affect receptive and expressive language abilities at 24 months of age (corrected age at both timepoints for the preterm-born group). In this study, gestational age was found to significantly affect receptive language skills both directly and indirectly through alerting (but not executive or orienting) attention. Meanwhile, although gestational age was directly associated with expressive language abilities, its effect was not significantly mediated by alerting, executive, or orienting attention abilities. These findings must be interpreted with caution as the statistical models did not control for the influence of auto-regressive paths (e.g., to account for the association between language abilities at the 18 and 24 month timepoints).

In an examination of the contribution made by multiple cognitive factors to the language development of preterm- and term-born children, Rose et al. (2009) examined the prospective associations between memory, representational competence, processing speed, and attention at 12 months of age and receptive language and verbal fluency scores at 36 months of age (corrected age for the preterm-born group). In an initial examination of the correlations between these cognitive and language measures, no significant preterm-term differences in these cross-domain associations were found. After controlling for the contributions of birth status (preterm/term) and 12-month-old language abilities, memory and representational competence predicted receptive vocabulary scores among the pooled sample of preterm- and term-born children. After similarly controlling for birth status and 12-month-old language abilities, representational competence significantly predicted the verbal fluency scores of the pooled preterm-/term-born sample.

Summary. These findings demonstrate how cognitive development is concurrently and prospectively associated with language development among preterm-born children. These cross-domain associations suggest how the language difficulties of preterm-born children may not be entirely domain-specific (e.g., Sansavini et al., 2010). Instead, they may be partly rooted in more domain-general neuropsychological impairments (e.g., executive function) which could affect their ability to acquire and use language.

Motor

While the prevalence of severe motor difficulties (e.g., cerebral palsy) among preterm-born cohorts has been falling (Platt et al., 2007), preterm-born children continue to be at heightened risk of experiencing poor motor development (Evensen et al., 2020). Importantly, motor development has been concurrently and prospectively associated with language development among preterm- and term-born children.

For example, the motor skills of preterm-born children at 3 months of age have been found to significantly predict their overall language abilities at 2 years of age (corrected age at both timepoints; Peyton et al., 2018). In a similar vein, 18-month-old preterm-born children (corrected age) with typical motor development have been found to demonstrate significantly higher expressive communication scores than preterm-born children with either mild (low tone, unstable gait, and/or clumsiness) or moderate-to-severe (unable to walk independently) motor difficulties (Ross et al., 2018). In this same study, preterm-born children with typical motor development obtained significantly higher receptive communication scores than those exhibiting moderate-to-severe motor difficulties.

Two pathways have been hypothesised to underlie the association between the motor development and language development of preterm-born children. Firstly, this cross-domain association could reflect the fact that these motor and language difficulties may be attributable to a common neurobiological cause (e.g., cerebellar abnormalities; Limperopoulos et al., 2007; Peyton et al., 2018; Ross et al., 2018). Secondly, the motor abilities of preterm-born children may affect their language learning opportunities through shaping how they explore and interact with their social and physical environments (Iverson, 2010; Peyton et al., 2018; Ross et al., 2018). This latter perspective can be seen to align with the developmental cognitive linguistic (Ibbotson, 2020) and neuroconstructivist (Karmiloff-Smith, 2009) views outlined previously. Although the neurobiological explanation is beyond the scope of this thesis, the second explanation is considered further below. Specifically, to consider how the motor abilities of preterm-born children may affect their interactions with their social and physical environments, studies which have investigated the functional motor abilities (e.g., gesturing, object exploration) of preterm- and term-born children are reviewed.

Gestures. Gestures can play a fundamental role in the pre-linguistic communicative repertoire of young infants by providing a means through which to engage with the social environment. Importantly, there is evidence to suggest that the ability to produce gestures is associated with both the motor abilities and subsequent language development of preterm-born children.

With relation to the link between motor skills and gesture use, fine (but not gross) motor skills have been found to be concurrently associated with the rate at which preterm- and term-born children produce communicative gestures at 12 months of age (corrected age for the preterm-born group; Benassi et al., 2016). In this study, motor skills were found to be positively associated with the gesture production of both preterm- and term-born children. In line with the poorer motor development of preterm-born children and its association with gesture production, preterm-born children have been found to exhibit delayed gestural developmental during the first two years of life (Sansavini et al., 2011; Stolt et al., 2014). Nonetheless, there is also conflicting evidence as non-significant preterm-term differences have been recorded in the quantity and quality of gestures produced during the second year of life (corrected age for the preterm-born group; Suttora & Salerni, 2012).

The three studies discussed above have additionally investigated the associations between gesture development and language development. Among their preterm-born sample, Suttora and Salerni (2012) found communicative gesture development (pointing) at 12 months of age to significantly predict 18-month receptive vocabulary and expressive vocabulary, as well as the quantity and diversity of words produced by the infant during mother-infant interactions at 24 months of age. In this same study, the combined use of gestures and words at 18 months of age significantly predicted the production of multi-word utterances at 24 months of age by preterm-born children (these associations were not investigated among the term-born comparison group). Interestingly, Stolt et al. (2014) found the association between gestural and language development to differ between preterm- and term-born groups. While gestural development (at 9, 12, and 15 months) significantly predicted the expressive language skills (at 24 months) of both preterm- and term-born children, gestural development (at 12 and 15 months) significantly predicted the receptive language skills (at 24 months) of preterm- but not term-born children. Finally, Sansavini et al.

(2011) found 18-month gesture-action production to significantly predict the word production abilities of the pooled sample of preterm-/term-born children at 24 months of age.

Object Exploration. Similar to the discussion of how motor skills may affect language development through shaping social experiences (communicative gesture use), motor development may also affect language learning through influencing how children engage with their physical environment. In particular, through exploring objects in their proximal environments, children create opportunities to develop linguistically relevant conceptual representations of objects (e.g., the formation of categories and semantic representations; see Zuccarini et al., 2018 for a discussion). Preterm-born infants have been observed to exhibit poorer motor object exploration abilities than term-born children at 6 months of age (corrected age for the preterm-born group; Zuccarini et al., 2017). While these preterm-term differences were found to diminish between 6 and 9 months of age (corrected age), the amount of time spent in oral object exploration significantly predicted hearing and language scores at 24 months of age (Zuccarini et al., 2017). In a similar study, the amount of time spent in oral object exploration at 6 months of age significantly predicted word comprehension at 12 months of age among a pooled sample of preterm- and term-born infants (corrected age for preterm-born group; Zuccarini et al., 2018). In this same study, the amount of time spent in manual object exploration at 6 months significantly predicted the amount of spontaneous gestures/vocalisations produced by the infant during mother-infant interactions at 12 months of age (corrected age for the preterm-born group).

Summary. The studies presented above demonstrate how preterm birth is associated with motor difficulties which have themselves been associated with poor language development. Drawing on the developmental cognitive linguistic perspective (Ibbotson, 2020), the motor-language link was explored further through examining the functional motor abilities of preterm-born children (gesture use, manual/oral object exploration). The discussion of these functional motor abilities illustrate how motor skills could impact the language learning opportunities of preterm-born cohorts through shaping how children engage with social partners and objects in their proximal environments.

Social-Emotional and Behavioural

The effect of preterm birth on social-emotional development and behavioural characteristics has been evidenced through preterm-term differences in the visual processing of social stimuli (Imafuku et al., 2021), adeptness with inter-personal interactions (e.g., reflecting prosocial interpersonal interactions and relations, empathy, imitation; Johnson, Matthews, et al., 2015), and broader temperamental profiles (e.g., lower attention and higher activity level; Cassiano et al., 2020). Critically, such social-emotional and behavioural characteristics have been found to be associated with the language development of preterm-born children.

With regards to the visual processing of social stimuli, Imafuku et al. (2021) used an experimental eye-tracking paradigm to compare the gaze-following ability and social looking preference (preference for dynamic social as compared to non-social geometric stimuli) of preterm- and term-born children at 6, 12, and 18 months of age (corrected age for the preterm-born group). In comparison to the term-born group, the preterm-born infants showed a reduced preference for dynamic social stimuli and displayed less frequent gaze following at all age-points. Among the pooled sample of preterm- and term-born children, there were no significant associations between social looking preference and either receptive or expressive language scores at 18 months of age. Meanwhile, 12-month and 18-month gaze-following ability were positively associated with 18-month expressive language ability (there were no significant associations between gaze-following and 18-month receptive language ability).

Complementing the experimental eye-tracking methodology of Imafuku et al. (2021), De Schuymer et al. (2011) investigated the ability of preterm-born children to navigate real social interactions through comparing how preterm- and term-born children (i) followed the attention (gaze or pointing gesture) of an interacting partner, (ii) proactively engaged the attention of their partner (through eye contact, gaze, pointing, object showing), and (iii) made behavioural requests of their partner (eye contact, reaching gesture, pointing; e.g., to acquire an object which was out of reach) during dyadic adult-child interactions. While this study found that the preterm-born children were less likely than term-born children to make behavioural requests of their partner, no significant differences were found in their response to, and proactive engagement of, their partner's attention. Crucially, the association between birth status (preterm/term) and receptive language ability at 30 months of age was jointly (but not independently) mediated by the three behavioural measures. Meanwhile, the association between birth status and expressive language ability at 30 months was only mediated by the child's proactive engagement of their partner's attention.

With regards to the broader behavioural profile of preterm-born children, temperamental characteristics (particularly high distractibility and low persistence) and behavioural characteristics (particularly endurance and co-operation) at 2 years of age have been found to predict the overall language abilities of preterm-born children at 4 years of age (corrected age at 2 year age-point; Sajaniemi et al., 2001). In a similar vein, Pérez-Pereira et al. (2016) found that temperamental characteristics at 10 months of age significantly predicted the lexical and grammatical abilities of preterm- and term-born children at 30 months of age (corrected age at both time points for the preterm-born group). Importantly, this study found that a different set of temperamental characteristics affected each language domain. For instance, word production abilities were positively predicted by approach, high intensity pleasure, and soothability, and were negatively predicted by low intensity pleasure and sadness. Meanwhile, the child's mean length of utterance (a measure of the morphosyntactic complexity of the child's speech productions) was positively predicted by high intensity pleasure and vocal reactivity, and negatively predicted by sadness and low intensity pleasure. Finally, the complexity of sentences produced by the child (another measure of morphosyntactic complexity) was positively predicted by approach and negatively predicted by low intensity pleasure.

Summary. As demonstrated above, preterm-born children are characterised by unique social, emotional, and behavioural characteristics which could have implications for language development. In comparison to the research on the association between the cognitive and language abilities of preterm-born children, the corresponding literature on the association between social-emotional and language development is limited. Given the centrality of social interactions to language development (Kuhl, 2007; further details can be found in Section 1.4), future research should consider how these social/emotional/behavioural characteristics may affect language development through shaping the child's interpersonal interactions. Similar to the preceding discussion of the motor-language association, this proposed mechanism of effect (via social interactions) also accords with the developmental cognitive linguistic perspective (Ibbotson, 2020). Furthermore, through signalling the reciprocal influences which transpire between the child and their interaction partners, these findings highlight the agentic role of the child and thereby align with transactional perspectives of development (Fiese & Sameroff, 1989; Sameroff & Mackenzie, 2003).

Parental Factors

As has been outlined in the preceding sections, non-linguistic abilities may affect language development through shaping a child's experiences with objects and social partners in their proximal environment. When considering the development of young children, parents constitute a particularly influential category of social partners. During the first years of life, parents provide for the physical and emotional needs of the child, and play a key role in enculturating the child into the wider socio-cultural environment (Bornstein, 2006; Bornstein

& Tamis-LeMonda, 2010). In line with the significant caregiving contribution made by parents, early parenting has been found to affect children's health, educational, and behavioural outcomes, as well as more distal outcomes in adulthood including wellbeing and employment (Smith, 2010).

While parents (or other adult caregivers) have been proposed to be biologically pre-programmed to guide the learning and development of infants (Papoušek & Papoušek, 2002), considerable variation in parenting behaviours nonetheless exist across individuals and within individuals across time and space (Bornstein, 2006; Papoušek & Papoušek, 2002). Among the factors that can affect parenting are the real/perceived characteristics of the child (e.g., temperament), characteristics of the parents (e.g., mental wellbeing), and socio-contextual factors (e.g., socioeconomic status; Belsky, 1984; Bornstein, 2006; Taraban & Shaw, 2018).

In light of the preceding discussion of preterm-term differences in child characteristics, it can be hypothesised that preterm birth may affect language development through influencing parenting experiences and behaviours. Such an effect would reflect transactional mechanisms (Fiese & Sameroff, 1989; Sameroff & Mackenzie, 2003) whereby children can be understood to affect their own development through shaping their proximal environments in developmentally significant ways. This possibility is considered in the following sections through reviewing studies which have investigated preterm-term differences in parenting experiences/behaviours and the association between these parental variables and language development.

Parenting in the Context of Preterm Birth

From the first days of life, preterm birth presents parents with a unique caregiving experience. Newborn preterm-born infants are often hospitalised within a neonatal intensive care unit and thus physically separated from their parents for extended periods of time (Manktelow et al., 2010). Even following discharge, preterm-born infants are at elevated risk for medical and neurodevelopmental difficulties which can have implications for daily life (e.g., need for special educational supports; Kerstjens et al., 2012; Twilhaar et al., 2018; World Health Organisation, 2012). Taking into account such circumstances, preterm birth has been associated with poorer mental wellbeing (anxiety and distress) among both mothers and fathers (Carson et al., 2015). In line with the determinants of parenting outlined above, the psychological wellbeing of mothers (depressive symptoms) has been found to be associated with the quality of mother-infant interactions (maternal positive affect and communication) following preterm birth (Korja et al., 2008). These findings highlight the importance of investigating preterm-term differences in parenting and their potential developmental implications.

The literature comparing the parenting behaviours and parent-child relationships of preterm- and term-born groups have yielded inconsistent results. In a systematic review of 18 studies investigating the parenting behaviours experienced by 0- to 24-month-old preterm- (< 37 weeks' gestational age or birth weight < 2,500g) and term-born infants, Korja et al. (2012) found preterm-born groups to be characterised by lower levels of sensitivity and higher levels of directive, active, and controlling parenting behaviour when compared to term-born groups. In a similar vein, Toscano et al. (2020) conducted a meta-analysis to synthesise the findings of 34 studies which compared the controlling parenting behaviours and attitudes experienced by preterm- (mean gestational age of the preterm-born samples = 30 weeks) and term-born children between 2 months and 9 years of age. This meta-analysis found that the preterm-born group was characterised by significantly higher levels of controlling parenting when compared to the term-born group (small effect size: Hedges' g = 0.29). In contrast to these two studies, a meta-analysis of 34 studies by Bilgin and Wolke (2015) found no significant difference between the supportive parenting behaviours (sensitivity, responsivity, and facilitation) experienced by preterm- and term-born children aged between 2 weeks and 8 years of age (mean gestational age of the preterm-born samples = 30 weeks).

In line with these three reviews, similarly conflicting results have been returned by individual studies which have investigated a broader range of parenting measures. For example, while a collection of studies have observed significantly higher levels of intrusive parenting behaviours among preterm- as compared to term-born groups (e.g., intruding on the child's activities, providing children with fewer choices during interactions, showing lower levels of support for the child's autonomy; Barratt et al., 1996; Jaekel et al., 2012; Landry et al., 1990; Loi et al., 2017; Potharst et al., 2012; Salvatori et al., 2015), other studies have found no such preterm-term differences (Hall et al., 2015; Muller-Nix et al., 2004; Smith et al., 1996). Similarly, while a number of studies have found parents in preterm-born groups to be more active/stimulating during parent-infant interactions when compared to parents in term-born groups (Barnard et al., 1984; Crnic et al., 1983; Field, 1980), other studies have found no preterm-term differences in such parental characteristics (Smith et al., 1996). The literature has been particularly fragmented with relation to parental affection. When preterm-term differences have been found, parents in preterm-born groups have been found to display more negative affectivity (Salvatori et al., 2015), less positive affectivity (Barnard et al., 1996; Barnard et al., 1984; Feldman & Eidelman, 2007; Sansavini et al., 2015), and more neutral affectivity (Sansavini et al., 2015) toward their children when compared to parents in term-born groups. In contrast, Korja et al. (2007) found no significant preterm-term differences in positive or negative maternal affectivity.

The conflicting findings above reflect the current incomplete understanding of the association between preterm birth and parenting behaviours/parent-child relationships. While the majority of this research has been conducted with mothers, the small body of literature comparing preterm- and term-born groups on paternal parenting behaviours has yielded similarly mixed results (Ahnert et al., 2017; Hall et al., 2015; McMahon et al., 2019). The possible origins of such inconsistencies will be considered in Section 1.4 through exploring how parents and children co-construct social interactions. Before doing so, the following section outlines the associations between parenting behaviours and the language development of preterm-born children.

Parenting and Language Development following Preterm Birth

A small number of studies have considered the associations between parental behaviours and the language outcomes of preterm-born children. In particular, the developmental influence of maternal attention-maintaining behaviours (i.e., related to the child's ongoing focus/goal) and directive behaviours (i.e., which constrain the child's attention/behaviour) have been investigated.

Smith et al. (1996) demonstrated that maternal attention-maintaining behaviours observed during two interaction scenarios (10-minute mother-child play; 60-minute period of daily activity) were concurrently positively associated with the receptive language and expressive language scores of a pooled sample of preterm- and term-born 6-month-old infants (corrected age for the preterm-born group). Using data from a longitudinal follow-up of the same participant sample, Hebert et al. (2004) found concurrent positive associations between maternal attention-maintaining behaviours (observed during the 10-minute mother-child play session) and the overall language abilities of 6-, 12-, and 24-month-old preterm- and term-born children (corrected age for the preterm-born group). Again, using the same longitudinal sample of preterm- and term-born children, Landry et al. (2002) found maternal attention-maintaining behaviours during infancy (observed during the 60-minute period of daily activity) to be positively associated with the level and growth of overall language ability (between 6 months and 8 years of age). In a more recent investigation, Younesian et al. (2021) documented concurring results through finding that maternal attention-maintaining behaviours (termed "supportive-directiveness") had a positive concurrent association with the overall language abilities of 2- to 3-year-old preterm-born children (corrected age).

The abovementioned studies by Hebert et al. (2004), Landry et al. (2002), and Younesian et al. (2021) additionally investigated the association between maternal directive behaviour and the language abilities of preterm-born children. In particular, Hebert et al. (2004) found a negative concurrent association between maternal directiveness (observed during the 10-minute mother-child play session) and overall language ability among the pooled sample of preterm- and term-born children at 24 months of age. Landry et al. (2002) similarly observed a significant negative association between maternal directiveness (during the 60-minute period of daily activity) and the level and growth of overall language ability among the pooled preterm- and term-born sample (between 6 months and 8 years of age). Finally, Younesian et al. (2021) found that maternal directiveness (termed "intrusive-directiveness") had a negative concurrent association with the overall language abilities of the 2- to 3-year-old preterm-born children (corrected age).

Interestingly, in the studies by Smith et al. (1996) and Younesian et al. (2021), birth status was found to moderate the association between parenting behaviours and language development. In particular, Smith et al. (1996) observed that the association between maternal attention-maintaining behaviours (during the 60-minute period of daily activity) and expressive language scores was significantly stronger among the preterm- as compared to the term-born group. In this same study, the association between maternal attention-maintaining behaviours (during the 10-minute mother-child play session) and receptive language scores was significantly stronger for the preterm- when compared to the term-born group. Furthermore, Younesian et al. (2021) found maternal attention-maintaining (supportive-directiveness) and directive (intrusive-directiveness) behaviours to be significantly associated with the overall language abilities of preterm-born, but not term-born, children. These differences in the developmental influence of parenting behaviours may critically indicate the presence of preterm-term divergences in environmental sensitivity. More specifically, these findings suggest how the biopsychosocial vulnerability of preterm-born children may make them particularly susceptible to positive and/or negative developmental influences (Belsky et al., 2007; Pluess, 2015).

Summary

The preceding paragraphs demonstrate how the aforementioned clinical and neurodevelopmental factors associated with preterm birth can have cascading effects which extend beyond the child to affect key individuals within their proximal social environments. Through drawing on insights from the developmental cognitive linguistic (Ibbotson, 2020) and transactional (Fiese & Sameroff, 1989; Sameroff & Mackenzie, 2003) perspectives, preterm birth was understood to be associated with a unique caregiving context which could have ramifications for the parenting experiences and behaviours of caregivers, and thus the development of the child.

While the literature comparing the parenting behaviours experienced by preterm- and term-born children has yielded conflicting findings, the research has nonetheless demonstrated how parenting behaviours can have implications for the language development of both preterm- and term-born children. These findings suggest how factors beyond the child (e.g., parental characteristics) can be considered as key indicators or targets when screening for developmentally at-risk preterm-born cohorts and when developing interventions aimed at preventing/mitigating language difficulties. The translation of these research insights into clinical applications will require much more cumulative research, particularly with respect to the parenting experiences and behaviours of fathers which have received little attention in the literature to date.

Conclusion

The pathways linking preterm birth to language development are likely to be complex given the variable findings of studies which have compared the language abilities of preterm- and term-born groups. The literature review above identified a number of candidate child (e.g., non-linguistic development and behaviour) and parental (e.g., parent behaviour) factors which may mediate the association between preterm birth and language development. These factors critically demonstrate how the language difficulties of preterm-born children may be partly rooted in the effect of preterm birth on the child's broader non-linguistic development and surrounding developmental environment.

These insights suggest how an ecologically valid understanding of preterm language development is likely to depend upon embedding a holistic view of the preterm-born child within their broader developmental environment. In addition, a comprehensive mechanistic understanding will require an acknowledgement of the developmental cascades which can flow through the resulting web of child and parent factors. The advancement of such a systems view of preterm language development is critical given that preterm-term divergences in developmental mechanisms have been suggested by findings that the language abilities of preterm- and term-born children are differentially affected by child/parent factors. Unfortunately, the development of a systems view of preterm language development has been hindered by the lack of studies which have simultaneously investigated the influence of multiple child/parent factors and the moderation of their influence by preterm/term birth status.

In recognition of this gap in knowledge, the final section of this literature review considers the confluence of child and parent factors through exploring the literature on parent-child conversations following preterm birth.

1.4 Parent-Child Conversation

The preceding section of this literature review examined how preterm birth may affect language development through shaping the interactions that the child has with their surrounding environment. Through considering the developmental influence of parental factors (e.g., parenting behaviours), parent-child interactions were identified as an important feature of the interface between the child and his/her environment. Specifically, parental factors were found to be affected by preterm birth and to also reciprocally affect the development of the preterm-born child. These findings highlight the value of taking a dyadic approach (considering both parent and child influences) to understanding both parenting and development in the context of preterm birth.

This dyadic approach departs from early traditions in parenting research in a number of important ways. Until the late 20th century, much of the parenting literature assumed that associations between parent and child behaviours reflected the influence of the parent (the socialisation agent) on the child (Bell, 1971; Hodapp & Dykens, 2006; Maccoby, 1992). Through predominantly focusing on the unidirectional influence of the parent on the child, this perspective yielded a rather passive conceptualisation of the role of the child in development (Hodapp & Dykens, 2006). From the late 20th century onwards, there has been a shift to consider the parent-child dyad as the unit of analysis in developmental research (e.g., Sears, 1951). Rather than considering the behaviours of each interactant in isolation, the dyadic perspective prioritises an exploration of how parents and children reciprocally and mutually co-regulate their behaviours.

For instance, Bell (1971) outlined how child behaviours can serve as the stimuli for parental responses, just as parental behaviours serve as the stimuli for children's responses. In line with such reciprocal chains of effect, Sameroff and colleagues (Fiese & Sameroff, 1989; Sameroff & Mackenzie, 2003) proposed a transactional view of development in which the child both affects, and is affected by, their environment. Specifically, the child can contribute to shaping their own development through engendering developmentally significant changes in their environments (e.g., eliciting developmentally conducive/maladaptive parental behaviours). A unifying theme across these dyadic approaches is that the behaviours of either interactant cannot be understood in isolation (Kuczynski et al., 2009) and a critical implication is the importance of acknowledging the active role played by the child in shaping their developmental trajectory and outcomes. This acknowledgement of the developmental contributions made by the child is particularly important in the context of preterm research given the unique developmental profile characterising this group.

The dyadic features of parent-child interactions can be investigated through the macroanalytic or microanalytic coding of parent-child interactions. Macroanalytic coding (otherwise known as molar coding) involves rating the global behavioural qualities of the parent, infant, or dyad over a subsection (e.g., 1-minute segment) or the entirety of the observed interaction (e.g., using Likert scales; Bornstein & Tamis-LeMonda, 2010). In contrast, microanalytic coding (otherwise known as molecular coding) involves annotating in detail the occurrence, duration, and temporal patterning of the behaviours of each interacting individual (Bornstein & Manian, 2013; Bornstein & Tamis-LeMonda, 2010). While macroanalytic and microanalytic coding approaches have complementary strengths, microanalytic coding in particular can provide nuanced and contextually-embedded characterisations of dyadic parent-child processes.

For example, while macroanalytic coding can capture the emergent properties of dyadic interactions (e.g., synchrony – dyadic exchanges characterised by features including co-regulation, mutual engagement, and shared attention), microanalytic coding can afford insights into the constituent parent/child behaviours which give rise to that property (in the case of synchrony, this could include an investigation of the manner in which the parent and child initiate dyadic interactions and respond to their interacting partner; see Leclère et al., 2014 for an in-depth discussion of "synchrony"). Furthermore, through characterising the moment-by-moment unfolding of parent and child behaviour, microanalytic coding can provide a contextually-embedded and mechanistic understanding of the origins of between-group differences in such interactional characteristics. The abovementioned strengths of microanalytic coding are particularly salient in research which characterises parent-child conversations with respect to their constituent verbal behaviours. As parent-child conversations play a central role in early language development, microanalytic coding can play a key role in elucidating the mechanisms underlying the language development of preterm-born children.

Language Learning as a Social Process

The parent-child conversations (comprising parent/child communicative behaviours) which can be captured through microanalytic coding play a pivotal role in language development. Specifically, social-interactionist perspectives (Bruner, 1983) propose that language development occurs within social interactions between infants and linguistically competent conversational partners (henceforth "parents"). These conversational interactions are co-constructed by the parent and child, as each individual adapts to the other in order to establish an effective communicative exchange (Bruner, 1983; Casillas, 2023). This process of co-construction yields a "language environment" which can support the acquisition of language among young learners. In particular, this language environment can support learning through providing a rich and accessible model of the target language and through supporting the child's ability to extract information from this model.

With respect to the language model, parents in both Western and non-Western cultures have been found to adopt a unique speech register when speaking with children as compared to other adults (Ferguson, 1964; Fernald & Morikawa, 1993). In brief, the speech directed to infants differs from that directed to adults in its phonological characteristics (higher and more variable pitch, slower rate of speaking, magnified intonation, extended pauses), its lexical characteristics (the use of a constrained vocabulary that focuses primarily on concrete objects/concepts), and in its syntactic features (shorter utterance length, simplified but complete syntactic constructions; Saxton, 2009).

Importantly, parents are found to flexibly modify, or "finetune", these features of child-directed speech in accordance with the linguistic knowledge, cognitive capacities, and communicative competencies of the conversing child (Bornstein et al., 1992; Pan et al., 1996; Snow, 1995; Yurovsky, 2018). For example, mothers have been found to adapt their speech through using syntactically and lexically simplified input (e.g., shorter utterance length), and more redundant speech (e.g., more repetitions of phrases) when addressing 2-year-old infants as compared to 10-year-old children (Snow, 1972).

Thus, one of the ways in which child-directed speech has been hypothesised to facilitate language development is through providing a developmentally attuned language model. Specifically, the simplified and redundant nature of child-directed speech can support language acquisition through accommodating the child's cognitive competencies and linguistic knowledge. For example, the minor structural modifications that often exist between phrase repetitions can shed light on the syntactic characteristics of the language being acquired (Hoff-Ginsberg, 1986). Phrase repetitions can additionally reduce the infant's need to rapidly store and analyse the adult's speech. Through minimising the information-processing demands associated with speech processing in this way (e.g., short-term memory), child-directed speech can be seen to increase the child's opportunities to process and learn from linguistic input (Fernald & Morikawa, 1993; Snow, 1972).

In addition to the structural features of parental speech, the broader interactional context provided by parent-child conversations can support language development. Firstly, the presence of a social partner (i.e., parent) can arouse a heightened state of attention in the child which may enhance the intake and processing of speech input (Kuhl, 2007). Secondly, the parent-child interactions (within which these conversations occur) can support the development of socio-cognitive competencies (e.g., understanding of intentionality and secondary intersubjectivity) which can aid language learning (Tamis-LeMonda et al., 2014). Thirdly, on a daily basis, children hear unfamiliar words which could refer to a large number of referents in their environments (word-referent ambiguity; Smith & Yu, 2008). During parent-child conversations, parents can significantly narrow the possible range of word-referent mappings through producing linguistic utterances which are temporally and conceptually related to the child's behaviours and focus of attention (Tamis-LeMonda et al., 2014).

Characterising the Language Environment

The language environment created by parent-child conversations can be investigated through recording and transcribing parent-child interactions. Recordings of brief parent-child interactions (e.g., 5 minutes) can be obtained in the child's home or a laboratory (e.g., parent-child free-play, shared book-reading). Alternatively, naturalistic daylong home audio-recordings can be obtained using audio-recorders worn by the child. The parent and child vocalisations captured by these recordings can then be transcribed manually or using automated procedures (e.g., using the Language ENvironment Analysis [LENA] system; Gilkerson & Richards, 2020). These transcripts can be further annotated (through manual or automated means) to include information such as the temporal onset and offset of each utterance. Using software programs and further manual coding, these transcripts can then be used to characterise parent-child conversations across a variety of features. Although there is no unified organisational taxonomy for these language environment features, for the purpose of this thesis, the features are arranged into two categories – those relating to parental speech and those describing the dyad.

Parental Speech Features

The speech produced by parents during parent-child conversations can be characterised across a range of paralinguistic (e.g., speech rate) and linguistic features. With regards to the linguistic features (which are the focus of this thesis), a variety of quantitative (e.g., number of words or utterances) and qualitative (e.g., vocabulary diversity, morphosyntactic complexity) features can be examined (Bang et al., 2020; Rowe & Snow, 2020). Bidirectional associations have been found to link such parental speech features with child development. Specifically, while both categories of linguistic features have been prospectively associated with the language development of typically developing infants (Hoff & Naigles, 2002; Rowe, 2012), parental speech patterns have also been observed to change in line with the child's development (Rowe et al., 2012).

Dyadic Features

In contrast to the parental speech features discussed above, the dyadic features jointly appraise the conversational contributions made by the parent and child. In particular, the moment-by-moment unfolding of parent-child conversations can be understood through examining the temporal onset and offset of each parent/child utterance. Through capturing the temporal sequencing of parent/child conversational contributions in this way, a range of developmentally significant conversational dynamics can be examined.

In the first instance, this temporal information can be used to quantify the proportion of parent/child utterances to which the child/parent responds within a critical time window (e.g., 2 seconds; Van Egeren et al., 2001). This proportional measure of temporally contingent responding can be seen to reflect the responsiveness of the parent/child during the conversational exchange. While parental responsiveness itself is an important construct given its ability to support language development (e.g., through reducing word-referent mapping ambiguity), a joint consideration of parent and child responsiveness can elucidate additional, developmentally significant, dyadic conversational dynamics. For instance, through comparing the responsiveness of the parent and child, and through examining how these measures covary, insights into conversational synchrony can be achieved through capturing the degree of interpersonal mutuality that is exhibited. At a higher level still, through combining the metrics of parent and child responsiveness, the total number of temporally contingent speaker-transitions can be computed (i.e., summing the number of temporally contingent parent-to-child and child-to-parent speaker transitions) to more broadly capture the occurrence of conversational back-and-forth exchanges.

Critically, this composite number of speaker-transitions (commonly referred to as "turn-taking" in the literature) has been found to be associated with a range of neurodevelopmental outcomes. For instance, a meta-analysis has found turn-taking to be significantly positively associated with the expressive and receptive language skills of children between 2 months and 4 years of age (Wang et al., 2020). Furthermore, adult-infant turn-taking (at 14 months of age) has been found to significantly mediate the positive association between a parental language coaching intervention (when infants were aged 6-18 months) and infant expressive vocabulary (at 18 months of age; Huber et al., 2023). A potential neural basis to these associations has also been indicated by studies involving 4- to 7-year-old children which have found that the associations between adult-infant turn-taking and child language skills are significantly mediated by functional and structural variations in language-related brain areas (Romeo et al., 2021; Romeo et al., 2018). Similar to the observation that child characteristics can reciprocally affect parental speech patterns, bidirectional longitudinal associations have been found between growth in the amount of adult-infant turn-taking and growth in parent-reported vocabulary between 9 and 24 months of age (Donnelly & Kidd, 2021).

A key observation in this research is that the association between turn-taking and language development remains statistically significant after controlling for variations in each interactant's vocal behaviours (e.g., adult and child volubility; Donnelly & Kidd, 2021; Huber et al., 2023; Romeo et al., 2018). Through highlighting the developmental importance of dyadically co-constructed conversational exchanges, such findings align with social-interactionist views of language development (Bruner, 1983). Indeed, explanations for the association between turn-taking and language development have adopted such a dyadic perspective. Temporally contingent conversational exchanges have been proposed to support language development through heightening the child's attention to speech stimuli (Masek, McMillan, et al., 2021) and exposing the child to direct (e.g., parents reformulating the child's utterances) and indirect (e.g., parents signalling a communicative breakdown through requesting clarifications) contingent feedback on their own speech productions (Nikolaus & Fourtassi, 2023). Furthermore, contingent conversational exchanges are thought to allow parents to become more familiar with the child's linguistic and communicative profile so that parental speech may be tailored to the child's developmental capabilities (Snow, 1995; Wang et al., 2020; Yurovsky, 2018; Zimmerman et al., 2009). Beyond shaping parental speech patterns, the child's language abilities are also proposed to transactionally affect the conversational exchange through influencing the child's real-time comprehension and production of speech (Casillas et al., 2016; Donnelly & Kidd, 2021; Gilkerson et al., 2018; Masek, McMillan, et al., 2021; Masek, Ramirez, et al., 2021).

Recent innovations in conversational turn-taking studies have advanced increasingly nuanced understandings of the pathways of effect between turn-taking and language development. For instance, research has begun to investigate the association between turn-taking and non-language skills which have previously been associated with language development (e.g., executive functions and social-emotional skills. See Section 1.3 for a discussion of the association between language and non-language development; Gómez & Strasser, 2021; Romeo et al., 2021). Innovations have also been pursued in the operationalisation of turn-taking itself. For instance, in place of counting the number of temporally-contingent speaker transitions, investigators have considered the developmental significance of engaging in extended turn-taking sequences (e.g., parent-child-parent-child exchange; see Beiting et al., 2022 for an example). This expanded conceptualisation of turn-taking additionally creates the possibility of investigating novel constructs such as the proportion of extended turn-taking exchanges which are initiated/terminated by the parent or child (e.g., Salo et al., 2022).

Language Environment of Preterm-Born Children

Parent-child conversations play a central role in language development through shaping the child's language environment. These conversational exchanges are co-constructed by the parent and child such that the language environment can be considered to reflect the confluence of child and parental influences, as well as their synergistic interplay. Since preterm-term differences in a range of child and parent factors have been reported (see Section 1.3 for details), corresponding between-group differences in parent-child conversations may also be expected.

The following sections review studies which have compared the language environments of preterm- and term-born groups. This review focuses on investigations which have used microanalytic coding methods to characterise the linguistic features of parental speech and the dyadic features of conversational exchanges. Unless stated otherwise, all of the studies reviewed below have used age corrected for prematurity for the preterm-born participants.

Parental Speech Features

Quantity. There is inconsistent evidence with regards to whether preterm-term differences exist in the amount of speech produced by parents. For instance, mothers of 3-month-old preterm-born children (with a mean gestational age of 31 weeks) have been found to exhibit lower levels of verbosity (rate per minute of utterances, types, and tokens) when compared to mothers of term-born children (Spinelli et al., 2022). In contrast, no significant differences have been found between preterm- and term-born parent-child dyads in the amount of parental speech addressed to 6-month-old (maternal utterances per minute, maternal number of words; mean preterm gestational age = 30 weeks; Salerni et al., 2007), 16-month-old (adult words per hour; mean preterm gestational age = 30 weeks; Adams et al., 2018), or 24-month-old (maternal utterances per minute; mean preterm gestational age = 30 weeks; Salerni & Suttora, 2022) infants.

Quality. With regards to the lexical diversity of parental speech (i.e., range of vocabulary used), no significant differences have been observed between the maternal speech directed to preterm- or term-born children at either 3 months (type-token ratio, a measure of lexical diversity; mean preterm gestational age = 31 weeks; Spinelli et al., 2022) or 6 months of age (type-token ratio; mean preterm gestational age = 30 weeks; Salerni et al., 2007). Meanwhile, inconsistent findings have been recorded with regards to preterm-term differences in the morphosyntactic complexity of parental speech. At the time of hospital discharge (mean gestational age of 40 weeks) and at approximately seven weeks post-discharge, mothers of preterm-born infants were found to use significantly more complex (mean length of utterance) interrogatives (but not imperatives or declaratives) than mothers of term-born infants (mean preterm gestational age = 30 weeks; Reissland et al., 1999). At 3 months of age, preterm-born groups have similarly been characterised by significantly more complex maternal utterances (mean length of utterance) when compared to term-born groups (mean preterm gestational age = 31 weeks; Spinelli et al., 2022). In contrast, no significant differences in speech complexity (mean length of utterance) have been found between mothers of 6-month-old preterm- and term-born infants (mean preterm gestational age = 30 weeks; Salerni et al., 2007).

Parental Adaptation. An earlier section of this literature review outlined how parental speech is often adapted to the developmental level of the child (Bornstein et al., 1992; Pan et al., 1996; Snow, 1995; Yurovsky, 2018). Indications of such fine-tuning have also been observed among preterm-born groups. For instance, an age-related increase in the quantity (utterances per minute) and quality (lexical diversity, syntactic complexity) of maternal speech was observed in a longitudinal study which tracked preterm-born infants from 6 months to 24 months of age (mean preterm gestational age = 30 weeks; Suttora & Salerni, 2011). In this same study, maternal speech characteristics were found to covary with the developmental characteristics of the preterm-born child. In particular, while the quantity of maternal speech was not predicted by the preterm-born child's cognitive, communicative, or motor development, the syntactic complexity and lexical diversity of maternal speech at 18 months were respectively predicted by the preterm-born infants' communicative abilities and motor development at 12 months of age (cognitive development did not predict either measure; Suttora & Salerni, 2011).

Dyadic Features

A small number of studies have compared the dyadic conversational dynamics of preterm- and term-born groups. These studies have examined the temporal patterning of parent/child vocalisations during mother-infant interactions to measure the responsiveness of parents and infants, as well as their respective likelihood of initiating vocal exchanges. The dyadic behaviours of parents and infants are discussed separately, before considering their characteristics in tandem.

Parent. With regards to the responsiveness of parents, Reissland and Stephenson (1999) investigated maternal responsiveness (the frequency with which mothers vocally responded to infant vocalisations) at the time of hospital discharge (mean gestational age of 40 weeks) and at 7 weeks post-discharge. While no significant preterm-term difference in maternal responsiveness was found at the time of discharge, mothers in the preterm-born group (mean gestational age = 30 weeks) exhibited significantly higher levels of responsiveness than mothers in the term-born group at 7 weeks post-discharge. In a similar vein, Salerni et al. (2007) found that mothers of 6-month-old preterm-born infants (mean gestational age = 30 weeks) exhibited significantly higher levels of responsiveness when compared to mothers of 6-month-old term-born infants (responsiveness measured as the mother's likelihood of vocally responding to an infant's vocalisation). In this same study, mothers of preterm-born infants were significantly more likely than mothers of term-born infants to vocally initiate an interaction following a silent period in the parent-infant conversation (a silence lasting more than 2 seconds; Salerni et al., 2007).

Infant. Both Reissland and Stephenson (1999) and Salerni et al. (2007) additionally compared the responsiveness of preterm-born and term-born infants. Similar to the patterns outlined above, at the time of hospital discharge, Reissland and Stephenson (1999) found no significant preterm-term differences in infant responsiveness. However, at 7 weeks post-discharge, preterm-born infants were found to exhibit significantly lower levels of responsiveness than their term-born peers (Reissland & Stephenson, 1999). Furthermore, Salerni et al. (2007) observed that 6-month-old preterm-born infants were significantly less responsive than term-born infants. These preterm-born infants were also significantly less likely than term-born infants to vocally initiate a conversational interaction following a silent period in the mother-infant conversation (Salerni et al., 2007).

Parent-Infant Dyad. Taken together, these studies indicate the presence of preterm-term differences in mother-infant conversational dynamics during early infancy. Specifically, in comparison to the mothers in term-born dyads, mothers in preterm-born dyads appear to be particularly stimulating or “active” conversation partners through exhibiting heightened levels of responsiveness and a greater likelihood of initiating conversational interactions. Meanwhile, in comparison to term-born infants, infants in preterm-born dyads appear to constitute relatively inactive or “passive” conversation partners as a result of exhibiting reduced levels of responsiveness and a lower likelihood of initiating conversations. This combination of an active mother and passive infant suggests that the mother-child conversations of preterm-born dyads may be characterised by greater levels of asymmetry and thus reduced synchrony when compared to those of term-born dyads.

Given the small number of studies which have compared preterm- and term-born groups on the dyadic features of parent-child conversations, these conclusions are preliminary and further research is needed. In particular, since the existing research has focused on the period of early infancy (infants ≤ 6 months of age), future research must investigate whether these dynamics may also be observed later in development. Furthermore, additional studies are needed to examine whether these preterm-term differences in mother-infant conversations will generalise to father-infant conversations.

Conclusion

The conversational exchanges which occur during parent-child interactions play a pivotal role in language development through shaping the child’s language environment. Through using detailed microanalytic coding methods, these conversational exchanges can be characterised on a number of developmentally significant features including the parent’s speech patterns as well as the dyad’s interpersonal dynamics. In spite of the language difficulties of preterm-born children, very few studies have compared the parent-child conversations which characterise preterm- and term-born groups. The literature that does exist has yielded inconsistent findings regarding the presence of preterm-term differences in parental speech patterns. Meanwhile, a small number of studies has provided tentative evidence to suggest that preterm-born dyads may exhibit lower levels of conversational synchrony when compared to term-born dyads.

This literature review additionally identified a number of gaps in knowledge regarding the language environments experienced by preterm-born children. Firstly, the majority of preterm studies have investigated the language environments of infants under 2 years of age. Given that the language difficulties of preterm-born children have been found to persist beyond this period of early infancy (e.g., Barre et al., 2011), further research is needed to characterise the parent-child conversations experienced by preterm-born children during later infancy and toddlerhood. This need to investigate the later infancy/toddlerhood period is particularly acute when considering the dyadic features of parent-child conversations (e.g., parent/child responsiveness). To date, preterm-term comparisons of such dyadic features have exclusively involved mother-infant dyads with preverbal infants (infants ≤ 6 months). The onset of verbal skills during the second year of life qualitatively alters the conversational experience of both the child (verbal skills bring with them the need to integrate interactional skills with linguistic abilities) and the parent (responding to linguistic as opposed to prelinguistic vocalisations; Casillas et al., 2016; Gilkerson et al., 2018). Thus, further research is needed to examine whether the preterm-term differences in conversational dynamics which are seen during the preverbal period may also be observed following the onset of verbal skills.

Secondly, studies comparing the language environments of preterm- and term-born children have thus far either exclusively focused on mother-infant interactions or have grouped mothers and fathers together for a broader investigation of parent-infant conversations. Since studies of typically developing cohorts have observed mothers and fathers to exhibit differing speech patterns as well as different effects on language development (Nandy et al., 2021; Shapiro et al., 2021; Tamis-LeMonda et al., 2004; however, see Grinberg et al. 2022 for a critical investigation of the association between parental gender and child-directed speech), a discrete investigation of father-infant conversations following preterm birth is required.

Thirdly, there has been limited investigation of whether the language environment features discussed above may similarly affect the development of preterm- and term-born children. While the amount of exposure to adult speech (at 16 months of age) was found to be similarly associated with the language abilities of preterm- and term-born infants (at 18 months of age; Adams et al., 2018), preterm-term comparisons of the developmental influence of the qualitative linguistic features of parental speech or the dyadic features of conversations could not be identified. Such investigations should be a priority given that preterm-term differences have been observed in the developmental influence of broader parenting behaviours (see Section 1.3 for details).

Chapter 2: Overview of Thesis

Thesis Aims and Structure

The literature review in Chapter 1 identified preterm birth as a risk factor for both language and non-language development. The proximal (e.g., school performance) and distal (e.g., employment) ramifications of such developmental difficulties make preterm birth a public health concern. With specific reference to the language development of preterm-born children, the manifestation of language difficulties was found to vary considerably across studies. This variability suggests that the association between preterm birth and language development is likely to be complex and multifaceted. Research which elucidates the factors contributing to the association between preterm birth and language development could substantially advance the identification of developmentally at-risk preterm-born cohorts and the prevention and mitigation of language difficulties. In this way, a deeper understanding of the developmental mechanisms underlying the language abilities of preterm-born children could improve the language abilities and broader life outcomes of preterm-born cohorts.

The aforementioned literature review identified a wide range of child and parent factors which could contribute to the association between preterm birth and language development. According to a developmental systems view (Barra & Coo, 2023; Ibbotson, 2020; Karmiloff-Smith, 2009; Spencer et al., 2011), the most ecologically valid understanding of the developmental significance of such factors can be achieved through acknowledging their inter-relations and synergistic influences. Put otherwise, the most comprehensive understanding of preterm language development will be afforded by embedding a holistic view of the child (e.g., considering the interplay between language and non-language development) within their broader developmental ecology (e.g., considering the influence of parent-child interactions). This dynamic perspective crucially accords with developmental cognitive linguistic (Ibbotson, 2020) and transactional (Fiese & Sameroff, 1989; Sameroff & Mackenzie, 2003) views which recognise the associations between linguistic and non-linguistic development as well as the bidirectional influences which flow between the parent and child across development.

Few instances of such systems-based approaches to researching the language development of preterm-born children could be identified in the published literature. In particular, studies commonly opted to investigate the influence of only a small number of risk/protective factors and often did not examine their interplay. Furthermore, by predominantly focusing on the developmental influences of mothers, the literature to date has afforded only a partial account of the developmental ecology of preterm-born children through failing to account for the parenting experiences of fathers. Given that neonatal healthcare providers are increasingly being encouraged to support the involvement of both mothers and fathers in the care of medically vulnerable infants (e.g., EFCNI, 2022b), further research is needed to understand the distinctive needs and developmental contributions of fathers of preterm-born infants.

To address these gaps in knowledge, the current thesis adopted a developmental and dynamic systems-based approach to studying the language abilities of preterm-born children in order to advance an ecologically valid and practicable understanding of preterm language development. In particular, the ecological validity of the findings was ensured through studying the interplay of multiple child and parental influences, with the latter crucially reflecting both maternal and paternal factors. The generation of practicable insights was prioritised through focusing on the developmental influence of modifiable factors (e.g., parent-child interactions) rather than more intractable clinical or biomedical indicators (e.g., brain injury). Finally, to reconcile the predominant focus of existing research on extremely/very preterm-born children and the consequent lack of consideration of moderate-to-late preterm births, this thesis investigated the language development of children of all degrees of prematurity.

To achieve these aims, the empirical investigations comprising this thesis were pursued in three parts:

Part 1. Multiple Avenues Linking Preterm Birth to Language Development

Part 1 (Chapter 3, Study 3.1) used longitudinal data from a nationally-representative cohort study to examine how the association between preterm birth and expressive language abilities at 3 and 5 years of age may be mediated by characteristics of the child (cognitive/motor/social-personal development, temperament), the parent (wellbeing), and the parent-child dyad (parent-child relationship).

Part 2. Constructing a Language Environment in the Context of Preterm Birth

Part 2 investigated the role of parent-child conversations in language development through microscopically analysing parent-child free-play interactions which were recorded at the Infant and Child Research Lab in Trinity College Dublin (details on the data collection procedure are presented in Chapter 4). To address the lack of research comparing the language environments experienced by preterm- and term-born children, these interactions were transcribed to understand the parental speech patterns (e.g., speech quantity, vocabulary diversity, grammatical complexity) and dyadic conversational dynamics (e.g., parent/child responsiveness, turn-taking) characterising each group. Given the dearth of research on the language environments of preterm-born infants during later infancy/toddlerhood and the lack of research on the dynamics of conversations involving verbal preterm-born infants, three studies examined the language environments experienced by verbal preterm-born infants at 2 years of age:

The first study characterised the degree of conversational synchrony exhibited by mother-infant and father-infant dyads involving 2-year-old verbal preterm-born infants (Chapter 5, Study 5.1).

The second study compared the language environments characterising the parent-infant dyads of preterm- and term-born groups at 2 years of age. This study additionally considered how this preterm-term contrast may be moderated by the gender of the interacting parent (mother/father; Chapter 5, Study 5.2).

The third study investigated how the language environment features may be concurrently associated with the language, cognitive, social-emotional, and neuropsychological (executive function) development of preterm- and term-born infants at 2 years of age (Chapter 5, Study 5.3).

Part 3. Assessing the Language Skills of Preterm-Born Infants

Part 3 (Chapter 6, Study 6.1) used the same observational data as that in Part 2 to generate evidence-based guidance regarding the choice and implementation of language assessments with preterm-born children. This was achieved through examining the language abilities of preterm- and term-born infants using two assessment approaches – standardised testing and language sample analysis.

Chapter 3: Multiple Avenues Linking Preterm Birth to Language Development

Study Details

The literature review in Chapter 1 outlined how the association between preterm birth and language development is likely to be complex and multifaceted. Chapter 1 additionally identified a range of child and parent factors which may independently and synergistically mediate this link. A detailed understanding of this dynamic network of effects could help to prevent and mitigate language difficulties through advancing a holistic and ecologically-valid account of preterm language development. Nonetheless, few studies to date have attempted to capture the operation of such developmental systems in the context of preterm birth.

Study 3.1

To address this gap in knowledge, Study 3.1 used data from a nationally-representative longitudinal cohort study to examine the direct and indirect pathways linking preterm birth to language development at 3 and 5 years of age. The indirect paths examined the mediating roles of non-linguistic child development (cognitive ability, social-personal ability, motor ability, and temperament), parental experiences (maternal/paternal wellbeing), and the parent-child relationship (mother-child/father-child relationship). The synergistic effect of these variables was also explored through investigating longitudinal transactional effects (e.g., preterm birth → temperament → parent-child relationship → language development).

Publication Status

Study 3.1 has been published in Early Childhood Research Quarterly (https://doi.org/10.1016/j.ecresq.2023.08.004).

Studies

Study 3.1: Preterm Birth and Expressive Language Development across the First 5 Years of Life: A Nationally-Representative Longitudinal Path Analysis

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Author Note

The first author (Sarah Coughlan) was responsible for the conceptualisation, formal analysis, and writing of this paper. These responsibilities were carried out under the guidance of the second and third authors (thesis supervisors).

This paper analysed data from Growing Up in Ireland which is a national longitudinal study of children in the Republic of Ireland. The first author was not involved in the fieldwork underlying this longitudinal study. The data from this longitudinal study can be accessed by contacting the Irish Social Science Data Archive (https://www.ucd.ie/issda/data/guiinfant/).

This paper has been published in Early Childhood Research Quarterly (https://doi.org/10.1016/j.ecresq.2023.08.004).

Abstract

Multiple factors including the child's non-linguistic characteristics and caregiving environment can affect language development. Since preterm birth (<37 weeks' gestation) can negatively affect language development, this study used path analysis to investigate whether the influence of preterm birth on expressive language development at 3 and 5 years of age is mediated by a child's non-linguistic characteristics (temperament and cognitive, motor, and social-personal abilities), caregiving environment (maternal and paternal stress and depression, mother-child and father-child relationship quality), and interactions between these domains. These analyses were conducted using three waves of data (ages: 9 months, 3 years, 5 years) on 8,712 children (4,300 female; 535 preterm) from a nationally-representative longitudinal study in Ireland. Preterm birth was indirectly (but not directly) associated with expressive language at 3 years of age via cognitive and social-personal abilities (but not motor abilities, mother-child relationship quality, or father-child relationship quality) at 9 months. There was no direct or indirect effect of preterm birth on expressive language at 5 years of age. Preterm birth negatively affected mother-child and father-child relationship quality at 3 years via fussy-difficult temperament and mother's/father's stress (but not depression) at 9 months. These findings are discussed with reference to international standards for neonatal care, including the need for long-term developmental monitoring of children born preterm by multidisciplinary healthcare teams, alongside parental supports promoting mental health and confidence in caregiving tasks. Future study recommendations are made to expand the tested models in line with family systems perspectives.

Keywords: preterm birth, language development, mother, father, transactional, developmental cascade

Introduction

Children born preterm (< 37 weeks' gestation; World Health Organisation, 2012) often experience expressive and receptive language difficulties which span both grammatical and semantic domains (van Noort-van der Spek et al., 2012). These developmental atypicalities are seen in infancy and childhood, with conflicting reports on whether they resolve with age (van Noort-van der Spek et al., 2012). Given the significant influence of early language abilities on school readiness (Justice et al., 2009) and later academic performance (Bleses et al., 2016), it is important to identify the pathways through which preterm birth may shape language development. Among typically developing children, a variety of factors, both internal (e.g., temperament) and external (e.g., parenting) to the child (Ibbotson, 2020; McNally & Quigley, 2014), individually and synergistically (e.g., temperament affecting parenting; Fiese & Sameroff, 1989) affect language development. This suggests that a multifactorial model (reflecting the independent and interactive effects of multiple developmental influences) is needed for an ecologically valid understanding of how preterm birth may affect language development.

Research on development following preterm birth has generally investigated the effects of isolated risk/protective domains (e.g., parenting), with little consideration for how multiple domains may interact over time to shape language outcomes. To address this gap, the current study uses path analysis to examine how birth status (term-birth or preterm birth) may directly and indirectly (i.e., mediation) affect the language development of children at 3 and 5 years of age. The path models draw on developmental cognitive linguistic (Ibbotson, 2020) and transactional (Fiese & Sameroff, 1989) perspectives to explore how the effect of birth status on language development may operate via the child's non-linguistic development (cognitive, motor, social-personal), the parenting context (parental stress, parental depression, parent-child relationship), and the child's temperament (fussy-difficult). This exploratory study coincides with increasing efforts to develop international standards to address the variability (both across and within countries) in the quality of care provided to preterm-born children (e.g., European Standards of Care for Newborn Health; EFCNI, 2022a). The findings of the current study may shed light on the validity of these proposed care standards with reference to their anticipated ability to optimise the developmental outcomes of this vulnerable cohort.

Non-Linguistic Development

The developmental cognitive linguistic perspective of Ibbotson (2020) highlights how language development may be shaped by the development of other non-linguistic abilities. Cognitive (Rose et al., 2009), motor (Wang et al., 2014), and social-personal (Slot et al., 2020) abilities can affect later language development among typically developing children. These effects are proposed to operate through various pathways. Cognitive abilities may shape language development through meeting the sophisticated information processing demands (e.g., attention and memory) of language learning (Rose et al., 2009). Motor abilities may influence the child's exposure to language learning opportunities through shaping how the child explores and interacts with their social (e.g., gestural communication) and non-social (e.g., object exploration) environments (Iverson, 2010). Finally, given the importance of social interactions for language learning (Kuhl, 2007), social-personal abilities (e.g., joint attention) may predict language development through influencing how a child learns from social partners (Tamis-LeMonda et al., 2014). These prospective cross-domain associations vary across development, thus potentially reflecting dynamic changes in the skills required at various stages of language acquisition (Gonzalez et al., 2019).

Children born preterm have been characterised by poorer cognitive, motor, and social-personal abilities which have each been found to negatively affect the language development of this cohort (Peyton et al., 2018; Rose et al., 2009; Sajaniemi et al., 2001). Despite this, it has been identified (for example, by Charkaluk et al., 2019) that few longitudinal studies have simultaneously examined the influences of multiple non-linguistic domains on language development following preterm birth. Given the importance of acknowledging the inter-relatedness of developmental domains when understanding the development of biologically vulnerable children (Karmiloff-Smith, 2009), further research must probe how multiple non-linguistic abilities may contribute to the association between birth status and language development.

Parenting Context

Language learning is fundamentally intertwined with social interactions (Kuhl, 2007), with mother-child and father-child relationships found to make unique and additive contributions to child language development (e.g., Tamis-LeMonda et al., 2004; see also the Early Childhood Research Quarterly special issue on father-child relationships and child development [Helmerhorst et al., 2023]). Preterm birth creates a unique parenting context which could have implications for language development. Lower gestational ages are associated with longer stays in neonatal intensive care units (and thus physical separation between parent and child; Manktelow et al., 2010) and increased medical (World Health Organisation, 2012) and neurodevelopmental (Kerstjens et al., 2012) risks. In line with such circumstances, mothers and fathers of infants born preterm exhibit higher levels of psychological distress when compared to parents of infants born at term (Carson et al., 2015). Furthermore, lower levels of maternal wellbeing have been associated with less positive parenting behaviours following preterm birth (Korja et al., 2008).

Nonetheless, inconsistencies abound in the literature regarding the presence or absence of differences between preterm and term-born dyads in the nature of mother-child (see Bilgin & Wolke, 2015 for a review) and father-child (e.g., Ahnert et al., 2017; Hall et al., 2015; McMahon et al., 2019) relationships. Such mixed findings highlight how the existing understanding of the parenting context following preterm birth is incomplete. This lack of understanding is particularly acute in relation to fathers, as a result of the limited (though growing) body of research on this cohort of caregivers. In parenting research in general, the majority of studies focus on mothers in spite of the increasing involvement of fathers in childcare (Cabrera et al., 2018). When fathers are studied as caregivers, there is a focus on the quantity (e.g., time spent with the child) rather than the quality of paternal involvement (Paquette et al., 2013). In addition, there is often a reliance on mother-reports of father behaviours (rather than direct father-report) and few attempts to associate paternal parenting behaviours with child language outcomes (Paquette et al., 2013; Varghese & Wachen, 2016). Therefore, to comprehensively understand the developmental environment of preterm and term-born children, the influence of qualitative features of maternal and paternal parenting (as ascertained from mother- and father-report, respectively) must be investigated.

Transactional Processes

Transactional perspectives (Fiese & Sameroff, 1989) highlight how child characteristics (e.g., temperament) may influence the environment (e.g., parent-child relationships) in developmentally significant ways. One such characteristic is temperament – the partly biologically-rooted individual differences in early child behaviour (Rothbart & Derryberry, 1981). Children born preterm exhibit distinct temperamental characteristics (e.g., lower attentional focusing and higher activity level; Cassiano et al., 2020) which may be partially attributable to the neural differences (Tamm et al., 2020) and perinatal experiences (e.g., undergoing painful medical procedures; Valeri et al., 2015) associated with preterm birth. Temperamental characteristics have been found to be associated with the quality of parent-child relationships among typically developing (Paulussen-Hoogeboom et al., 2007) and preterm-born cohorts (Gray et al., 2013). However, only one published study (Harel-Gadassi et al., 2020) has investigated how birth status affects the mother-child relationship via its influence on child temperament. While this study by Harel-Gadassi et al (2020) did not find a significant mediation, given the contextual sensitivity of such transactional effects, research must continue to examine this potential mediation among both mothers and fathers. Since temperament has also been found to influence language development (Pérez-Pereira et al., 2016), research should additionally examine the developmental implications of these mediational effects involving mothers and fathers.

The Current Study

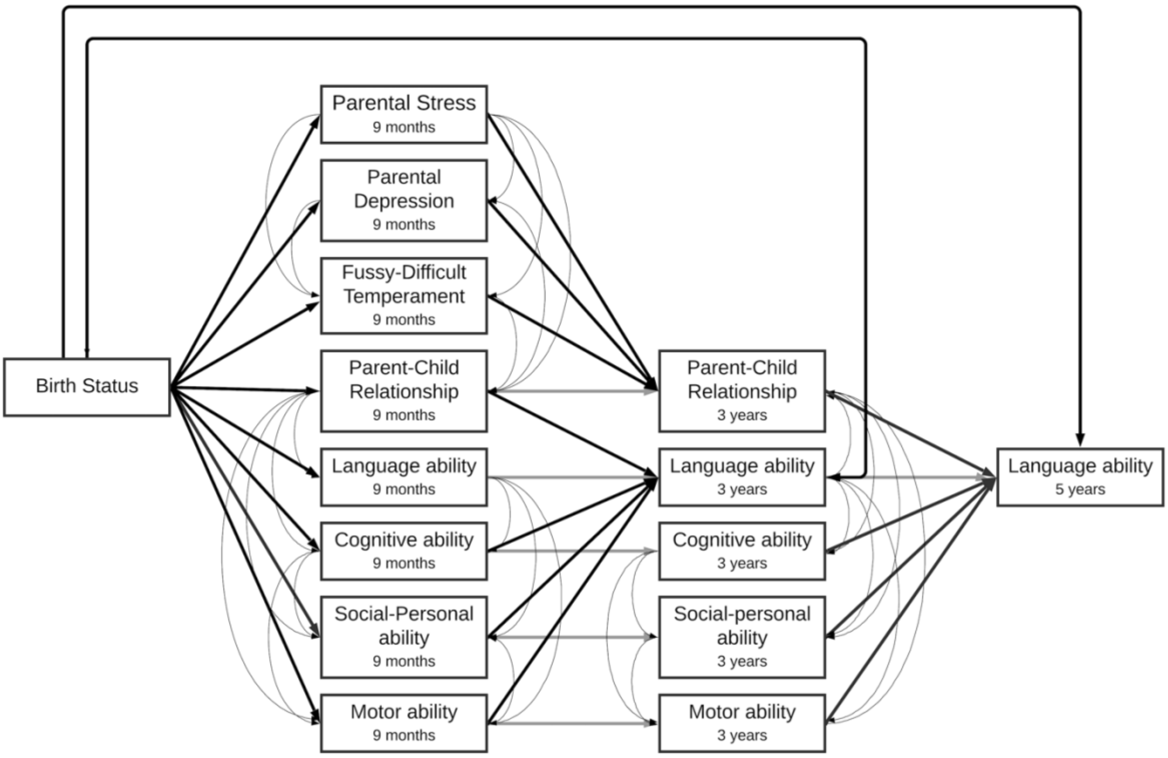
The literature indicates that a comprehensive model of the effect of birth status on language development must span multiple risk/protective domains (e.g., non-linguistic development and the parenting context including both mothers and fathers), feature interactions between these domains, and accommodate developmentally dynamic pathways. Such a multifactorial model can be investigated using path analysis which allows for the simultaneous estimation of multiple direct and indirect (mediated) paths between variables (Streiner, 2005; Ullman & Bentler, 2012). The ability to concurrently model multiple paths and chains of effects allows for the examination of complex models which may more closely approximate reality (Streiner, 2005). Despite these strengths, no published study has used path analysis to longitudinally model how non-linguistic development and the parenting context contribute to the association between birth status and language development.

To address these gaps, the current exploratory study used path analysis on three waves of data (at 9 months, 3 years, and 5 years of age) from a nationally-representative longitudinal study in Ireland to investigate how birth status (‘0’ = term-birth, ‘1’ = preterm-birth) may directly and indirectly (mediation) affect expressive language abilities at 3 and 5 years of age. Using the path model depicted in Figure 3.1.1, the following two research questions were investigated. (1) How does birth status affect expressive language abilities at 3 years of age, either directly or indirectly via the parent-child relationship and the child’s non-linguistic skills (cognitive, motor, and social-personal abilities – reflecting the developmental cognitive linguistic perspective) at 9 months of age? (2) How does birth status affect expressive language abilities at 5 years of age, either directly or indirectly via sequential mediational paths involving parental wellbeing (stress and depression – reflecting the parenting context) and child temperament (reflecting transactional mechanisms) at 9 months of age, and the parent-child relationship at 3 years of age?

These research questions were investigated among both mothers and fathers by examining two versions of the path model in Figure 3.1.1 – one with the parental variables (parental stress, depression, parent-child relationship) related to the child's mother, and the other with corresponding variables related to the father. The latter model with father-related variables addresses the particular lack of research investigating fathers' self-reported parenting behaviours, qualitative features of paternal caregiving (represented in this study by the father-child relationship), and the influence of paternal caregiving on child language development. The mother and father variables were included in separate (though structurally identical) path models as the inclusion of both mother and father variables in a single model would impede statistical parsimony given the large number and complexity of the hypothesised paths (e.g., sequential mediations).

Figure 3.1.1

Hypothesised Path Model of the Direct and Indirect Effects of Birth Status on Language Ability at 3 and 5 Years of Age



Note. Hypothesised path model depicting the direct and indirect effects (via parental wellbeing, parent-child relationship, and child abilities and temperament) of birth status ('0' = term-born, '1' = preterm) on expressive language abilities at 3 and 5 years of age. Two versions of this model – 'Mother model' and 'Father model' – were analysed with the parent-related variables (parental stress, depression, parent-child relationship) respectively relating to the child's mother and father. Double-headed curved arrows (grey) represent correlations. Grey and black unidirectional arrows represent regression paths (grey = auto-regressive paths; black = cross-domain paths of theoretical interest). For parsimony, the confounding variables (income and study child sex) are not depicted. Details of the indirect paths and confounding variables are provided in-text.

Method

Design

This study analysed data from the Infant Cohort of Growing Up in Ireland (GUI), a national longitudinal study of children in the Republic of Ireland. The Infant Cohort comprises children born between December 1st 2007 and the end of June 2008 who were sampled by the GUI study team from the Child Benefit Register (register held by the Department of Social Protection; Thornton et al., 2013). Of the 41,185 households who were eligible to participate, 11,134 were included in the first wave of data collection which occurred when the children were 9 months of age. These households were re-contacted for further data collection when the children were 3, 5, 7/8, 9, and 13 years of age.

The current study used the first three waves of data corresponding to when the children were aged 9 months, 3 years, and 5 years (data accessed through the Irish Social Science Data Archive [https://www.ucd.ie/issda/data/guiinfant/]). At each of these waves, home visits were conducted by trained interviewers who used parental interviews, parental questionnaires, and direct child assessments to collect data about the household's socio-demographic characteristics, the Study Child's development, and the caregiving context (among other topics). Parental interviews and questionnaires were completed by a primary caregiver and a secondary caregiver (resident spouse or partner of the primary caregiver) at each wave. At each wave, written consent was obtained from a parent or guardian. The GUI study received ethical approval from dedicated ethics committees in the Department of Health and Children (Waves 1, 2) and Department of Children and Youth Affairs (Wave 3).

Participants

To facilitate longitudinal analysis and the application of survey weights (further details below), the analysis was restricted to those 8,712 households (from the original 11,134 households) who participated at all three waves. Among the 8,712 included households, the

Study Child was born preterm (< 37 weeks' gestation) in 535 families (46.17% female), and at term in 8,151 families (49.98% female; 26 families did not report gestational age). The average gestational age was 33.87 and 39.87 weeks for the infants born preterm and at term, respectively. Among the infants born preterm, 4.95% were born extremely preterm (< 28 weeks' gestation), 10.67% very preterm (28 ~ < 32 weeks' gestation), and 86.29% moderate-to-late preterm (32 ~ < 37 weeks' gestation). On average, the preterm-born sample had significantly larger households compared to the term-born sample at 9 months of age ($M_{preterm}$ = 4.22; M_{term} = 4.06; t[589] = -2.74, p = .006, d = .13), but not at 3 years ($M_{preterm}$ = 4.39, M_{term} = 4.33; p = .250) or 5 years ($M_{preterm}$ = 4.55, M_{term} =4.54; p = .777) of age. A significantly larger proportion of the term-born (than preterm-born) sample had siblings at 3 years (76% of preterm, 80% of term-born; $\chi 2$[1, N = 8712] = 4.25, p = .039) and 5 years of age (85% of preterm, 88% of term-born; $\chi 2$[1, N = 8712] = 4.76, p = .029), while there was no between-group difference at 9 months of age (60% of preterm, 61% of term-born; p = .862).

The majority of the primary caregivers (99.71%) and secondary caregivers (92.13%) reported to be the female parent and male parent of the Study Child, respectively. Thus, primary caregivers and secondary caregivers will be respectively referred to as mothers and fathers. Among the mothers who reported their ethnicity, 82.51% were White Irish, 11.79% White non-Irish, 2.86% Black, 2.39% Asian, and 0.45% were multi-ethnic or of another ethnic background (information on mother ethnicity was missing for 26 families). Among the fathers who reported their ethnicity, 82.37% were White Irish, 12.27% White non-Irish, 2.57% Black, 2.35% Asian, and 0.44% were multi-ethnic or of another ethnic background (information on father ethnicity was missing for 1,737 families).

Measures

Study Child

Birth Status. Mothers reported the gestational age of the Study Child as the number of weeks of pregnancy after which the child was born. Of the 8,672 valid responses (26 households did not answer this question), 8,662 fell between 26 and 46 weeks, while the remaining 10 were coded as ≤ 25 weeks. Since the age of viability ranges from 22 to 24 weeks (World Health Organisation, 2012), these 10 datapoints were not suspected to vary greatly. Therefore, gestational age was treated in its entirety (i.e., including the ≤ 25 weeks values) as a continuous variable ranging between 25 and 46 weeks.

A 'birth status' variable was created from this gestational age data. In line with the World Health Organisation (2012), births which occurred at < 37 weeks' gestation were labelled 'preterm' and those which occurred at ≥ 37 weeks were labelled 'term-birth'. In the path analyses, binary coding was used whereby '0' = term-birth and '1' = preterm-birth.

Language Abilities. At Wave 1, mothers completed items on the 10-month Ages and Stages Questionnaire (Squires et al., 1999) which corresponded to the 'communication' domain (possible score range: 0-60; Cronbach's alpha = .53; Nixon et al., 2013). At Waves 2 and 3, the expressive language ability of the Study Child was directly assessed by administering the Naming Vocabulary subtest (Cronbach's alpha = .86; Elliott et al., 1997) of the British Ability Scales – second edition (Early Years Battery; Elliott et al., 1996). The total 'ability' scores (raw scores adjusted for item difficulty; possible score range: 10-170) were used in the analysis. On both measures, higher scores indicate better language abilities.

Cognitive Abilities. At Wave 1, mothers completed items on the 10-month Ages and Stages Questionnaire (Squires et al., 1999) which corresponded to the 'problem solving' domain (possible score range: 0-60; Cronbach's alpha = .65; Nixon et al., 2013). At Wave 2, the interviewer assessed the Study Child's non-verbal reasoning ability using the Picture Similarities subtest (Cronbach's alpha = .82; Elliott et al., 1997) of the British Ability Scales – second edition (Early Years Battery; Elliott et al., 1996). The total 'ability' scores (raw scores adjusted for item difficulty; possible score range: 10-119) were used in the analysis. On both measures, higher scores indicate greater cognitive abilities.

Social-Personal Abilities. At Wave 1, mothers completed items on the 10-month Ages and Stages Questionnaire (Squires et al., 1999) which corresponded to the 'personal social' domain (possible score range: 0-60; Cronbach's alpha = .53; Nixon et al., 2013). Higher scores indicate greater social-personal abilities. At Wave 2, mothers reported on the Study Child's social-personal abilities through completing the Strengths and Difficulties Questionnaire (Goodman, 1997). The total difficulties score from the Strengths and Difficulties Questionnaire was used in this analysis (possible score range: 0-40; Cronbach's alpha = .78; Theunissen et al., 2013). This score was reversed in the analyses such that higher scores indicate fewer behavioural and psychosocial difficulties.

Motor Abilities. At Wave 1, mothers reported on the Study Child's motor abilities through completing items on the 10-month Ages and Stages Questionnaire (Squires et al., 1999) which corresponded to the 'fine motor' and 'gross motor' domains (Cronbach's alpha = .66 and .80 respectively; Nixon et al., 2013). The scores from these two domains were summed to create an overall motor score in this analysis. This overall motor score could range from 0-120, with higher scores indicating greater motor ability. At Wave 2, the interviewer assessed motor ability through observing the child performing two gross motor skills (standing on one leg for ⩾ 2 seconds, throwing a ball overhand) and two fine motor skills (drawing a straight line, holding a pencil using a pincer grasp). In line with Hadfield et al. (2017), a score of 1 was assigned for each of the four tasks that were performed successfully. These scores were summed to create a composite motor score ranging from 0 to

4, with higher scores indicating greater motor ability (there are no data on the internal consistency of this composite score).

Fussy-Difficult Temperament. At Wave 1, mothers rated the child's temperament on the fussy-difficult subscale of the Infant Characteristics Questionnaire (Bates et al., 1979). The total score on this subscale can range from 6 to 42, with higher scores indicating a more difficult temperament (Cronbach's alpha = .79; Bates et al., 1979).

Caregiving Context

Parental Depression. At Wave 1, mothers and fathers each completed the 8-item version of the Centre for Epidemiological Studies Depression Scale (Melchior et al., 1993). The composite scores were separately computed for mothers and fathers (possible score range: 0-24; Cronbach's alpha = .87 and .81 respectively; Nixon et al., 2013) with higher scores indicating higher levels of distress.

Parental Stress. At Wave 1, mothers and fathers each completed the Parental Stress Scale (Berry & Jones, 1995) which surveys their experiences of the positive and negative sides of parenthood. The total stress scores for mothers and fathers were computed separately and used in this analysis. The total stress score can range from 18 to 90, with higher scores indicating higher levels of parental stress (Cronbach's alpha = .83; Berry & Jones, 1995).

Parent-Child Relationship. At Wave 1, the quality of the parent-child relationship was assessed through self-report measures of parent-to-infant attachment quality. The mothers completed the Quality of Attachment subscale (9 items) from the Maternal Postnatal Attachment Scale (Condon & Corkindale, 1998), while fathers completed the Quality of Attachment subscale (5 items) from the Paternal Postnatal Attachment Scale (Condon et al., 2008). The total score for mothers can range from 9 to 45, while the total score for fathers can range from 5 to 25. In both the maternal and paternal scales (Cronbach's alpha = .52 and .45 respectively; Nixon et al., 2013), higher total scores indicate a higher quality of attachment.

At Wave 2, parent-child relationship quality was assessed through mother and father responses on the Child-Parent Relationship Scale – short form (Pianta, 1992). The total score on the Positive subscale (closeness in the parent-child relationship) was calculated separately for mothers and fathers. This score can range from 7 to 35, with higher values indicating a more positive parent-child relationship (Cronbach's alpha = .71; McCrory et al., 2013).

Covariates

Household Income. At Wave 1, mothers reported the annual income of the household. With this data, an 'equivalised household income' value (which adjusts income figures for the number of adults and children in the household) was computed for each household by the GUI study team to facilitate comparisons across households (Murray et al., 2015). This equivalised household income value was used in the current study. This value was rescaled (divided by 100) for the path analyses to facilitate model fitting.

Sex. The Study Child's sex (male or female) was included as a covariate in the path analyses. Binary coding was used in the path analyses whereby '0' = female and '1' = male.

Data Analysis

The following analyses were conducted using R (version 4.1.2; R Core Team, 2021). All statistical significance tests were two-tailed (α = .05).

Missing Data

Among the 8,712 included families (see Appendix A for a comparison of included and excluded families), the following variables contained missing datapoints (percentage of missing values in parentheses) – birth status (0.30%), equivalised household income (7.11%), 9-month maternal (0.79%) and paternal (20.01%) stress; 9-month mother (1.35%) and father (20.93%) depression; 9-month mother-child (0.29%) and father-child (19.77%) relationship; 9-month fussy-difficult temperament (0.28%); 9-month language (0.62%), cognitive (6.67%), motor (3.16%), and social-personal (1.30%) ability; 3-year mother-child (0.26%) and father-child (21.35%) relationship; 3-year language (0.06%), cognitive (2.23%), motor (1.25%), and social-personal (0.07%) ability; 5-year language ability (1.26%).

Path Analysis

Hypothesised Model. Two structurally identical path models were specified – one with the caregiving variables (parental stress, depression, 9-month and 3-year parent-child relationship) related to the mothers (‘Mother model’), and another with corresponding variables gathered from fathers (‘Father model’). To protect against biased longitudinal parameter estimates (MacCallum & Austin, 2000), the path model structure (Figure 3.1.1) included within-wave correlations and auto-regressive paths between repeated-measure variables. The confounding influence of income and Study Child sex were controlled by regressing birth status and language ability (9-month, 3-year, and 5-year) on income and child sex, and by regressing parent-child relationship (9-month, 3-year), stress (9-month), and depression (9-month) on income. Pearson correlations between all continuous path model variables were computed (see Appendix B). To avoid issues of multicollinearity, predictor variables with moderate or large correlations ($r \geq 0.3$; Cohen, 1988) were allowed to covary.

In addition to the direct paths, indirect paths were estimated to examine whether (i) the effect of birth status on 3-year language ability is mediated by 9-month parent-child relationship, 9-month cognitive ability, 9-month motor ability, and/or 9-month social-personal ability, (ii) the effect of birth status on 3-year parent-child relationship is mediated by 9-month stress, 9-month depression, and/or 9-month fussy-difficult temperament. Finally, the mediations in part (ii) were extended into sequential mediations to estimate how they may influence 5-year language ability.

Model Fitting. The lavaan package (v0.6-9; Rosseel, 2012) was used to fit the models using diagonally weighted least squares (DWLS) estimation to accommodate the two categorical variables (birth status, sex). The sample weight generated by the GUI study team was applied to make the sample representative of the population in the Republic of Ireland by adjusting for differential response and inter-wave attrition (Murray et al., 2015). While the data were not missing completely at random in the Mother or Father models (Little's test), pairwise deletion was chosen over listwise deletion (the two options for handling missingness in lavaan when using DWLS) as the former deletes a smaller number of cases.

Using a model generation strategy, the models were modified to improve their fit and parsimony (see Appendix C for a more technical overview of this model fitting procedure. See also Appendix D and E for a detailed description of the application of this model fitting procedure to the Mother and Father models, respectively). Specifically, the following three non-significant paths were identified and iteratively removed from each model, starting with the path with the highest p-value: (i) child sex → 5-year language, (ii) correlation between 9-month parent-child relationship and 9-month motor ability, (iii) income → 3-year parent-child relationship. The remaining non-significant paths in each model were retained as they were related to the central research questions. Modification indices did not identify any theoretically relevant paths which could be added to either model.

The modified Mother model (RMSEA = 0.066, SRMR = 0.054; 8,712 observations with 173 missing patterns handled by pairwise deletion) and the modified Father model (RMSEA = 0.053, SRMR = 0.043; 8,712 observations with 232 missing patterns handled by pairwise deletion) achieved satisfactory model fit indices, according to the following criteria: root mean square error of approximation (RMSEA) < 0.06 and standardised root mean square residual (SRMR) < 0.08 (Hu & Bentler, 1999). Cumulative fit indices (Tucker-Lewis index and comparative fit index) were not used as they can misleadingly indicate poor model fit when the model contains small between-variable correlations (as was the case here). Finally, using these modified Mother and Father models, bootstrapped 95% confidence intervals (1,000 draws) were computed. The modified Mother and Father models achieved adequate statistical power by surpassing the minimum requirement of 20 cases (households) for each estimated parameter (96 parameters were estimated in each model; Kline, 2011).

Results

Preliminary Analyses

Between-group t-tests were used to compare the preterm and term-born groups on key continuous path model variables. The distribution of each variable was examined for normality in the preterm and term-born groups (see Appendix F). Despite the deviations from normality, parametric t-tests were used given the large sample size. When homogeneity of variance was not found between the groups, Welch's t-test was used.

As can be seen in Table 3.1.1, the preterm group had a significantly lower equivalised household income (rescaled) compared to the term-born group. The preterm group had significantly lower language scores than their term-born counterparts at 9 months and 3 years of age, but not at 5 years of age. The cognitive, motor, and social-personal abilities of the preterm group were significantly lower than those of the term-born group at 9 months and 3 years of age. There were significantly higher levels of maternal and paternal stress and depression among the preterm as compared to the term-born group. Finally, there was a significantly more positive father-child relationship at 3 years of age among the preterm as compared to the term-born group. No corresponding effect was observed with the 3-year mother-child relationship.

Table 3.1.1

Comparisons of Preterm and Term-Born Groups on Continuous Path Model Variables

Variable	Preterm		Term-born					
	N	*M (SE)*	*N*	*M (SE)*	*t*	*df*	*p*	*Cohen's d*
Wave 1 (9 month old)								
Equivalised household income (rescaled) [a]	499	197.21 (5.06)	7573	223.37 (1.56)	4.94	596.71	< **.001**	0.21
Fussy-difficult temperament	534	15.00 (0.22)	8131	14.74 (0.05)	-1.17	8663	.242	0.05
Language ability [a]	531	38.61 (0.64)	8101	44.80 (0.12)	9.46	568.77	< **.001**	0.47
Cognitive ability [a]	510	40.37 (0.70)	7685	46.50 (0.15)	8.52	553.57	< **.001**	0.42
Motor ability [a]	522	71.21 (1.09)	7892	85.56 (0.24)	12.89	573.79	< **.001**	0.62
Social-personal ability [a]	525	38.53 (0.63)	8051	44.03 (0.13)	8.55	569.08	< **.001**	0.42
Maternal parental stress [a]	530	32.59 (0.32)	8097	31.86 (0.07)	-2.24	589.37	**.025**	0.10
Paternal parental stress	419	31.49 (0.33)	6537	30.80 (0.08)	-2.19	6954	**.029**	0.11
Maternal depression [a]	524	2.81 (0.17)	8052	2.32 (0.04)	-2.75	576.56	**.006**	0.13
Paternal depression [a]	414	1.60 (0.14)	6464	1.30 (0.03)	-2.08	451	**.038**	0.11
Mother-child relationship	534	42.52 (0.12)	8129	42.55 (0.03)	0.23	8661	.822	0.01
Father-child relationship	420	24.20 (0.07)	6557	24.09 (0.02)	-1.52	6975	.127	0.08
Wave 2 (3 year old)								
Language ability	497	72.36 (0.88)	7703	75.27 (0.22)	3.20	8198	**.001**	0.15
Cognitive ability	513	58.06 (0.64)	7983	61.05 (0.16)	4.61	8494	< **.001**	0.21
Motor ability	523	3.12 (0.04)	8055	3.27 (0.01)	3.95	8576	< **.001**	0.18
Social-personal ability [a]	534	31.50 (0.21)	8146	32.35 (0.05)	3.89	592.67	< **.001**	0.18
Mother-child relationship	532	33.74 (0.10)	8133	33.83 (0.02)	1.05	8663	.295	0.05
Father-child relationship [a]	407	33.23 (0.11)	6428	32.94 (0.03)	-2.50	470.52	**.0128**	0.12
Wave 3 (5 year old)								
Language ability	521	109.52 (0.84)	8057	111.10 (0.20)	1.94	8576	.052	0.09

Note. Statistically significant between-group differences ($p < .05$) are shown in bold.

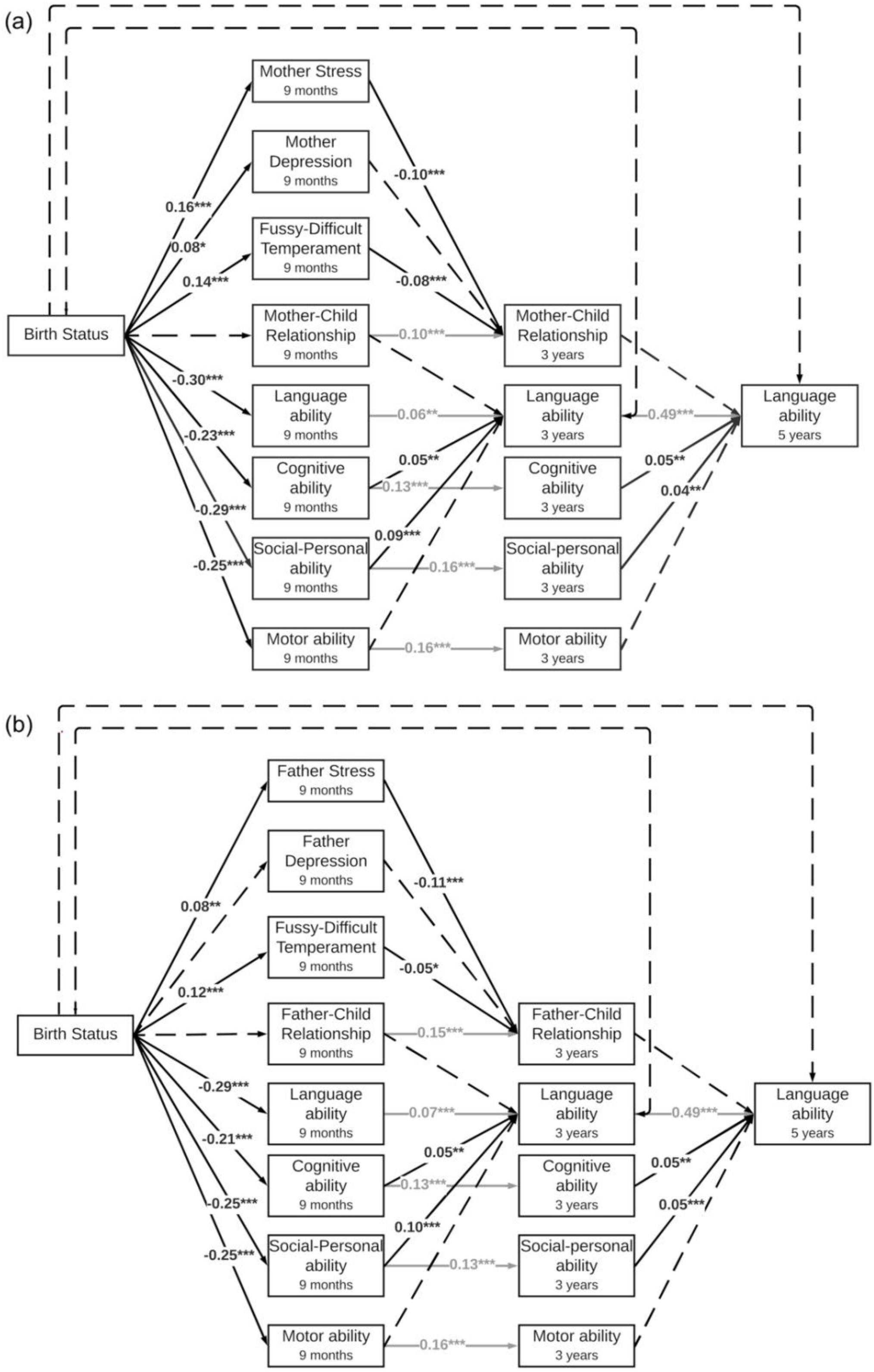
[a] Welch's t-test (when homogeneity of variance was not found).

Path Analyses

The standardised coefficients and significance levels of statistically significant direct paths are displayed in Figures 3.1.2a and 3.1.2b for the Mother and Father models, respectively. The corresponding statistics for the non-significant direct paths are reported in the following text. The standardised coefficients and significance levels for the indirect paths are reported in Table 3.1.2. In both the Mother and Father models, the R^2 value was 7% for language ability at 3 years and 30% for language ability at 5 years.

Figure 3.1.2

Standardised Estimates and Statistical Significance of Paths in the (a) Mother Model and (b) Father Model



Note. Modified (a) 'Mother model' (8,712 observations with 173 missing patterns) and (b) 'Father model' (8,712 observations with 232 missing patterns) illustrating the direct and indirect effects (via parental wellbeing, parent-child relationship, and child abilities and temperament) of birth status ('0' = term-birth, '1' = preterm) on expressive language ability at 3 and 5 years of age. Grey and black solid arrows represent significant paths ($p < .05$; grey = auto-regressive paths; black = cross-domain paths of theoretical interest). Dashed arrows represent non-significant paths. Standardised parameter estimates and significance levels are provided for statistically significant paths (corresponding statistics for non-significant paths are reported in-text). Indirect effects are reported in Table 3.1.2. For parsimony, covariances and confounding variables (income and study child sex) are not depicted.

Table 3.1.2

Standardised Parameter Estimates (ß), Bootstrapped 95% Confidence Intervals, and p-values of Indirect Paths in the Mother and Father Models

Indirect effect	ß	95% CI	*p*
Mother model			
BS ⟶ Mother-child rel (9mo) ⟶ Language (3yr)	< 0.001	- 0.018, 0.018	1.000
BS ⟶ Cognitive (9mo) ⟶ Language (3yr)	- 0.011	- 0.372, - 0.055	.010
BS ⟶ Motor (9mo) ⟶ Language (3yr)	0.007	- 0.017, 0.309	.133
BS ⟶ Social-personal (9mo) ⟶ Language (3yr)	- 0.026	- 0.739, - 0.311	< .001
BS ⟶ Mother stress (9mo) ⟶ Mother-child rel (3yr)	- 0.016	- 0.059, - 0.013	.007
BS ⟶ Mother depress (9mo) ⟶ Mother-child rel (3yr)	< 0.001	- 0.010, 0.006	.939
BS ⟶ Fussy-difficult (9mo) ⟶ Mother-child rel (3yr)	-0.011	- 0.039, - 0.008	.007
BS ⟶ Mother stress (9mo) ⟶ Mother-child rel (3yr) ⟶ Language (5yr)	< 0.001	- 0.022, 0.000	.181
BS ⟶ Mother depress (9mo) ⟶ Mother-child rel (3yr) ⟶ Language (5yr)	< 0.001	- 0.003, 0.002	.945
BS ⟶ Fussy-difficult (9mo) ⟶ Mother-child rel (3yr) ⟶ Language (5yr)	< 0.001	- 0.015, 0.000	.176
Father model			
BS ⟶ Father-child rel (9mo) ⟶ Language (3yr)	0.001	- 0.016, 0.062	.560
BS ⟶ Cognitive (9mo) ⟶ Language (3yr)	- 0.011	- 0.355, - 0.060	.006
BS ⟶ Motor (9mo) ⟶ Language (3yr)	0.007	- 0.014, 0.317	.120
BS ⟶ Social-personal (9mo) ⟶ Language (3yr)	- 0.024	- 0.661, - 0.288	< .001
BS ⟶ Father stress (9mo) ⟶ Father-child rel (3yr)	- 0.008	- 0.041, - 0.006	.029
BS ⟶ Father depress (9mo) ⟶ Father-child rel (3yr)	- 0.001	- 0.014, 0.005	.769
BS ⟶ Fussy-difficult (9mo) ⟶ Father-child rel (3yr)	- 0.005	- 0.029, - 0.004	.039
BS ⟶ Father stress (9mo) ⟶ Father-child rel (3yr) ⟶ Language (5yr)	< 0.001	- 0.008, 0.003	.588
BS ⟶ Father depress (9mo) ⟶ Father-child rel (3yr) ⟶ Language (5yr)	< 0.001	- 0.002, 0.001	.831
BS ⟶ Fussy-difficult (9mo) ⟶ Father-child rel (3yr) ⟶ Language (5yr)	< 0.001	- 0.006, 0.002	.571

Note. BS = Birth status; rel = relationship; mo = months; yr = years; depress = depression; Fussy-difficult = Fussy-difficult temperament.

Direct and Indirect Effects of Preterm Birth on Expressive Language at 3 Years of Age

In both the Mother and Father models, 3-year language ability was significantly and positively predicted by 9-month language, cognitive, and social-personal abilities, while it was not predicted by 9-month motor ability (mother: ß = -0.03, p = .098; father: ß = -0.03, p = .10) or 9-month mother-child (ß = 0.01, p = .489) or father-child (ß = 0.02, p = .228) relationship quality. In both models, birth status (i.e., preterm birth) had a significant negative effect on 9-month language, cognitive, social-personal, and motor abilities while it did not have a significant effect on either 9-month mother-child (ß < .01, p = 1.00) or father-child (ß = 0.03, p = .345) relationship quality.

While there was no significant direct effect of birth status on 3-year language ability in either model (mother: ß < .01, p = .906; father: ß = 0.01, p = .803), it had a significant indirect effect via 9-month cognitive ability and social-personal ability. The effect of birth status on 3-year language ability was not significantly mediated by 9-month motor ability, mother-child relationship quality, or father-child relationship quality.

Direct and Indirect Effects of Preterm Birth on Expressive Language at 5 Years of Age

In the Mother and Father models, 5-year language ability was significantly positively predicted by 3-year language, cognitive, and social-personal abilities while it was not significantly predicted by 3-year motor abilities (mother: ß = -0.01, p = .611; father: ß = -0.01, p = .702), or 3-year mother-child (ß = 0.03, p = .074) or father-child relationship quality (ß = .01, p = .493). There was no significant direct effect of birth status on 5-year language ability in the Mother (ß = .01, p = .601) or Father (ß =.01, p = .617) model.

The indirect effect of birth status on 3-year parent-child relationship quality (via stress, depression, or fussy-difficult temperament at 9 months) was examined. In the Mother model, birth status had a significant positive effect on 9-month mother stress, mother depression, and fussy-difficult temperament. Furthermore, 3-year mother-child relationship quality was negatively predicted by 9-month mother stress and 9-month fussy-difficult temperament, while it was not significantly predicted by 9-month mother depression (ß < .01, *p* = .932). In the Mother model, the negative effect of birth status on 3-year mother-child relationship quality was significantly mediated by 9-month mother stress and fussy-difficult temperament, but not by mother depression.

In the Father model, birth status had a significant positive effect on 9-month father stress and 9-month fussy-difficult temperament. In contrast to the Mother model, birth status did not have a significant effect on 9-month father depression. Father-child relationship quality at 3 years was negatively predicted by 9-month father stress and 9-month fussy-difficult temperament, while it was not significantly predicted by 9-month father depression (ß = -0.05, *p* = .116). Similar to the Mother model, the negative effect of birth status on 3-year father-child relationship quality was significantly mediated by 9-month father stress and fussy-difficult temperament, but not by father depression.

Finally, the models examined whether these three hypothesised mediational effects of birth status on 3-year parent-child relationship may extend into sequential mediation effects which are associated with 5-year language abilities (birth status → depression, parental stress, or fussy-difficult temperament [9 months] → parent-child relationship [3 years] → language ability [5 years]). None of these three sequential mediation effects (involving depression, stress, or fussy-difficult temperament) were statistically significant in either the Mother or Father model.

Full statistical output (e.g., covariance matrix, z-scores, confidence intervals) for the Mother and Father models can be found in Appendix D and Appendix E, respectively.

Discussion

Children born preterm often experience poorer language outcomes (van Noort-van der Spek et al., 2012) which may be partly attributable to their non-linguistic development

(Aylward, 2014), temperamental characteristics (Cassiano et al., 2020), and unique caregiving environments (Korja et al., 2008). Nonetheless, few published studies have investigated how these factors may simultaneously and interactively shape language development following preterm birth. To address these gaps, the current study used path analysis with a nationally-representative longitudinal sample to examine (1) how birth status (term-birth, preterm birth) may directly and indirectly (via non-linguistic child development and mother-child or father-child relationship) affect expressive language abilities at 3 years of age, and (2) how birth status may directly and indirectly (via child temperament, maternal or paternal wellbeing, and mother-child or father-child relationship) affect expressive language abilities at 5 years of age. Importantly, these research questions were investigated with reference to the parenting experiences and developmental influences of both mothers and fathers in order to address the limited focus on fathers in developmental research.

Compared to their term-born peers, the children born preterm exhibited poorer expressive language skills at 3 years (but not 5 years) of age. Preterm birth indirectly affected expressive language ability at 3 years of age via 9-month cognitive and social-personal abilities (but not through 9-month motor ability, mother-child relationship, or father-child relationship). Meanwhile, there was no direct or indirect effect of preterm birth on expressive language ability at 5 years of age. For both mothers and fathers, preterm birth indirectly negatively affected parent-child relationship quality at 3 years via 9-month parental stress and fussy-difficult temperament (but not via parental depression). These findings highlight how the prevention and treatment of language difficulties following preterm birth should embody a multidisciplinary approach which can address the inter-relations between linguistic and non-linguistic development. Furthermore, supports should extend beyond the preterm-born child to promote the wellbeing (e.g., mental health screening; e.g., Hynan et al., 2015) and caregiving skills (e.g., actively involving parents in the care of their infants during their hospitalisation to enhance familiarity with caregiving tasks and their infant's cues; e.g., Craig et al., 2015) of both mothers and fathers.

Given that non-linguistic developmental abilities and the caregiving environment can shape language development (Ibbotson, 2020; McNally & Quigley, 2014), the broad developmental difficulties and unique parenting context associated with preterm birth (Aylward, 2014; Korja et al., 2008) may mediate the association between preterm birth and language development. In the current study, preterm birth was associated with poorer linguistic and non-linguistic (cognitive, social-personal, and motor) abilities at 9 months and 3 years of age. Among these, cognitive and social-personal abilities (but not motor abilities) at 9 months significantly mediated the association between preterm birth and language abilities at 3 years of age. These mediational findings support the developmental cognitive linguistic perspective which proposes that a child's non-linguistic abilities may influence their language development through shaping their exposure to, and ability to learn from, social and non-social experiences (Ibbotson, 2020).

The non-significant longitudinal effect of motor abilities on language abilities (and the accompanying non-significant mediation by motor abilities of the effect of preterm birth on language development) accords with previous research and highlights the nuanced associations between non-linguistic and linguistic development. Previous studies have found the motor-to-language association to be stronger at younger (rather than older) age-points (Wang et al., 2014) and over shorter (rather than longer) time-lags (Gonzalez et al., 2019). Future research with shorter intervals between data collection waves, a separation of fine motor and gross motor scores, and the inclusion of both receptive and expressive language scores may shed light on the mechanisms underlying the motor-language association.

Contrary to predictions, the association between preterm birth and 3-year language abilities was not mediated by either the quality of the mother-child or father-child relationship at 9 months. There was no significant effect of preterm birth on either the mother-child or the father-child relationship, with neither variable significantly affecting language ability at 3 years. Similarly, 3-year mother-child and father-child relationship did not significantly affect 5-year language abilities. The non-significant effect of preterm birth on parent-child relationship sits alongside the conflicting literature which characterises the caregiving contexts associated with preterm birth (Bilgin & Wolke, 2015). Importantly, however, the non-significant results may also be attributable to the narrow scope of the parent-child relationship measures used at 3 and 5 years of age (note that parent-child relationship was measured differently at each age-point). Parent-child relationship quality at 9 months reflected the affection felt by the parent toward their child (parent-to-infant attachment rather than infant-to-parent attachment). Meanwhile, 3-year parent-child relationship selectively reflected positive dimensions (and omitted the negative dimensions) of the parent-child relationship. Different results may be obtained if parent-report measures of other aspects of the parent-child relationship were included, or if objective assessments of parent-child relationships (via observation of parent-child interactions) were used.

Transactional perspectives propose that child characteristics can shape the caregiving context in developmentally significant ways (Fiese & Sameroff, 1989). Since preterm birth is associated with a unique temperamental profile (Cassiano et al., 2020), temperamental characteristics may mediate the association between birth status and parent-child relationship quality. The current results support such transactional perspectives through finding that fussy-difficult temperament at 9 months significantly mediated the association between birth status and mother-child and father-child relationship quality at 3 years. Specifically, preterm birth was associated with higher parental ratings of fussy-difficult temperament, which subsequently predicted poorer parent-child relationships. This finding conflicts with the only published study on this topic which did not find the effect of birth status on mother-child relationships to be significantly mediated by temperament (Harel-Gadassi et al., 2020). Future research should examine possible moderators (e.g., child gender, parental expectations of child behaviour; Gerstein & Poehlmann-Tynan, 2015; Yates et al., 2010) of the effects of these and other child characteristics on mother-child and father-child relationships among preterm and term-born children.

Parental mental wellbeing may also contribute to the documented differences in parenting experienced by children born preterm and at term. Parental stress at 9 months significantly mediated the association between birth status and mother-child and father-child relationship at 3 years, such that preterm birth led to elevated stress which subsequently predicted poorer parent-child relationships. In contrast, parental depression symptoms (9 months) did not mediate the effect of birth status on mother-child or father-child relationship (3 years). While birth status had a significant effect on the depression scores of mothers (but not fathers), depression scores did not significantly affect the mother-child or father-child relationship. Previous research reports that elevated parental distress (following preterm birth) at 9 months post-partum may be most evident among parents of very, as compared to moderate-to-late, preterm infants (Carson et al., 2015). Hence, the non-significant effect of birth status on the depression scores of fathers may be due to the predominance of moderate-to-late preterm-born children in the current study. Meanwhile, the non-significant effect of depressive symptoms on mother-child and father-child relationship may arise from the fact that depressive symptoms often hold stronger associations with negative dimensions of parent-child relationships when compared to the positive dimensions that were included here (Lovejoy et al., 2000).

The three hypothesised mediation effects of birth status on 3-year parent-child relationship (via depression, parental stress, and temperament) did not extend into significant sequential mediation effects which affect language abilities at 5 years (e.g., birth status →

parental stress [9 months] → parent-child relationship [3 years] → language ability [5 years]). While birth status had a significant indirect effect on language abilities at 3 years, it did not have a significant direct or indirect effect on language abilities at 5 years. Since the same measure of expressive language ability was used at 3 and 5 years of age, this may signify developmental catch-up in expressive language abilities between these two age points. This interpretation is tentative as the between-group t-test indicated that the difference between the 5-year language abilities of children born preterm and at term was tending toward significance. Given the earlier discussion about the possible problems associated with the narrow scope of the self-report parent-child relationship measures used in this study, alternative measures of the parent-child relationship may return differing sequential mediation results.

Limitations and Implications

Some study limitations must be considered. As only expressive language abilities were assessed, the path model findings may not generalise to receptive abilities. The parameter estimates of some paths may be biased owing to the low reliability of some measurement tools (particularly for language and social-personal abilities, and the mother-child and father-child relationship at 9 months) and the use of pairwise deletion (as the data was not missing completely at random). The Mother and Father models may not be completely comparable for two reasons. First, 3-year parent-child relationship was measured differently among mothers and fathers. Second, as mothers completed the questionnaires related to themselves and their child, shared responder bias may lead to larger associations between these mother-reported child characteristics (e.g., temperament) and mother-reported maternal variables (e.g., mother-child relationship) when compared to the associations between the same child characteristics and father-reported paternal variables (e.g., father-child relationship).

In addition to addressing these concerns, it is recommended that future research attempts to enhance the models' explanatory power through adopting a family systems perspective (Kerig, 2019) to more comprehensively map the caregiving context. Maternal and paternal variables should be jointly investigated within a single model to examine the additive effects of mothers, fathers, and the mother-father relationship (e.g., coparenting relationship) on child language development. In addition to the role of caregivers, future research should examine the influence of siblings on language development among preterm and term-born children. In the current longitudinal sample, a larger proportion of the term-born sample had siblings when compared to the preterm-born sample at 3 and 5 years of age, while there was no difference in the proportion with siblings at the 9 month age-point. Future research could examine how the experience of having a preterm birth may affect the subsequent evolution of the household's composition in ways that could shape the language environment of the developing preterm-born child (e.g., the presence or absence of siblings; see Chen et al., 2022 for an investigation of the future childbearing decisions of parents following a preterm birth).

Through adopting a developmental cognitive linguistic (Ibbotson, 2020) and transactional (Fiese & Sameroff, 1989) perspective on development, the current study used path analysis with a nationally-representative longitudinal dataset from Ireland to investigate how preterm birth may directly or indirectly affect expressive language development at 3- and 5-years of age. The insights that are derived from these multifactorial models support the family-centred care approach embodied within recently established international standards for neonatal care (e.g., European Standards of Care for Newborn Health; EFCNI, 2022a). Specifically, these standards strive to support positive developmental outcomes through addressing the needs of the child as well as those in their environment (e.g., caregivers).

With regards to the needs of the child, the current finding that the preterm-born sample performed significantly more poorly than their term-born peers across multiple developmental domains at 9-months and 3-years of age supports the proposed guideline to periodically assess preterm-born children across multiple developmental domains at 2 years of age and again prior to school-entry (EFCNI, 2022a). Furthermore, the indirect effect of preterm birth on 3-year-old language abilities through non-linguistic skills supports proposed standards regarding the importance of multidisciplinary healthcare teams that can coordinate the long-term developmental monitoring and support of preterm-born children by recognising the dynamic inter-relations between developmental domains. With regards to the needs of caregivers, the standards also recommend supports for mothers and fathers in the form of mental health screening and active involvement in the care of their preterm-born infant during their stay in the neonatal intensive care unit (EFCNI, 2022a). These recommendations are in line with the present finding that preterm birth can negatively affect mother-child and father-child relationships through the mediators of increased parental stress and a more fussy-difficult child temperament.

The current study can be understood to aid the advancement of care for children born preterm through providing evidence which aligns with international best-practice guidelines for neonatal care. Through building on the foundation provided by this exploratory study, future extensions of the path models investigated here can provide further insights regarding the validity and comprehensiveness of these care standards, and possibly guide the development of additional standards. The growth of such research is critical to ensure a holistic evidence-based approach to the promotion of optimal linguistic development among this vulnerable cohort.

Chapter 4: Fieldwork for Chapters 5 and 6

4.1 Introduction

The studies in Chapters 5 and 6 used a subset of data from two longitudinal research projects which are being conducted at the Infant and Child Research Lab (Trinity College Dublin). Section 4.2 of this chapter provides details of the fieldwork involved in each longitudinal project. Section 4.3 outlines how participants and measures were subsampled from these larger studies for inclusion in Chapters 5 and 6. Finally, Section 4.4 outlines how the author of this thesis contributed to the work outlined in this chapter.

4.2 Longitudinal Cohort Studies

Design

The two longitudinal projects use observational methods to investigate parent-child interactions and development across early infancy and childhood. The first longitudinal project examines these topics among a preterm-born cohort of children (< 37 weeks' gestational age). Meanwhile, the second longitudinal project examines these topics among a cohort of typically developing children (the majority of which were born ≥ 37 weeks' gestation; further details below).

The preterm-born and term-born samples in the studies presented in Chapters 5 and 6 respectively constitute a subset of the preterm-born and typically developing cohorts. While further details of the precise subsampling procedure and inclusion/exclusion criteria are provided later on in this chapter, a description of each longitudinal project/cohort is presented below.

Preterm-Born Cohort

In line with the World Health Organisation (2012), "preterm birth" in this project is defined as a birth occurring before the 37th week of pregnancy. Participants in the preterm-born cohort were recruited through two methods. The first method reflected a community recruitment strategy whereby study advertisements were distributed through social media, parenting forums, crèches, and "home visitors" (trained practitioners who visit families with young children in socioeconomically disadvantaged localities). The advertisements, which were primarily distributed in Dublin (Ireland), invited families with 2- to 3-year-old preterm-born children (< 37 weeks' gestational age) to participate in this longitudinal study about parent-child interaction and development.

The second method involved contacting families with preterm-born infants who had previously participated in a medical study regarding the association between gender and inflammation during the perinatal period (PhD research conducted by Dr. Matthew McGovern). The fieldwork for this medical study was conducted in maternity hospitals in Dublin (Ireland) between the years 2017 and 2020. At the time of participation in this medical study, the families consented to being contacted again regarding future opportunities to take part in research. These consenting families were contacted (by phone/email) and informed about this longitudinal study.

Of the 109 families that took part in the original medical study, 14 were not contacted as the child was either deceased (n = 6) or born in a maternity hospital that had not agreed to take part in this follow-up (n = 8). The families of a further 10 children could not be reached as their contact details had been incorrectly recorded. Of the remaining 85 original study children, the families of 43 children agreed to take part in this longitudinal study (51% participation rate). Meanwhile, of the 42 study children (and their families) who did not take part, nine declined participation, while 33 expressed an interest in the study yet did not ultimately take part.

These two recruitment drives yielded a total sample of 72 preterm-born children who were between 2 and 4 years of age. This sample was recruited (and tested) between 2021 and 2022 and constituted the first wave of this longitudinal project (further waves have not been conducted at the time of writing). As the fieldwork for this wave (wave 1) coincided with the COVID-19 pandemic, further details are provided in this chapter regarding how data collection was carried out while abiding by government health regulations.

Ethical Approval. The longitudinal cohort study of preterm-born children received ethical approval from the School of Psychology Research Ethics Committee (Trinity College Dublin; Appendix G) and the Research Ethics Committee of the Coombe Women and Infants University Hospital (Appendix H). The information leaflet, consent form, and debriefing sheet used with the families who were recruited from the community and from the medical study can be found in the Appendices I and J, respectively.

Typically Developing Cohort

The participants in the typically developing cohort were recruited from the local community (primarily in Dublin, Ireland) through placing advertisements on social media, parenting forums, and in crèches. These advertisements invited families with 2-year-old infants to take part in a study about parent-infant interaction and development. The first wave of data collection occurred between 2014 and 2017, and involved families with typically developing 2-year-old infants. Since then, three more waves of data collection have been conducted when the children were approximately 3, 4, and 9 years of age.

Note that this cohort was named “typically developing” by the Infant and Child Research Lab to distinguish it from other clinical cohorts which were being investigated by the lab (e.g., Down syndrome cohort). The author uses the term “typically developing” here to maintain continuity with previous studies conducted at the lab. Through using the term “typically developing”, the author does not intend to imply that the preterm-born cohort is atypical in any way.

Ethical Approval. The longitudinal cohort study of typically developing children received ethical approval from the School of Psychology Research Ethics Committee (Trinity

College Dublin; Appendix K). The information leaflet, consent form, and debriefing sheet used with the families of the typically developing cohort (wave 1) can be found in Appendix L.

Methodology

As outlined previously, these two longitudinal projects investigate the parent-child interactions and development of preterm-born and typically developing children. The primary methods used by these projects include standardised developmental assessments (e.g., Bayley-III), parent-report measures of parent/child characteristics (e.g., child executive function skills), and observational measures of parent-child interactions. While standardised developmental assessments and parent-report measures are frequently used in developmental research, observational measures are less common. Hence, the following section discusses the conceptual value of observational measures as well as the methodological considerations associated with their use.

Observational Methods

Observations of parent-child interactions can allow for the naturalistic characterisation of an array of interpersonal dynamics (e.g., dyadic synchrony). Furthermore, the microanalytic coding of parent-child interactions can facilitate an understanding of the origins of such dyadic features through capturing the moment-by-moment unfolding of parent/child behaviours (Aspland & Gardner, 2003; Gardner, 2000). Such insights can be difficult to obtain through alternative methods, such as parent-report, as dyadic concepts (such as synchrony) may be variously interpreted by differing respondents (Gardner, 2000). Furthermore, parents may be unaware of (and thus unable to report on) the rapid parent-child behavioural sequences underlying the emergence of such features (Gardner, 2000).

Observational recordings of parent-child interactions can be obtained in a variety of ways. For example, variations are possible in the duration (e.g., daylong recording or brief 5-

10 minute recording) and setting (e.g., laboratory or home) of observational recordings. Importantly, the duration and setting of observations are not entirely independent (e.g., while daylong recordings can be obtained in the home but not the laboratory, brief semi-structured interactions may be observed in either setting), and the appropriateness of each observational approach depends on the research questions being pursued (Gardner, 2000).

The studies in Chapters 5 and 6 sought to characterise the linguistic and dyadic features of parent-child conversations through observing brief semi-structured parent-child play interactions in a laboratory setting. The alignment between these research objectives and observational measures are outlined below while discussing the methodological factors which must be considered when employing observational methods.

Observation Duration. An initial important consideration is the qualitatively different insights that are offered by daylong recordings and by recordings of brief semi-structured interactions (e.g., 5-10 minute interaction observed in the home/laboratory). Daylong recordings can provide a naturalistic window into children's daily exposure to certain parenting behaviours, as well as the context in which this exposure occurs (e.g., the amount of parental speech that the child is exposed to during mealtimes). In contrast, brief semi-structured parent-child interactions (e.g., dyadic parent-child play involving a standardised set of toys) provide detailed insights into the parent-child dynamics which characterise concentrated periods of parent-child engagement (e.g., frequency of parent-child conversational turn-taking during joint toy play). Thus, while daylong recordings can capture the daily occurrence of parent-child interactions, brief semi-structured interactions can capture what transpires during these engagements.

Since the studies in Chapters 5 and 6 seek to characterise the linguistic and dyadic features of the parent-child conversations experienced by preterm-born children, brief semi-structured observations can be understood to be best suited to this goal.

Observation Setting. Brief semi-structured interactions can be recorded in a laboratory or in the family home. When choosing between these two settings, the reactivity and physical embeddedness of human behaviours must be considered. With regard to reactivity, the use of minimally obtrusive observational techniques is imperative as the perceived presence of an observer could alter the behaviour of research participants (Gardner, 2000). In comparison to the use of manually-operated cameras during observations in the home, the more inconspicuous recording equipment provided by purpose-built observation facilities (e.g., remotely operated wall-mounted cameras) may offer a more unobtrusive means of recording parent-child interactions.

With reference to the physical embeddedness of human behaviour (e.g., Tamis-LeMonda & Masek, 2023), researchers must be sensitive to the influence that variations in the home environment may have on the behaviour of the observed individuals. Such environmental variations (e.g., space, noise) could create spurious differences between the observational measures obtained from different families and thereby reduce the ability to detect effects of theoretical interest. The use of a standardised observational setting (e.g., a laboratory setting) can help to mitigate such confounding influences through increasing the comparability of observations obtained across different families. Furthermore, standardised observational settings are immune to changes over time in home environments (e.g., increasing presence of technology), and can thus be particularly valuable when comparing across cohorts which have been recruited and tested during different time periods.

As the studies in Chapters 5 and 6 sought to analyse comparable recordings of dyads from differing households and time-periods, observational recordings obtained using the unobtrusive recording equipment in the purpose-built observation facility of the Infant and Child Research Lab can be understood to be preferable to those obtained in the home environment.

Procedure

Similar procedures were used to test the 2-year-old infants in the typically developing cohort (participants at wave 1) and in the preterm-born cohort (a subset of participants at wave 1). Parents in each cohort completed questionnaires (regarding their family's sociodemographic characteristics, their own parenting experiences, and their child's development) and attended an in-person appointment at the university laboratory alongside their child.

The in-person appointment was conducted at the purpose-built testing facility of the Infant and Child Research Lab (Trinity College Dublin). The testing facility consists of a lab play room and an adjoining observation room. The lab play room is furnished with a table and chairs to facilitate the administration of developmental assessments. The room also contains a soft play mat, two wall-mounted cameras, and a hidden audio-recorder to enable the recording of parent-child interactions. The observation room is equipped with audio-visual recording software which allows for the monitoring of parent-child interactions and the remote controlling of the wall-mounted cameras.

Each appointment at the lab lasted approximately 2.5 to 3 hours (families were offered breaks when needed). During the appointment, a trained examiner administered a standardised developmental assessment to the child (Bayley-III assessment) and recorded a series of semi-structured parent-child interactions. Further details of these observational recordings are outlined below.

Parent-Infant Observations

The families in each cohort engaged in six recorded interactions. Specifically, the mother-father-child triad, the mother-child dyad, and the father-child dyad were each observed as they engaged in a free-play task and a structured-play task. In both the triadic and dyadic contexts, the free-play and structured-play tasks were differentiated by the toys and instructions that were given to the participating families. Each interaction recording began with the examiner presenting a toy or toys to the parent and child. The examiner then left the room, and returned at the end of the 5-10 minute recording period. In each cohort, triadic interactions were observed first.

Triadic Structured-Play and Free-Play. During the triadic structured-play interactions, the mother-father-child triad was presented with either a teddy-bear skills puzzle board (typically developing cohort) or a door skills puzzle board (preterm-born cohort). The teddy-bear skills puzzle board featured removable pieces that allowed the child to practice a range of dressing skills (e.g., using zips, fastening buttons). The door skills puzzle board featured a range of doors with knobs and latches which could be opened/closed. When presented with these toys, the parents were asked to assist their child to attempt as many of the skills as possible.

During the triadic free-play interactions, the mother-father-child triad was presented with a box of age-appropriate toys (e.g., building blocks, toy cars, balls). The mother and father were asked to play with their child as they normally would at home.

Dyadic Structured-Play and Free-Play. After recording the triadic structured-/free-play interactions, the mother-child/father-child dyadic interactions were recorded. Specifically, the dyadic structured-/free-play interactions involving one parent (e.g., mother) were recorded, following which the same set of dyadic structured-/free-play interactions involving the second parent (e.g., father) were recorded (mother-father order was counterbalanced across families). During each dyadic recording, the non-participating parent (i.e., father in the case of the mother-child dyad) was asked to vacate the room.

During the dyadic structured-play task, the examiner presented the parent-child dyad with a magnetic puzzle board. One dyad (e.g., mother-child dyad) was presented with a race-car themed puzzle board and the other dyad (e.g., father-child dyad) was presented with an aquatically themed puzzle board (the presentation of the race-car/aquatically themed puzzle boards to the mother/father was counterbalanced across families). Each puzzle-board contained ten loose puzzle pieces which could be removed using a magnetic apparatus resembling a fishing rod (a magnet attached to a piece of wood with a short length of string). The parent was asked to help their child to use the fishing rod to remove as many of the puzzle pieces as possible.

During the dyadic free-play task, the parent-child dyad was presented with the same box of toys as that used during the triadic free-play task. Again, the parents were asked to play with their child as they normally would at home.

Procedural Variations

A number of differences existed between the testing protocols used with the preterm-born cohort and the typically developing cohort. These differences are outlined below, with a dedicated subsection to describe the measures which were taken to mitigate the spread of COVID-19 while testing the preterm-born cohort.

Firstly, the duration for which each parent-child interaction was recorded varied between the preterm-born and typically developing cohorts. Among the preterm-born cohort, each triadic/dyadic free-play/structured-play interaction was recorded for 5 minutes. Meanwhile, among the typically developing cohort, each triadic and dyadic free-play interaction was recorded for 10 minutes, while each triadic and dyadic structured-play interaction was recorded for 5 minutes.

Secondly, the sequencing of the developmental assessment and interaction recordings during the in-person appointment differed between the two cohorts. In the preterm-born cohort, all six interaction sessions were recorded prior to administering the Bayley-III assessment. Among the typically developing cohort, the triadic structured-/free-play interactions were recorded first, following which the cognitive subtest of the Bayley-III was administered. After completing the cognitive subtest, the child was then recorded as they engaged in dyadic structured-/free-play with one parent (e.g., the mother). After observing this first set of dyadic interactions, the language subtest of the Bayley-III was administered. Finally, after completing the language subtest, the child was observed as they engaged in dyadic structured-/free-play with the second parent (e.g., father).

Thirdly, while the full Bayley-III assessment (comprising the cognitive, language, and motor subtests) was administered to the preterm-born cohort, only the cognitive and language subtests were administered to the typically developing cohort.

COVID-19. As the recruitment/testing of the preterm-born cohort (between 2021 and 2022) coincided with the COVID-19 pandemic, the fieldwork involving this cohort was conducted while observing government health regulations. These necessary precautions resulted in a number of procedural deviations from the testing protocol which had been implemented with the typically developing cohort. These precautions and procedural variations are outlined below.

In the 24 hours prior to their in-person appointment, the examiners contacted the participating families by phone to complete a COVID-19 screening questionnaire (Appendix M). This questionnaire asked parents to report on whether they or their child was (i) experiencing any symptoms of COVID-19, (ii) a close contact of an individual with COVID-19, (iii) self-isolating. If a family responded affirmatively to any of these questions, the appointment was rescheduled for a later date. Parents were additionally asked if they had travelled to Ireland from a foreign country within the past 14 days. If they had travelled, they were asked to confirm that they had abided by government regulations regarding international travel.

On the morning of the appointment, the examiners personally completed the COVID-19 screening questionnaire as well as a temperature check (body temperature < 38 °C) to ensure that they were symptom-free. At the time of the appointment, the family was greeted at either the entrance to the Trinity College Dublin campus, or the entrance to the Psychology building (where the Infant and Child Research Lab is located). The COVID screening questionnaire was repeated, and the body temperature of parents was checked using an infrared thermometer. If the COVID questionnaire responses and temperature check were satisfactory, the family was invited into the Psychology building. When entering the building, parents were requested to sanitise their hands and to wear FFP2 masks which were provided by the research team. The FFP2 masks were worn by parents throughout the appointment, with the exception of the interaction recordings when the examiner had vacated the room. The examiner wore an FFP2 mask at all times during the appointment and sanitised their hands after coming into contact with high-touch surfaces.

To curb the spread of the virus, the observation room, assessment materials, and free-/structured-play toys were thoroughly disinfected after each appointment. Some of the toys which had been used with the typically developing cohort featured fabric surfaces which could not be sanitised. Hence, these toys were replaced with non-fabric alternatives (e.g., a fabric soccer ball was replaced with a plastic ball). As the triadic structured-play toy which was used with the typically developing cohort (teddy-bear skills board) featured fabric parts, this toy was replaced with the doors skills board.

Finally, to reduce the amount of time that the family spent in the laboratory, parents in the preterm-born cohort completed the parental questionnaires online. This contrasts with the typically developing cohort who had completed these questionnaires during the in-person appointment at the laboratory.

4.3 Participants, Measures, and Analyses in Chapters 5 and 6

Participants

As outlined previously, the preterm-born and term-born samples of the studies in Chapters 5 and 6 constitute subsamples of the preterm-born and typically developing longitudinal cohorts described in Section 4.2. As the studies in these chapters sought to address the lack of literature on the parent-child conversations experienced by preterm-born children during late infancy/early toddlerhood, infants of approximately 2 years of age were selected from each cohort.

During this subsampling process, the age of preterm-born children under 24 months was "corrected" for their degree of prematurity. As outlined in Chapter 1, adjusting age for prematurity allows for preterm-term comparisons which are not confounded by between-group discrepancies in biological maturity. There are conflicting views regarding the age at which such adjustments should stop being applied. As the standardised developmental assessment which was administered to both the preterm-born and typically developing cohorts – the Bayley-III (Bayley, 2006) – specifies that at 24 months, age should no longer be adjusted for, this criterion was applied consistently throughout the subsampling procedure as well as in the statistical analyses in Chapters 5 and 6.

Subsampling Procedure

Preterm-Born Sample. The preterm-born cohort included 72 children. Within this cohort, observational data were not available for 23 children (22 did not participate in the observational recording, and one child used a non-English language during the observation which could not be transcribed). Of the 49 children with observational data (age range: 22-58 months), 18 children (community-recruitment = 12; medical study recruitment = 6) were aged < 36 months and were thus included in this thesis. Five children in the typically developing cohort were identified to be born preterm (< 37 weeks' gestation) and to be aged

< 36 months (at wave 1) and were thus also included in this thesis. This yielded a total preterm-born sample of 23 infants.

Term-Born Sample. To date, the typically developing cohort has been tested at four time-points (at approximately 2 years, 3 years, 4 years, and 9 years of age). As the current thesis focuses on the late infancy/toddlerhood period, data from wave 1 (at approximately 2 years of age) were used. At wave 1, the typically developing cohort contained 71 term-born children (≥ 37 weeks' gestation) with observational data. A subset of this group was selected to comprise the term-born sample for the studies in Chapters 5 and 6.

While the studies in Chapters 5 and 6 were cross-sectional, it was anticipated that future longitudinal analyses may be conducted once follow-up assessments of the preterm-born cohort have been completed. To allow for such longitudinal analyses, the 71 term-born children were first filtered to retain only those who participated at both waves 1 and 2. This resulted in a smaller longitudinal sample of 33 term-born children.

Due to time constraints, it would not be possible to microanalytically code the data from all 33 children (19 female, 14 male). Hence a smaller sample of 25 children was chosen by matching the term-born children to the aforementioned preterm-born sample on demographic characteristics. To match the sex balance and age profile of the preterm-born sample, the term-born sample was chosen by selecting all 14 male children and through selecting the 11 oldest female children. This participant matching was conducted manually as propensity score matching had not achieved statistically satisfactory solutions (as determined through balance diagnostics).

Demographic Details

The demographic characteristics of the selected preterm-born (n = 23) and term-born (n = 25) samples are displayed in Table 4.3.1. Both samples consisted of English-speaking singleton-born children who were being raised in two-parent households. The ethnicity of all participating families was White. Among the preterm-born children, five children were born extremely preterm (< 28 weeks' gestation; 21.74%), seven were born very preterm (28 ~ < 32 weeks' gestation; 30.43%), and 11 were born moderate-to-late preterm (32 ~ < 37 weeks' gestation; 47.83%).

As there are slight differences in the inclusion/exclusion criteria of each study, formal statistical comparisons of the demographic characteristics of the preterm- and term-born samples are carried out in each individual study (see Chapters 5 and 6).

Table 4.3.1

Demographic Characteristics of the Preterm-Born (n = 23) and Term-Born (n = 25) Samples

	Preterm			Term		
	%	*M (SD)*	Range	%	*M(SD)*	Range
Infant						
Sex (female)	43.48	—	—	44.00	—	—
Age (months) [a]	—	26.92 (3.75)	20.87 - 33.07	—	24.30 (1.41)	22.00 - 27.03
Gestational age (weeks) [b]	—	31.07 (3.72)	24.00 - 36.71	—	≥ 37.00 (N/A)	≥ 37.00
Mother						
Age (years) [c]	—	37.43 (3.12)	32.00 - 44.00	—	35.04 (5.03)	25.00 - 45.00
Highest level of education						
Second-level qualification	0	—	—	0	—	—
Third-level qualification	47.83	—	—	72.00	—	—
Postgraduate qualification	43.48	—	—	28.00	—	—
Missing data	8.70	—	—	0	—	—
Father						
Age (years) [d]	—	40.11 (3.97)	33.00 - 48.00	—	37.00 (6.77)	23.00 - 55.00
Highest level of education						
Second-level qualification	8.70	—	—	20.00	—	—
Third-level qualification	39.13	—	—	60.00	—	—
Postgraduate qualification	30.43	—	—	20.00	—	—
Missing data	21.74	—	—	0	—	—

Note. [a] Corrected age for preterm-born infants < 24 months of age. [b] Gestational age in weeks was not reported by families with term-born infants. [c] Data missing for three families (two preterm, one term). [d] Data missing for six families (five preterm, one term).

Measures

Sociodemographic Measures

Infant Sex. The infant's sex (male or female) was reported by parents.

Infant Age. The infant's age was calculated as the difference between the infant's date of birth (as reported by the parent) and the date of the in-person appointment. This difference was first expressed in months and days and then converted to a single decimal figure through dividing the number of days by 30 (e.g., 25 months and 15 days → 25.5 months). As outlined previously, the age of preterm-born infants < 24 months of age was adjusted for prematurity.

Infant Gestational Age. Parents of preterm-born infants reported the gestational age of their infant in weeks and days. These responses were converted to a single decimal figure through dividing the number of days by 7 (e.g., 28 weeks and 4 days → 28.57 weeks). Parents of term-born infants were not requested to report the gestational age of their infant.

Parent Education. Mothers and fathers each reported the highest level of education they had attained on a scale ranging from "*1 = no formal education*" to "*8 = doctorate or higher*". The educational attainment of the mother was used as a proxy measure of the socioeconomic status of the infant's household.

Developmental Measures

Bayley Scales of Infant and Toddler Development (3rd edition; Bayley, 2006). The Bayley-III is a standardised tool which assesses the development of 1- to 42-month-old children. This tool uses examiner-administered tests to assess the child's cognitive, language, and motor development, while parent-report measures are used to ascertain the infant's social-emotional and adaptive development. The current thesis used scores corresponding to the cognitive, language, and social-emotional domains.

Cognitive. The cognitive scale assesses the child's memory and sensorimotor skills, as well as their understanding of concepts and object relatedness. The child's responses to the items of the cognitive test were summed to create a raw score, which was then converted into a norm-referenced scaled score (normative mean of 10 and standard deviation of 3; split-half reliability = .91; Bayley, 2006).

Language. The language scale comprises a receptive communication and expressive communication subtest. The receptive communication subtest assesses preverbal communicative behaviours, social referencing abilities, vocabulary skills (e.g., identifying named objects), and morphological skills (e.g., understanding pronouns, prepositions, and morphological markers). Meanwhile, the expressive communication subtest assesses preverbal communication (e.g., gesture use), vocabulary (e.g., naming pictures and object attributes), and morphosyntactic (e.g., producing multiple-word utterances) skills.

Norm-referenced scaled scores (normative mean of 10 and standard deviation of 3) were computed for the receptive communication subtest (split-half reliability = .87; Bayley, 2006) and the expressive communication subtest (split-half reliability = .91; Bayley, 2006). A language composite score was additionally computed through standardising the sum of the receptive and expressive scaled scores (normative mean of 100 and standard deviation of 15; split-half reliability = .93; Bayley, 2006).

Social-Emotional. The social-emotional scale assesses the child's ability to self-regulate, adaptively manage their emotions, and engage in inter-personal interactions and relationships. Parental responses to the items of the social-emotional questionnaire were summed to create a raw score which was then converted to a norm-referenced scaled score (normative mean of 10 and standard deviation of 3; Cronbach's alpha = .90; Bayley, 2006).

Interpretation of Scaled Scores. For each of the measures outlined above, higher scaled scores reflect higher levels of ability. In line with Johnson et al. (2014), scores > 1 standard deviation below the normative mean were taken to signify possible developmental delays.

Behavior Rating Inventory of Executive Function Preschool (BRIEF-P; Gioia et al., 2003). The BRIEF-P is a questionnaire which assesses the executive function development of children between 24 months and 71 months of age. The questionnaire can be completed by either a parent or teacher. In both the typically developing and preterm-born cohorts, parents were requested to complete this questionnaire. The 63 questionnaire items form five scales reflecting the executive function domains of inhibit (ability to exercise inhibitory control), shift (ability to volitionally switch focus), emotional control (ability to regulate emotional responses), working memory (ability to hold and manipulate information in mind), and plan/organise (ability to engage in systematic goal-oriented action). These five scales form three indices (inhibitory self-control index, flexibility index, emergent meta-cognition index) as well as a composite score (global executive composite). The three indices and composite score were used in this thesis.

Inhibitory Self-Control Index. The inhibitory self-control index comprises the "inhibit" and "emotional control" scales and reflects the child's ability to use inhibitory control to regulate their behaviours and emotions (Cronbach's alpha = .92; Gioia et al., 2003).

Flexibility Index. The flexibility index comprises the "shift" and "emotional control" scales and reflects the child's ability to voluntarily switch between behaviours and emotions (Cronbach's alpha = .89; Gioia et al., 2003).

Emergent Meta-Cognition Index. The emergent meta-cognition index comprises the "working memory" and "plan/organise" scales and reflects the child's ability to take a co-ordinated approach to goal-oriented problem solving (e.g., through planning and implementing a problem-solving strategy; Cronbach's alpha = .91; Gioia et al., 2003).

Global Executive Composite. The global executive composite comprises the five constituent scales of the BRIEF-P (inhibit, shift, emotional control, working memory, plan/organise) and thereby provides an overall measure of the child's executive function skills (Cronbach's alpha = .95; Gioia et al., 2003).

Interpretation of Scaled Scores. In line with the BRIEF-P manual, the raw scores on each scale/index were standardised (normative mean = 50, standard deviation = 10). Higher scaled scores indicate greater levels of executive dysfunction. Scores on each scale/index ≥ 65 signify potentially clinically significant levels of executive dysfunction (Gioia et al., 2003).

Observational Measures

The recordings of the parent-infant interactions were transcribed and analysed to capture a range of parent/infant speech features and conversational dynamics. The following subsections outline how interaction recordings were selected for transcription, and how the selected recordings were transcribed and analysed to calculate these speech/conversational measures.

Sampling Recordings. A key objective of Chapter 5 was to examine how the dyadic conversational dynamics experienced by preterm-born infants in early infancy (e.g., Reissland & Stephenson, 1999; Salerni et al., 2007) may also characterise the conversations experienced by preterm-born infants in later infancy/early toddlerhood. To conceptually replicate and extend these previous studies, this thesis specifically analysed the recordings of dyadic mother-infant and father-infant free-play interactions.

As mentioned previously, each dyadic free-play interaction was recorded for 5 minutes among the preterm-born cohort and for 10 minutes among the typically developing cohort. In order to analyse recordings of similar durations, a 5 minute segment of each 10 minute recording was analysed. Specifically, the first uninterrupted 5 minute segment of each

10 minute recording was chosen (interruptions included the examiner entering the play room mid-recording). Since the frequency of verbal behaviours has been found to change across the period of observation (Burgess et al., 2023), choosing the first 5 minutes maximised the comparability of the recordings which were analysed for the preterm-born and term-born cohorts.

Transcribing. The dyadic free-play interactions were transcribed at the utterance-level in accordance with the Codes for the Human Analysis of Transcripts (CHAT; MacWhinney, 2000). Utterances were defined as speech-units which were separated by a pause, change in intonation, or grammatical structure. The audio waveform was inspected to time-stamp each transcribed utterance with a start- and end-time. All of the completed transcripts were reviewed and corrected by a senior transcriber (thesis co-supervisor: Dr. Jean Quigley).

Analysis of Transcripts. A key difference between the parent-child vocal exchanges which occur in early infancy (≤ 6 months, as in Salerni et al., 2007 and Reissland & Stephenson, 1999) and in later infancy/toddlerhood (2 years of age, as in the current thesis) is the ability of the child to verbally express themselves during the latter period of development. The onset of verbal skills fundamentally alters the mechanisms underlying parent-child turn-taking. The verbal child faces the novel challenge of integrating their linguistic and interactional skills to respond to their parent's utterances (Casillas et al., 2016). This concurrently presents a new challenge for parents who must now comprehend and respond to their infant's linguistic (rather than pre-linguistic) vocalisations.

To provide a fine-grained examination of the conversational dynamics underlying this newly verbal exchange, the completed transcripts were manually filtered to retain only the speech-related vocalisations of the parent and infant. Specifically, speech segments, conversational fillers, and unintelligible utterances were retained. Meanwhile, non-voluntary sounds and voluntary but non-conversational sounds (e.g., vegetative sounds, singing, crying, laughing) were removed. Utterances which featured both qualifying and disqualifying features were retained in the transcripts (e.g., speech [qualifying] produced while crying [disqualifying]).

These filtered transcripts were analysed using the Computerised Language Analysis program (CLAN; MacWhinney, 2000) to characterise parent/infant speech on a range of linguistic (e.g., lexical diversity, morphosyntactic complexity) and paralinguistic (e.g., speech rate) features. A variety of dyadic conversational dynamics (e.g., parent/infant responsiveness, turn-taking) were additionally quantified through manually annotating the transcripts to identify temporally-contingent speaker transitions (in line with Van Egeren et al., 2001, a temporally-contingent transition was identified as a gap of < 2 seconds between the end of one speaker's utterance and the start of the second speaker's utterance).

While such speaker-transitions can be annotated automatically using software such as LENA, manual annotation was favoured in this thesis given the lack of certainty regarding the validity of automatic annotations. For example, a systematic review of LENA validation studies (Cristia et al., 2020) investigated the comparability of turn-taking measures obtained through manual and automatic (LENA) annotations of the same recordings. Relative to the manual annotations, this review found LENA to underestimate the occurrence of conversational turn-taking. Given these findings, manual annotation was used in this thesis to maximise the precision and accuracy of the dyadic conversational measures. An additional benefit of manually annotating the temporal contingency of speaker transitions on the transcripts themselves is that the transcripts can later be used to investigate the semantic relatedness of the contingent transitions.

Further details of the operationalisation and calculation of each speech and conversational measure are provided in Chapters 5 and 6.

Statistical Analyses

The statistical analyses in Chapters 5 and 6 were conducted in R (version 4.2.2; R Core Team, 2022). Unless stated otherwise, statistical significance tests used an alpha level of .05 (two-tailed). The sociodemographic characteristics of family socioeconomic status, infant sex, and infant age were controlled in a subset of analyses. Socioeconomic status and infant sex were chosen as each has been found to be associated with birth status (Joseph et al., 2014; Peelen et al., 2021) and language development (McNally & Quigley, 2014; Pace et al., 2017). Infant age was chosen as the descriptive statistics in Table 4.3.1 suggested that the preterm-born sample was marginally older than the term-born sample.

4.4 Author's Contribution

Fieldwork

The author and Merve Ataman (PhD student) were responsible for the fieldwork (participant recruitment and data collection) involving the preterm-born cohort. The participant recruitment process was outlined above, and data collection involved distributing online questionnaires, scheduling in-person appointments, administering standardised developmental assessments, and recording parent-child interactions. The author was not involved in the recruitment or data collection associated with the longitudinal study of typically developing children.

Analyses

The parent-child interactions of the preterm-born and term-born samples were transcribed by research assistants (or PhD students) working in the Infant and Child Research Lab. The author analysed the transcripts using computer software to characterise the linguistic features of parent/child speech. The author also manually annotated the completed transcripts to code the dyadic conversational features of the parent-child interactions (e.g., responsiveness, turn-taking). The author conducted the statistical analyses in this thesis.

Chapter 5: Constructing a Language Environment in the Context of Preterm Birth

Study Details

Study 3.1 (Chapter 3) investigated how features of the parent, child, and parent-child relationship longitudinally contribute to the association between preterm birth and language development. To complement the insights offered by these multifaceted path models, the studies in Chapter 5 advanced a deeper understanding of preterm language development through pursuing a targeted examination of parent-child interactions.

The literature review in Chapter 1 illustrated how parent-child interactions reflect the confluence of parent and child characteristics. Furthermore, this review demonstrated how the conversations that occur during these interactions can play a pivotal role in early language development through shaping the child's language environment. In spite of the unique parent/child characteristics and language difficulties associated with preterm birth, few studies have characterised the language environments experienced by preterm-born children. Even fewer studies have examined how the language environment may be associated with the language development of preterm-born infants.

To address this gap in knowledge, Study 5.1, Study 5.2, and Study 5.3 used observational data from the Infant and Child Research Lab (see Chapter 4 for details) to investigate the characteristics and developmental implications of the preterm language environment.

Study 5.1

Mother-infant vocal exchanges involving preterm-born infants have been found to be characterised by lower levels of synchrony when compared to those involving term-born infants (Reissland & Stephenson, 1999; Salerni et al., 2007). Since these investigations have been conducted among infants ≤ 6 months of age, it is unclear whether this pattern of reduced synchrony similarly characterises mother-infant exchanges in later infancy. Furthermore, since these studies have focused on mother-infant dyads, there is limited understanding of the conversational dynamics which characterise father-infant dyads following preterm birth. Study 5.1 addressed these outstanding questions by characterising the dynamics of mother-infant and father-infant conversations involving 2-year-old verbal preterm-born infants.

Study 5.2

Study 5.2 builds on the findings of Study 5.1 through examining whether the language environment features which were found to characterise the preterm-born sample significantly differ from those characterising a term-born sample. This study additionally investigated how these preterm-term contrasts may be moderated by the gender of the conversing parent (mother/father).

Study 5.3

Chapter 1 identified how parenting behaviours can differentially affect the development of preterm- and term-born children. Nonetheless, very little research has investigated the differential effect of parent-child conversations on the language development of preterm- and term-born groups. To understand the developmental significance of the preterm-term contrasts examined in Study 5.2, Study 5.3 investigated how language environment features associate with the development of preterm- and term-born infants.

Publication Status

Study 5.2 is in-press at Journal of Speech, Language, and Hearing Research. Study 5.3 has been published in Journal of Experimental Child Psychology (https://doi.org/10.1016/j.jecp.2023.105809).

Studies

Study 5.1: Conversational Synchrony and Turn-Taking following Preterm Birth: Associations with Language Development

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Author Note

The first author (Sarah Coughlan) was responsible for the conceptualisation, formal analysis, and writing of this paper. These responsibilities were carried out under the guidance of the second and third authors (thesis supervisors).

The data analysed in this paper were collected and curated by the research team at the Infant and Child Research Lab (Trinity College Dublin). As part of this collective effort, the first author contributed to data collection through engaging in participant recruitment, scheduling, and testing. Recordings of parent-child interactions were transcribed by research assistants and past PhD students. These transcripts were microanalytically annotated and analysed by the first author.

Abstract

While preterm birth (< 37 weeks' gestation) is associated with language difficulties, few studies have investigated the parent-infant conversations within which these language skills develop. The current study examined mother-infant and father-infant conversational synchrony and turn-taking among 22 families with two-year-old preterm-born infants (10 female). The association between turn-taking and the infant's linguistic (receptive/expressive communication) and non-linguistic (executive function, cognitive, social-emotional) development was also investigated. Turn-taking features were manually annotated from five-minute recordings of mother-infant and father-infant dyadic free-play interactions, while infant development was assessed using direct assessments and parent-report questionnaires. Mother-infant and father-infant dyads exhibited limited conversational synchrony. While non-linguistic development was not associated with turn-taking, receptive and expressive communication were respectively positively associated with the rate of mother-infant turn-taking and the temporal duration of father-infant turn-taking exchanges. The findings indicate that preterm-born infants' language development is linked with conversational experiences through mechanistic pathways which may differ across social relationships.

Keywords: turn-taking, conversational synchrony, father-infant interaction, preterm birth, infant language

Introduction

Numerous studies have identified links between the language environment and language development of young children (e.g., Gilkerson et al., 2017; Gilkerson et al., 2018). While much research has focused on the developmental significance of linguistic features of the language environment (e.g., quantity and quality of parental speech), a growing body of literature is demonstrating the importance of the conversational context in which these features are experienced by the child. For instance, temporally contingent back-and-forth conversational exchanges (turn-taking) have been found to be positively associated with language development (e.g., Donnelly & Kidd, 2021).

The frequency and nature of turn-taking hinges upon speakers achieving conversational synchrony through exercising interpersonal mutuality and coordination (Leclère et al., 2014). Such conversational synchrony and interpersonal adaptation can vary across dyads and within dyads across development (Chai et al., 2022; Hsu & Fogel, 2003; Leclère et al., 2014; Reissland & Stephenson, 1999). For example, in comparison to term-born infants, preterm-born infants (< 37 weeks' gestation; World Health Organisation, 2012) exhibit poorer language development across childhood (van Noort-van der Spek et al., 2012) and lower levels of synchrony in mother-infant vocal exchanges during the first six months of life (i.e., prior to the onset of verbal skills; Reissland & Stephenson, 1999; Salerni et al., 2007). The current study adopts dynamic systems (Spencer et al., 2011), social-interactionist (Bruner, 1983), and transactional (Fiese & Sameroff, 1989) perspectives to investigate the patterns of conversational synchrony and turn-taking which characterise the dyadic exchanges of mothers and fathers with their verbal two-year-old preterm-born infants. Associations between turn-taking and the linguistic and non-linguistic development of preterm-born infants are also examined.

Conversational Synchrony, Turn-Taking, and Language Development

The language environment can be broadly characterised on quantitative and qualitative dimensions. The quantitative dimension can include the number of words, utterances, and/or gestures in language input (Bang et al., 2020). Meanwhile, the qualitative dimension encompasses three categories of features (Rowe & Snow, 2020): interactional (e.g., contingent responding), linguistic (e.g., lexical and grammatical complexity of input), and conceptual (e.g., language relating to abstract or hypothetical topics). The interactional features of the qualitative dimension critically underpin conversational synchrony through encompassing mutually contingent and responsive speaker behaviours which facilitate conversational turn-taking.

Turn-Pairs

The association between conversational turn-taking and language development has been investigated by examining the temporal organisation of adult and child vocalisations within naturalistic daylong home audio recordings or within home-/lab-based recordings of shorter semi-structured interactional episodes (e.g., book sharing and toy play). These recordings are annotated manually or using automated procedures (e.g., Language Environment Analysis [LENA] system) to count the number of times one speaker's turn (e.g., infant's turn) is followed by a temporally contingent response by the conversation partner (e.g., adult). While there is variability between studies in the temporal window for contingent responses (many studies have adopted a 5 second window to align with LENA defaults), each temporally contingent speaker transition is denoted a turn-pair. Higher numbers of turn-pairs are taken to reflect greater turn-taking and thus greater conversational engagement.

Consistent with the hypothesised association between conversational engagement (as reflected in turn-taking) and language development, a meta-analysis of studies utilising the LENA system found significant positive associations between adult-infant turn-pairs and the expressive and receptive language skills of children between two months and four years of age (Wang et al., 2020). More recent investigations of naturalistic daylong home audio recordings have provided greater insight regarding the direction of this effect. In an example of the prospective effect of turn-taking on language development, an intervention study found that parent language coaching (when infants were aged 6-18 months) positively affected infants' expressive vocabulary (at 18 months) through increasing the number of adult-infant conversational turn-pairs (at 14 months; Huber et al., 2023). Meanwhile, the reverse contribution of language skills to turn-taking has been demonstrated by an observational study which found bidirectional longitudinal associations between growth in the number of adult-infant turn-pairs and growth in parent-reported vocabulary between 9 and 24 months of age (Donnelly & Kidd, 2021). Finally, a biological basis to these associations has been suggested by findings among four- to seven-year-old children that functional and structural variations in language-related brain areas mediate the association between adult-infant turn-pairs and language skills (Romeo et al., 2021; Romeo et al., 2018).

Since the association between turn-pairs and language development remains statistically significant after controlling for variations in individual speaker behaviours (e.g., adult and child volubility; Donnelly & Kidd, 2021; Huber et al., 2023; Romeo et al., 2018), explanations for this relationship must invoke dyadic conversational processes. To explain the effect of turn-taking on language development, it has been proposed that contingent adult-child exchanges may heighten a child's attention to ongoing activities and thereby enhance the child's ability to process incoming speech and to learn from the direct (e.g., parental reformulations) and indirect (e.g., clarification request from parents which reflects a communicative breakdown) contingent feedback that they receive on their own speech productions (Masek, McMillan, et al., 2021; Nikolaus & Fourtassi, 2023). Through engaging in conversations with their children, parents may also learn how to adjust their speech outputs to align with their child's linguistic capabilities and communicative preferences (Snow, 1995; Wang et al., 2020; Yurovsky, 2018; Zimmerman et al., 2009).

In the opposite direction, child language abilities may shape the frequency and nature of turn-taking exchanges through affecting the child's real-time comprehension and production of speech and through affecting the responses elicited from conversational partners (Casillas et al., 2016; Donnelly & Kidd, 2021; Gilkerson et al., 2018; Masek, McMillan, et al., 2021). These two directions of effect are not mutually exclusive and may operate simultaneously to create a dynamic interaction between the child's development and social environment. Such dynamic interactions align with social-interactionist perspectives which propose that language acquisition occurs within co-constructed social exchanges (e.g., Bruner, 1983). More broadly, these bidirectional associations also reflect transactional perspectives (Fiese & Sameroff, 1989) in which the child is viewed as having an active role in their own development through shaping their environment in developmentally significant ways. While proposals have also been made regarding the existence of similar bidirectional associations between turn-taking and non-linguistic competencies (e.g., attentional, social, and emotional skills; Fields-Olivieri & Cole, 2022; Masek, McMillan, et al., 2021; Romeo et al., 2021) which could indirectly facilitate language development, few studies have investigated such pathways to date (though see Romeo et al., 2021 for a demonstration of the association between turn-pairs and executive function).

Multiturn Conversational Episodes

As outlined above, existing explanations for the association between turn-pairs and language development hinge on the mutual and synchronous conversational engagement of a responsive and supportive adult speaker and an active and attentive infant. However, high numbers of turn-pairs cannot guarantee mutuality or synchrony in conversational exchanges as they do not consider the direction of speaker transitions. Specifically, on the basis of turn-pair counts alone, it is not possible to differentiate between conversations in which turn-transitions flow equally in both directions (50% child-to-parent turn-transitions, 50% parent-to-child turn-transitions) and conversations in which turn-pairs are comprised of speaker transitions flowing predominantly in one direction (e.g., 90% child-to-parent turn-transitions, and 10% parent-to-child turn-transitions). While the former would be reflective of conversational synchrony and mutuality, the latter would not.

A more reliable indication of mutual engagement in synchronous conversational exchanges may be provided by measures of extended turn-taking sequences involving at least two consecutive turn-pairs (i.e., child-parent-child transitions, or parent-child-parent transitions). Such multiturn conversational episodes (Beiting et al., 2022) rely on the mutual responsiveness of both speakers and thus may provide a more reliable measure of synchronous conversational engagement and its association with language development. Furthermore, insights into the mechanisms underlying the associations between conversational turn-taking and language development may be gained through examining the duration of multiturn conversational episodes as measured in turns and seconds. While associations between language scores and episode duration in turns may reflect the value of receiving linguistic feedback within contingent back-and-forth exchanges, the association with episode duration in seconds may reflect the importance of engaging in extended periods of shared attention (Beiting et al., 2022).

Despite the potential importance of multiturn conversational episodes, only one published study has investigated this construct. Among a sample of infants between 13 and 27 months of age, Beiting et al. (2022) found language abilities to be significantly associated with the rate of turn-pairs and the rate of multiturn conversational episodes (involving vocal and non-vocal communicative behaviours) occurring during semi-structured mother-infant interactions. Language abilities were not associated with turn-pairs involving only vocal behaviours. No published study has investigated multiturn conversational episodes involving vocal behaviours only. Furthermore, no previous investigation has examined the association between language abilities and the duration of multiturn conversational episodes (measured in either seconds or turns).

Preterm Birth and Conversational Synchrony

Preterm birth is an increasing public health concern given the risks it poses for the survival and neurodevelopment of children (Barra & Coo, 2023). With regards to the neurodevelopmental sequelae, preterm-born children are found to be at elevated risk for expressive and receptive language difficulties (van Noort-van der Spek et al., 2012). These language difficulties are found to affect both grammatical and semantic abilities with inconsistent findings relating to whether these difficulties resolve with age (van Noort-van der Spek et al., 2012). Efforts to elucidate the roots of such developmental difficulties are increasingly adopting dynamic systems-based perspectives (Barra & Coo, 2023). These perspectives advance beyond purely biomedical understandings of preterm birth through conceptualising child development as the outcome of dynamic and reciprocal interactions between the child and the surrounding environment (Barra & Coo, 2023; Ibbotson, 2020; Karmiloff-Smith, 2009; Spencer et al., 2011). These systems perspectives thereby dovetail with the aforementioned social-interactionist (Bruner, 1983) and transactional (Fiese & Sameroff, 1989) perspectives.

From a dynamic systems perspective, it is pertinent to contextualise the language development of preterm-born children with respect to their social environments. In line with such a systems perspective, previous studies have found preterm birth to be associated with unique child and parent characteristics which could hypothetically affect the child's conversational experiences in developmentally impactful ways. Preterm birth is associated not only with linguistic difficulties but also non-linguistic difficulties (e.g., cognitive and social-emotional difficulties; Aylward, 2014; Johnson, Matthews, et al., 2015) and neuropsychological atypicalities (e.g., poorer executive function, slower processing of heard speech; Aylward, 2014; Marchman et al., 2019). These child characteristics may affect the conversational contributions made by preterm-born children and also determine the type of scaffolding that could encourage and support their conversational engagement. Critically, the ability of parents to provide such appropriate conversational supports may be moderated by the lower levels of maternal and paternal mental wellbeing found among parents of preterm- as compared to term-born children (Carson et al., 2015).

In line with these expectancies for an effect of preterm birth on parent-child conversation dynamics, previous studies have found lower levels of synchrony in mother-infant vocal exchanges following preterm- as compared to term-birth. In comparison to term-born dyads, mothers in preterm-born dyads exhibit elevated levels of responsiveness (temporally contingent responding) and a greater likelihood of initiating vocal interactions following a conversational silence (Reissland & Stephenson, 1999; Salerni et al., 2007). In contrast, preterm-born infants are less responsive to maternal utterances and less likely to initiate conversations when compared to their term-born peers (Salerni et al., 2007). These findings suggest that preterm birth may be associated with low levels of mother-infant mutuality (limited reciprocity in responsiveness) and low levels of conversational balance (limited sharing of responsibility for initiating conversations). These conversational features can be summarised as reflecting an interaction between an active mother and passive infant (Reissland & Stephenson, 1999; Salerni et al., 2007). This active-passive dynamic curtails conversational synchrony and critically departs from cross-cultural observations of interpersonal coordination between mothers and typically developing infants (positive correlation between the responsiveness of mothers and infants; Bornstein et al., 2015). Furthermore, this limited interpersonal synchrony may also hinder the dyad’s ability to sustain turn-taking exchanges, and this may manifest in the frequency and duration of the dyad's multiturn conversational episodes.

The abovementioned conversational investigations of preterm-born cohorts have selectively studied mother-infant vocal interactions during the first six months of life. As a result, there is currently no understanding of whether this pattern of reduced conversational synchrony (and the associated active-passive dynamic) may also characterise mother-infant exchanges following the onset of linguistic skills in later infancy. The onset of linguistic skills in the second year of life sets the stage for verbal turn-taking exchanges which differ from preverbal exchanges by requiring the child to integrate their developing interactional skills with their emerging linguistic abilities (Casillas et al., 2016). Furthermore, the infant's increasing use of verbal communicative behaviours may alter the conversational dynamic through eliciting differential response patterns in parents as well as a change in the distribution of conversational responsibilities (e.g., Gilkerson et al., 2018). For instance, a developmental pattern has been observed within parent-infant conversations whereby parents initiate a larger proportion of conversations than six-month-old infants, the same proportion of conversations as one-year-old infants, and a smaller proportion of conversations than two-year-old infants (Chai et al., 2022; Fields-Olivieri & Cole, 2022; Salo et al., 2022). As the mechanisms underlying adult-infant vocal turn-taking can be understood to qualitatively change as children transition from preverbal to verbal communication, the literature on conversational synchrony following preterm birth must be extended beyond early infancy to capture both stages of the communicative development trajectory.

In addition to the gaps outlined above, research is required to investigate whether the positive association between turn-taking and language development documented among typically developing infants may also be seen among preterm-born infants. Many existing studies of typically developing infants have collapsed mother-infant and father-infant interactions to investigate the association between adult-infant turn-pairs and language development (Donnelly & Kidd, 2021; Huber et al., 2023; Romeo et al., 2021; Romeo et al., 2018). A separate investigation of turn-taking in mother-infant and father-infant conversations could illuminate differences both in conversational dynamics and their associations with language development, building on previous studies finding differences between the child-directed speaking styles of mothers and fathers, as well as their respective associations with language development (Shapiro et al., 2021; Tamis-LeMonda et al., 2004). A discrete consideration of mother-infant and father-infant turn-taking would also allow for an examination of their differential susceptibility to ecological factors such as the child's developmental characteristics. This final point is particularly relevant in the context of preterm birth which has been associated with a unique developmental profile.

Current Study

The current study investigated conversational synchrony and turn-taking within mother-infant and father-infant interactions involving two-year-old preterm-born infants. Associations between mother-infant and father-infant turn-taking and the infants' linguistic and non-linguistic development were also examined.

Conversational synchrony and turn-taking were investigated by manually annotating the temporal sequencing of parent and infant non-vegetative vocalisations occurring during mother-infant and father-infant dyadic free-play interactions. The free-play interactions were recorded in a standardised lab setting to counteract the potential confounding of mother-infant and father-infant conversations by differing activity contexts. In line with prior investigations of interactional contingencies (Van Egeren et al., 2001), temporally contingent turn-taking was defined as a turn-transition involving a gap of less than 2 seconds between the end of one speaker's turn and the beginning of the second speaker's turn. With this definition, the following turn-taking variables were quantified: parent (mother/father) and infant responsiveness (proportion of interlocutor turns to which the speaker responded within 2 seconds), coordination of responsiveness (correlation between parent [mother or father] and infant responsiveness), turn-pairs (rate per minute), multiturn conversational episodes (rate per minute), average duration of multiturn conversational episodes (in seconds and in turns), and the proportion of conversations (of any turn duration) initiated by the parent (mother/father). While executive function and social-emotional development was measured via parent-report questionnaires, the infants were administered direct assessments of cognitive and language skills.

In line with dynamic systems (Spencer et al., 2011), social-interactionist (Bruner, 1983), and transactional (Fiese & Sameroff, 1989) perspectives of child development, the above turn-taking and developmental variables were used to address two research objectives.

The first objective was to characterise and compare mother-infant and father-infant conversational turn-taking exchanges involving preterm-born infants. Based on previous investigations of mother-infant vocal exchanges which found preterm birth to be associated with limited conversational synchrony and an active-passive dynamic (Reissland & Stephenson, 1999; Salerni et al., 2007), it was predicted that the mother-infant dyads would exhibit limited signs of interpersonal mutuality and coordination. Specifically, it was hypothesised that mothers would be more responsive than their infants, and that the responsiveness of the mother and infant would not be correlated. While previous studies have found parents to initiate fewer parent-infant conversations than their typically developing two-year-old infants (e.g., Chai et al., 2022), it was hypothesised that an active-passive dynamic would translate into mothers initiating a similar or greater number of conversations than their preterm-born infants. Given the paucity of research on father-infant interactions, no predictions were made regarding the turn-taking dynamics of these dyads.

The second objective was to investigate the association between mother-infant and father-infant turn-taking and the linguistic (receptive communication, expressive communication) and non-linguistic (executive function, cognitive, social-emotional) development of the infant. It was hypothesised that turn-taking (rates of turn-pairs and multiturn conversational episodes) would be positively associated with the infant's linguistic and non-linguistic abilities. Due to the lack of previous research, no predictions were made regarding the association between the duration of multiturn conversational episodes (in seconds or turns) and development.

Method

Participants

Families with two- to four-year old preterm-born infants (< 37 weeks' gestation) were recruited into a larger study on parent-child interaction. Participants were recruited using study advertisements distributed through social media sites and 'home visitors' (trained practitioners who visit families with young children in socioeconomically disadvantaged localities). Study advertisements were also sent to families with preterm-born infants who had previously participated in a medical study and had consented to being contacted about future research projects.

The current study included a subset of 23 two-parent English-speaking families with two-year-old singleton preterm-born infants. One family was removed from the current analysis as the infant was non-verbal. Of the remaining 22 families, the infants (10 female) were aged between 21 and 33 months ($M = 26.98$, $SD = 3.82$; corrected age used for those under 24 months) and had gestational ages between 24 and 36 weeks ($M = 31.19$, $SD = 3.77$).

Mothers were aged between 32 and 41 years ($M = 36.72$; $SD = 2.65$. Four families did not report mother age) with all but one mother reporting to be Irish nationals. With regards to the highest level of education achieved by the participating mothers, 13.64% ($n = 3$) had a third-level non-degree (e.g., diploma), 27.27% (*n* = 6) had a bachelors degree, while 40.91% (*n* = 9) had a masters degree (educational information was not reported by four mothers).

For a variety of reasons (e.g., difficulty taking time off work), fathers in five of the 22 families did not attend the in-person testing session when the dyadic interaction was recorded. The 17 participating fathers were aged between 33 and 44 years (*M* = 39.14, *SD* = 3.46. Three families did not report father age) with all fathers reporting to be Irish nationals. With regards to the highest level of education achieved by the fathers, 11.76% (*n* = 2) had completed high school education, 5.88% (*n* = 1) had a third-level non-degree (e.g., diploma), 35.29% (*n* = 6) had a bachelors degree, while 29.41% (*n* = 5) had a masters degree (educational information was not reported by three fathers).

Procedure

Ethical approval for the broader research project was granted by the Research Ethics Committee of the Coombe Women and Infants University Hospital and the School of Psychology in Trinity College Dublin. Participating mothers and fathers provided written consent on behalf of themselves and their infants before taking part in the study.

Consenting families attended the Infant and Child Research Lab (School of Psychology, Trinity College Dublin) where the infant completed the cognitive and language (receptive and expressive communication) scales of the Bayley Scales of Infant and Toddler Development 3rd edition (Bayley-III; Bayley, 2006) and the parent-infant dyads engaged in recorded play sessions. During the dyadic mother-infant and father-infant free-play interactions, parent-infant pairs were presented with a box of age-appropriate toys (e.g., a ball, toy cars, and building blocks), and parents were requested to play with their infant as they normally would at home. Dyads were video-recorded (using two wall-mounted cameras) and audio-recorded (Zoom H2n Handy Recorder positioned behind a covering in a corner of the playroom) for approximately 5 minutes, starting when the investigator and the second parent vacated the room. The order of the dyadic interaction recordings (mother-infant or father-infant) was counterbalanced to counteract the potentially confounding influence of infant fatigue.

Prior to attending the university lab, consenting parents were also emailed online questionnaires relating to the family's sociodemographic characteristics and the infant's development (e.g., executive function, social-emotional development).

Measures

Child Development Measures

Bayley Scales of Infant and Toddler Development – 3rd edition (Bayley, 2006). Infants were administered the cognitive, receptive communication, and expressive communication scales of the Bayley-III by a trained investigator during their visit to the university lab. Either the mother or father completed the Bayley-III social-emotional questionnaire as part of the online questionnaires that were emailed prior to the lab visit. Scaled scores (reliability in parentheses) for the cognitive (split-half reliability = .91), receptive communication (split-half reliability = .87), expressive communication (split-half reliability = .91), and social-emotional (Cronbach's alpha = .90) scales were included in the present analysis (higher scores indicate higher levels of ability; Bayley, 2006). The scaled scores are distributed with a normative mean and standard deviation of 10 and 3, respectively. In the current study, scaled scores > 1 standard deviation below the normative mean were taken to signal possible developmental delays.

Behavior Rating Inventory of Executive Function Preschool (BRIEF-P; Gioia et al., 2003). Either the mother or father completed the BRIEF-P as part of the emailed online questionnaires. The BRIEF-P consists of 63 items which form five scales reflecting the executive function domains of inhibit, shift, emotional control, working memory, and plan/organise. These five scales form three indices (constituent scales and Cronbach's alpha in parentheses): inhibitory self-control index (inhibit, emotional control; *a* = .92), flexibility index (shift, emotional control; *a* = .89), emergent metacognition index (working memory, plan/organise; *a* = .91). The five scales together form the global executive composite (*a* = .95). The standardised scores on each scale/index are distributed with a normative mean and standard deviation of 50 and 10, respectively. Higher scores indicate greater executive dysfunction, with scores on each scale/index ≥ 65 signifying potentially clinically significant levels of dysfunction (Gioia et al., 2003).

Parent-Child Interaction Recordings

Data Pre-Processing. Audio recordings of the 5-minute mother-infant and father-infant free-play interactions were transcribed at the utterance level in line with the CHILDES CHAT transcription format (MacWhinney, 2000). Utterances were identified as speech units separated by a pause or a change in intonation or grammatical structure. Through viewing the audio waveform, each transcribed utterance was time-stamped with a start and end time. The recordings were first transcribed and time-stamped by trained research assistants. All transcripts were then reviewed and corrected by a senior transcriber (Dr. Jean Quigley).

As the current study was concerned with conversational turn-taking exchanges, the time-stamped transcripts were manually filtered to retain only conversational speech-related vocalisations. To do so, speech segments, conversational fillers, and unintelligible utterances were retained, while non-voluntary sounds and voluntary but non-conversational sounds (e.g., vegetative sounds, singing, crying, laughing) were removed. When an utterance was characterised by both qualifying and disqualifying features (e.g., speech [qualifying] produced while laughing [disqualifying]), the utterance was retained.

Linguistic Measures. Using the CLAN software (MacWhinney, 2000), the filtered and time-stamped transcripts were analysed to characterise the volubility (words per minute), lexical diversity (type-token ratio), and morphosyntactic complexity (mean length of utterance in morphemes, mean length of utterance in words, verbs per utterance) of the speech produced by mothers, fathers, and infants. For the infants, these speech metrics were computed twice to separately characterise infant speech within mother-infant and father-infant interactions.

Mean length of turn ratios were computed to characterise the distribution of conversational load between speakers in mother-infant pairs and father-infant pairs. The ratio was computed by dividing the infant's mean length of turn (words per turn) by the parents' mean length of turn (words per turn). Mean length of turn ratios closer to 1.00 indicate a more equal distribution of conversational load between the parents and infants. For the purposes of the mean length of turn ratio calculation, CLAN defines a "turn" as a sequence of consecutive utterances produced by a single speaker (with no upper or lower limit on the temporal gap between utterances). Note that this definition of "turn" differs from that used in the turn-taking coding outlined in the following section.

Turn-Taking Measures. To capture the temporal organisation of mother-infant and father-infant conversations within the time-stamped transcripts, the following turn-taking features were manually coded.

Turns. Turns were defined as one or more consecutive utterances (separated by pauses no more than 2 seconds) produced by one speaker.

Responsiveness. Responsiveness was defined as the proportion of interlocutor turns to which the speaker responded within 2 seconds. With this definition, the responsiveness of each speaker (mother, father, infant) was calculated. As was the case with the linguistic analyses, the infant's responsiveness was calculated separately in the mother-infant and father-infant interaction contexts to capture the infant's responsiveness to each parent.

Turn-Pairs. A turn-pair occurred whenever there was a pause of less than 2 seconds between the end of one speaker's turn, and the beginning of the second speaker's turn (speaker transitions involving overlaps were counted as turn-pairs). For each mother-infant and father-infant dyad, the rate of turn-pairs per minute was calculated by dividing the number of turn-pairs by the length of the audio recording.

Multiturn Conversational Episodes. Multiturn conversational episodes were defined as sequences of ≥ 3 alternating turns between speakers which were separated by pauses < 2 seconds (as with the turn-pairs, speaker transitions involving overlaps were allowed). The end of the conversational episode was indicated by a pause of ≥ 2 seconds. Multiturn conversational episodes involving the first or last turn in the transcript were excluded as it was possible that the conversational episode may have extended beyond the time period captured by the transcript. An exception to this rule was if the first/last turn was preceded/followed by a pause of ≥ 2 seconds.

For each mother-infant and father-infant dyad, the rate of multiturn conversational episodes per minute was calculated by dividing the number of multiturn conversational episodes by the length of the audio recording.

The duration of multiturn conversational episodes was calculated in seconds (time elapsed between the start of the first turn and the end of the final turn in each episode) and in turns (number of turns within each episode). For each mother-infant and father-infant dyad, an average duration of multiturn conversational episodes (in seconds and in turns) was calculated by dividing the corresponding durational measure by the number of multiturn conversational episodes.

Conversational Initiation. The conversation initiator was identified as the first speaker (mother/father or infant) in a turn-taking sequence (either a turn-pair or multiturn conversational episode) which followed a conversational pause of ≥ 2 seconds. The proportion of such conversations initiated by the mother/father was calculated for each mother-infant/father-infant interaction.

Data Analysis

All analyses were conducted in R (version 4.2.2; R Core Team, 2022) with an alpha level of .05 (two-tailed). To compare the linguistic and turn-taking features of mother-infant and father-infant conversations, paired-samples t-tests were used with a subset of 17 families where free-play recordings had been obtained for both mother-infant and father-infant interactions (i.e., excluding the five families where fathers did not participate in the free-play recordings). To examine conversational synchrony within mother-infant conversations, paired-samples t-tests compared the responsiveness of mothers and infants, bivariate correlations examined the co-ordination of responsiveness between mothers and infants, and a one-sample t-test investigated whether mothers initiated significantly more or less than 50% of conversations. Identical tests (paired-samples t-test, bivariate correlation, one-sample t-test) were conducted to investigate conversational synchrony in father-infant conversations. Finally, bivariate correlations were used to examine the association between the turn-taking characteristics of mother-infant and father-infant conversations and the linguistic and non-linguistic development of the infant. In all analyses, missing values were handled with pairwise deletion.

The analysis of mother-infant conversational synchrony and the investigation of associations between mother-infant turn-taking and infant development were carried out with the full sample of 22 mother-infant free-play recordings. Meanwhile, the corresponding analyses involving father-infant interaction variables utilised the subsample of 17 families where fathers had participated in the in-lab free-play recordings. Supplementary analyses were carried out to examine the comparability of families where both parents (mother and father; n = 17) or only one parent (mother; n = 5) participated in the free-play recordings. Specifically, independent-samples t-tests compared the demographic (child age, child gestational age at birth, mother age, mother educational attainment), linguistic (volubility, lexical diversity, and morphosyntactic complexity of mother and infant speech, and the mother-infant mean length of turn ratio), and turn-taking (turn-pairs [rate], multiturn conversational episodes [rate, duration in seconds, duration in turns]) characteristics of mother-infant dyads belonging to families where both parents (mother and father; n = 17) or only one parent (mother only; n = 5) participated in the in-lab testing session. While families with both parents attending had significantly younger mothers than families with only the mother in attendance, no other significant differences were found between the demographic, linguistic, or turn-taking features of these dyads (for full results, see Appendix N).

Statistical Assumptions

The parametric assumptions for paired-samples t-tests (normal distribution), correlations (normal distribution, linear relationship, no extreme outliers), and one-sample t-tests (normal distribution) were examined using graphical (scatterplot) and statistical techniques (Shapiro-Wilk test). When parametric assumptions were violated, non-parametric variants were adopted. Specifically, Wilcoxon signed rank tests were used in place of parametric paired-samples t-tests and Spearman correlations were used in place of Pearson correlations. With regards to the paired-samples t-tests, effect size was calculated as Cohen's d in the parametric case and as r when using the Wilcoxon signed rank test (r = $Z/\sqrt{N}$; r can range between 0 and 1, with higher values indicating a larger effect).

Statistical Power

The current study was sufficiently powered (80% power, a = .05) to detect medium, medium-to-large, and large effects within the one-sample t-test, paired-samples t-test, and correlations, respectively (t-test effect size indices [d]: small = 0.2, medium = 0.5, large = 0.8. Correlation effect size indices [r]: small = 0.1, medium = 0.3, large = 0.5; Cohen, 1969).

Results

Preliminary Analyses

To contextualise this study's primary analyses, the infant's developmental profile and the linguistic characteristics of the mother-infant and father-infant interactions are described below.

Developmental Profile

As can be observed in Table 5.1.1, there was wide variability in scores on each scale of the BRIEF-P and Bayley-III. Clinically significant BRIEF-P scores (≥ 65) were found for 16.67% ($n = 3$) of infants on the inhibitory self-control index, 11.11% ($n = 2$) on the flexibility index, 12.5% ($n = 2$) on the emergent metacognition index, and 12.5% ($n = 2$) on the global executive composite. With regards to the Bayley-III scores, potential signs of developmental delay (scaled scores > 1 SD below normative mean) were found among 9.09% ($n = 2$) of infants on the cognitive scale, 21.05% ($n = 4$) on the receptive communication scale, 21.05% ($n = 4$) on the expressive communication scale, and 18.75% ($n = 3$) on the social-emotional scale. While all infants completed the cognitive scale of the Bayley-III, three infants could not complete the receptive and expressive communication scales owing to fatigue, attentional difficulties, and/or fussiness.

Table 5.1.1

BRIEF-P and Bayley-III Scores of Participating Infants

	n	*M (SD)*	*Mdn*	Min-Max
BRIEF-P				
Inhibitory self-control index	18	50.94 (10.41)	49.5	36-70
Flexibility index	18	49.72 (12.04)	44.5	37-78
Emergent metacognition index	16	53.38 (12.54)	55.0	37-80
Global executive composite	16	52.75 (12.45)	52.0	36-80
Bayley-III				
Cognitive	22	9.32 (2.77)	9.0	1-14
Receptive communication	19	9.95 (3.54)	10.0	4-17
Expressive communication	19	9.95 (4.33)	10.0	3-19
Social-emotional	16	9.88 (2.92)	10.0	6-16

Linguistic Features of Mother-Infant and Father-Infant Conversations

As can be seen in Table 5.1.2, no significant differences were found between the volubility (words per minute), lexical diversity (type-token ratio), and morphosyntactic complexity (mean length of utterance in morphemes, mean length of utterance in words, verbs per utterance) of speech produced by mothers and fathers. According to these same variables, the infants' speech patterns did not significantly differ between mother-infant and father-infant free-play settings. The distribution of conversational load (mean length of turn ratio) did not significantly differ between mother-infant and father-infant dyads. As indicated by the small ratio, in both mother-infant and father-infant interactions, the parent carried the majority of the conversational load.

Table 5.1.2

Parametric Paired-Samples t-tests (n = 17) Comparing Mother-Infant and Father-Infant Free-Play Interactions on the Linguistic Features of Parent and Infant Speech

	Mother-infant free-play		Father-infant free-play		
	M	*SD*	*M*	*SD*	Paired-samples t-test
Parent					
Words per minute	69.84	24.46	73.47	33.59	$t(16) = -0.31$, $p = .761$, 95% CI [-22.53, 16.80], $d = 0.07$
Type-token ratio	0.29	0.07	0.28	0.07	$t(16) = 0.36$, $p = .727$, 95% CI [-0.04, 0.05], $d = 0.09$
MLU (morphemes)	4.20	0.87	4.16	0.87	$t(16) = 0.37$, $p = .719$, 95% CI [-0.41, 0.59], $d = 0.09$
MLU (words)	3.94	0.80	3.92	0.80	$t(16) = 0.27$, $p = .794$, 95% CI [-0.41, 0.53], $d = 0.06$
Verbs per utterance	0.72	0.16	0.72	0.16	$t(16) = 0.04$, $p = .965$, 95% CI [-0.13, 0.12], $d = 0.01$
Infant					
Words per minute	14.74	10.96	11.85	9.78	$t(16) = 0.89$, $p = .388$, 95% CI [-2.38, 5.80], $d = 0.22$
Type-token ratio	0.51	0.16	0.52	0.16	$t(16) = 0.08$, $p = .937$, 95% CI [-0.10, 0.09], $d = 0.02$
MLU (morphemes)	2.07	0.69	1.96	0.67	$t(16) = 1.42$, $p = .175$, 95% CI [-0.06, 0.29], $d = 0.34$
MLU (words)	1.96	0.62	1.86	0.62	$t(16) = 1.47$, $p = .162$, 95% CI [-0.05, 0.30], $d = 0.36$
Verbs per utterance	0.26	0.18	0.27	0.22	$t(16) = 0.14$, $p = .892$, 95% CI [-0.07, 0.08], $d = 0.03$
Dyad					
MLT ratio	0.22	0.16	0.19	0.16	$t(16) = 0.67$, $p = .514$, 95% CI [-0.06, 0.12], $d = 0.16$

Note. CI = confidence interval; MLU = mean length of utterance; MLT = mean length of turn.

Turn-Taking and Conversational Synchrony

Comparison of Mother-Infant and Father-Infant Conversations

As can be seen in Table 5.1.3, there were no statistically significant differences between the responsiveness of mothers and fathers, or between the infants' responsiveness to each parent. Mother-infant and father-infant conversations did not significantly differ in the rate of turn-pairs or multiturn conversational episodes, or in the average duration (in either seconds or turns) of multiturn conversational episodes. Finally, the proportion of conversations initiated by mothers and fathers did not significantly differ.

Table 5.1.3

Paired-Samples t-tests (n = 17) Comparing the Turn-Taking Characteristics of Mother-Infant and Father-Infant Free Play Interactions

	Mother-infant free-play			Father-infant free-play						
	M	*SD*	*Mdn*	*M*	*SD*	*Mdn*	Test statistic	*p*	95% CI	Effect size
Responsiveness										
Parent [a]	0.86	0.14	0.89	0.90	0.07	0.90	*V* = 59	.431	-0.09, 0.04	*r* = 0.20
Infant	0.49	0.22	0.55	0.50	0.19	0.56	*t*(16) = -0.27	.791	-0.11, 0.09	*d* = 0.07
Turn-pairs										
Rate per minute	9.34	5.18	9.14	9.17	4.07	9.09	*t*(16) = 0.15	.880	-2.17, 2.51	*d* = 0.04
Multiturn conversational episodes										
Rate per minute	1.54	0.72	1.64	1.59	0.57	1.58	*t*(16) = -0.34	.736	-0.32, 0.23	*d* = 0.08
Average duration – seconds [a]	14.28	4.17	13.72	17.74	14.77	13.73	*V* = 68	.712	-5.86, 3.44	*r* = 0.10
Average duration – turns	5.69	1.93	5.17	5.87	1.76	5.54	*t*(16) = -0.26	.795	-1.63, 1.27	*d* = 0.06
Conversation initiation										
Proportion initiated by parent	0.55	0.16	0.50	0.59	0.23	0.57	*t*(16) = -0.83	.421	-0.153, 0.067	*d* = 0.20

Note. CI = confidence interval.

[a] Wilcoxon signed rank test (when difference scores were not normally distributed).

Conversational Synchrony in Mother-Infant Conversations (n = 22)

A Wilcoxon signed rank test found that mothers (*Mdn* = 0.89) were significantly more responsive than their infants (*Mdn* = 0.59) within mother-infant conversations ($V = 0$, $p < .001$, 95% CI [-0.42, -0.20], $r = 0.88$). Meanwhile, there was no significant correlation between the responsiveness of mothers and infants ($\rho = -0.02$, $p = .945$). A one-sample t-test found that the proportion of conversations initiated by the mother ($M = 0.53$, $SD = 0.20$) did not significantly differ from 0.50 ($t[21] = 0.79$, $p = .436$, 95% CI [0.44, 0.62], Cohen's $d = 0.17$).

Conversational Synchrony in Father-Infant Conversations (n = 17)

A paired-samples t-test found that fathers were significantly more responsive than their infants within father-infant conversations ($t[16] = -7.65$, $p < .001$, 95% CI [-0.50, -0.29], Cohen's $d = 1.86$). There was no significant correlation between the responsiveness of fathers and infants ($r[15] = -0.05$, $p = .839$, 95% CI [-0.52, 0.44]). A one-sample t-test found that the proportion of conversations initiated by the father did not significantly differ from 0.50 ($t[16] = 1.69$, $p = .111$, 95% CI [0.48, 0.71], Cohen's $d = 0.41$).

Turn-Taking and Infant Development

Correlations were computed to examine the association between mother-infant and father-infant turn-taking characteristics and the infant's BRIEF-P and Bayley-III scores. As some pairs of variables exhibited multivariate outliers, Spearman correlations were computed and are reported in Table 5.1.4. The full correlation matrices for the mother-infant and father-infant turn-taking variables can be found in Appendix O and P, respectively.

Table 5.1.4

Spearman Correlations between Mother-Infant and Father-Infant Turn-Taking Features and Scores on the BRIEF-P and Bayley-III

	GEC (BRIEF-P)		Cognitive (Bayley-III)		Receptive communication (Bayley-III)		Expressive communication (Bayley-III)		Social-emotional (Bayley-III)	
	rho	*p*	rho	*p*	rho	*p*	rho	*p*	rho	*p*
Mother-infant free-play										
Infant responsiveness	0.04	.888	0.36	.103	**0.46**	**.045**	0.38	.107	0.19	.482
Mother responsiveness	0.13	.619	-0.18	.428	0.07	.785	-0.05	.835	0.10	.710
Turn-pairs rate (per minute)	0.01	.961	0.35	.110	**0.48**	**.039**	0.41	.081	0.13	.641
MTCE rate (per minute)	0.2	.447	0.10	.644	0.31	.196	0.18	.452	0.02	.939
MTCE – av duration (seconds)	0.33	.212	0.04	.860	0.12	.633	0.19	.431	-0.01	.961
MTCE – av duration (turns)	0.15	.575	0.09	.694	0.30	.212	0.40	.090	0.24	.379
Father-infant free-play										
Infant responsiveness	0.47	.127	0.42	.095	0.51	.063	0.53	.054	-0.06	.853
Father responsiveness	0.21	.505	-0.04	.869	-0.17	.571	0.16	.587	0.39	.214
Turn-pairs rate (per minute)	0.43	.162	0.37	.144	0.43	.122	0.46	.099	-0.22	.488
MTCE rate (per minute)	0.08	.812	0.19	.470	0.29	.312	0.05	.875	-0.25	.427
MTCE – av duration (seconds)	0.29	.353	0.40	.110	0.46	.098	**0.62**	**.018**	-0.08	.802
MTCE – av duration (turns)	0.51	.091	0.23	.371	0.29	.322	0.49	.075	-0.05	.875

Note. The coefficients and p-values corresponding to statistically significant associations ($p < .05$) are shown in boldface. GEC = global executive composite; MTCE = multiturn conversational episode; av duration = average duration.

The infant's responsiveness and the turn-pair rate (per minute) within mother-infant conversations were significantly positively associated with receptive communication scores. Meanwhile, the average duration of father-infant multiturn conversational episodes (in seconds) was significantly positively associated with expressive communication scores. There were no other statistically significant associations between the turn-taking variables and the BRIEF-P and Bayley-III scores displayed in Table 5.1.4.

Discussion

In line with dynamic systems (Spencer et al., 2011), social-interactionist (Bruner, 1983), and transactional (Fiese & Sameroff, 1989) perspectives of child development, the current study utilised developmental assessments and observations of parent-infant free-play interactions to contextualise the language development of two-year-old preterm-born infants within their social environments. Specifically, the present investigation characterised and compared mother-infant and father-infant conversational synchrony and turn-taking, and examined their respective associations with infant development in linguistic and non-linguistic domains.

Among the included sample of two-year-old verbal preterm-born infants, a lack of mutuality and coordination between parent and infant responsiveness suggested limited conversational synchrony in both mother-infant and father-infant conversations. Furthermore, while there were no significant associations between turn-taking and non-linguistic infant development (executive function, cognitive, and social-emotional development), the preterm-born infants' language development (receptive and expressive communication) was found to be differentially associated with aspects of mother-infant and father-infant turn-taking. These findings suggest that reduced conversational synchrony may be a characteristic of preterm-born dyads which traverse developmental periods (preverbal and verbal) and interlocutors (mothers and fathers). However, the pathways linking turn-taking to language development may differ across different interlocutors (mothers and fathers), thereby raising the possibility that preterm-born infants' language development operates via unique developmental mechanisms within differing social relationships.

Limited Mother-Infant and Father-Infant Conversational Synchrony

Previous studies of preverbal infants (infants aged ≤ 6 months) have found preterm birth to be associated with reduced synchrony in mother-infant vocal exchanges, a pattern which seemingly arises from the combination of highly active mothers and passive infants (Reissland & Stephenson, 1999; Salerni et al., 2007). The first objective of the present study was to examine whether this reduced conversational synchrony and active-passive dynamic may characterise mother-infant and father-infant conversational exchanges among preterm-born cohorts following the onset of linguistic skills. In the current study, both mothers and fathers were significantly more responsive than their infants, with this pattern suggesting limited mutual reciprocity between parents and preterm-born infants. Furthermore, the lack of a significant correlation between the responsiveness of mothers and infants and between the responsiveness of fathers and infants indicated limited interpersonal coordination within mother-infant and father-infant conversations. This lack of mutual reciprocity and interpersonal coordination indicate that the mother-infant and father-infant conversations of this preterm-born cohort are marked by limited signs of conversational synchrony.

In both mother-infant and father-infant conversations, the proportion of conversations initiated by parents did not significantly differ from 50%, thereby suggesting that mothers/fathers and infants initiated a similar proportion of conversations. This parent-infant distribution of conversational initiations contrasts with that seen among dyads involving typically developing infants whereby parents initiate fewer conversations than infants during the third year of life (e.g., Chai et al., 2022). The similar proportion of conversations initiated by mothers/fathers and preterm-born infants in the present study may therefore reflect a developmentally atypical parent-infant dynamic which could be attributed to high levels of activity in the parent and/or passivity in the infant. Taken alongside the aforementioned mismatch between the responsiveness of mothers/fathers and infants in the present sample, these findings suggest an active-passive parent-infant dynamic. This pattern echoes the active-passive divide documented among mother-infant dyads with preverbal preterm-born infants (Reissland & Stephenson, 1999; Salerni et al., 2007), and provides evidence for the generalisability of this interpersonal dynamic to verbal preterm-born infants and to father-infant interactions.

The observations of limited interpersonal mutuality and co-ordination within both mother-infant and father-infant conversations is reflective of a broader similarity in the linguistic and turn-taking characteristics of these interactions. Specifically, no significant differences were found between mother-infant and father-infant conversations in the volubility, lexical diversity, or morphosyntactic complexity of parental or infant speech, nor in the parent-infant distribution of conversational load. Furthermore, there were no significant differences between mother-infant and father-infant conversations with regards to the responsiveness of the parent or infant, turn-pairs (rate per minute), or multiturn conversational episodes (rate per minute, duration in seconds, duration in turns).

These similarities between mother-infant and father-infant interactions contrast with previous research (e.g., Shapiro et al., 2021) finding mothers and fathers to exhibit differing interactional behaviours (though see Grinberg et al., 2022 for a detailed examination of the influence of parental sex on child-directed speech). The alignment between mother-infant and father-infant interactions in the present study may be attributable to sample characteristics (e.g., culturally-specific expectations of maternal/paternal behaviour; unique experience of mothering/fathering a medically vulnerable infant) and/or the interaction context (conducting play observations in a standardised environment may have dampened the confounding influence of differing activity contexts that are prototypically associated with mothers and fathers). These proposed explanations are not mutually exclusive, and further research is required to examine their relevance.

Conversational Turn-Taking and Language Development

Vocal exchanges exhibiting limited signs of synchrony have now been found to characterise the interactions of parents with preterm-born infants at both preverbal (Reissland & Stephenson, 1999; Salerni et al., 2007) and verbal (current study) stages of development. However, distinct developmental mechanisms may underlie these conversational dynamics at each timepoint. The increasing use of verbal communicative behaviours following the onset of linguistic skills alters the conversational landscape through requiring the child to integrate interactional and linguistic skills, through eliciting differential responses in conversational partners, and through laying the foundation for a redistribution of conversational responsibilities (Casillas et al., 2016; Chai et al., 2022; Fields-Olivieri & Cole, 2022; Gilkerson et al., 2018; Salo et al., 2022). Indeed, just as parent-infant turn-taking has been found to predict later linguistic and non-linguistic (executive function) skills (Huber et al., 2023; Romeo et al., 2021), growth in language skills has also been found to predict growth in turn-taking among typically developing samples (Donnelly & Kidd, 2021). Hence, the second objective of the current study was to investigate the developmental relevance of the turn-taking dynamics of preterm-born cohorts and to understand the mechanisms underlying these conversational patterns. To achieve this objective, the study methodologically extended previous research through examining multiple linguistic and non-linguistic developmental domains, through separately studying the turn-taking patterns of mother-infant and father-infant interactions, and through operationalising multiple aspects (turn-pairs, multiturn conversational episodes) and dimensions (rate, duration) of turn-taking.

Turn-taking within mother-infant and father-infant conversations was positively associated with the language development of preterm-born infants. In the absence of a significant association between maternal or paternal responsiveness and language abilities, this finding points to a particularly close relationship between dyadic conversational engagement (compared to individual parental behaviours) and the language development of preterm-born infants at two years of age. The developmental relevance of turn-taking was domain-specific, as no significant associations were observed between turn-taking and non-linguistic development (executive function, cognitive, social-emotional development). While few studies have investigated the association between turn-taking and non-linguistic development, the non-significant association between turn-taking and executive function conflicted with a previous study finding a positive association between these constructs (Romeo et al., 2021). These conflicting findings may be rooted in methodological differences (e.g., different executive function assessment; differing temporal window for contingent responses; using growth rather than static scores of executive function and turn-taking) or differences in sample characteristics including age (Romeo et al., 2021 investigated four- to six-year-old children) and developmental profile (e.g., the rate of clinically significant executive dysfunction among the current preterm-born sample was approximately twice that seen among typically-developing children; Gioia et al., 2003).

Such domain-specificity and potential sample-specificity of the associations between turn-taking and infant development also featured in the comparison of mother-infant and father-infant conversations. Specifically, different features of mother-infant and father-infant turn-taking were found to be associated with distinct aspects of language development. With respect to mother-infant conversations, turn-pairs (rate per minute) were positively associated with receptive communication scores, while there was no significant association between multiturn conversational episodes (rate, duration in seconds, duration in turns) and either receptive or expressive communication skills. These findings suggest that, among two-year-old preterm-born infants, higher numbers of turn-transitions (as reflected in turn-pairs) may be more developmentally relevant than engaging in extended mother-infant turn-taking exchanges (as reflected in multiturn conversational episodes). Given the abovementioned higher responsiveness of mothers as compared to infants within this sample, these turn-pairs are likely to be dominated by child-to-parent (rather than parent-to-child) turn-transitions. Hence, the positive association between mother-infant turn-pairs and receptive communication may be explained by the provision of direct and indirect linguistic and communicative feedback by mothers to infants during conversational turn-taking exchanges which pique the infant's interest and attention (Masek, McMillan, et al., 2021; Nikolaus & Fourtassi, 2023). These contingent conversational inputs may then facilitate the growth of receptive communicative skills in the infant.

Given that cross-sectional data were used, the opposite direction of effects must also be considered. As suggested by previous research, the language skills of children may affect the temporal organisation of turn-taking exchanges by affecting their real-time comprehension and production of speech (Casillas et al., 2016). In the present case, the receptive communication skills of infants may have affected their ability to provide temporally contingent responses (and thus engage in turn-taking) through affecting the speed and accuracy with which they processed their mother's speech. This interpretation is bolstered by the finding that both turn-pair rate and receptive communication scores were significantly positively associated with infant responsiveness (turn-pair rate and infant responsiveness measured from mother-infant conversations). Thus, it is possible that the infant's receptive communication skills may have affected the rate of turn-pairs through influencing the infant's responsiveness to the mother.

In contrast to the association between mother-infant turn-taking and receptive communication skills, father-infant turn-taking was positively associated with the expressive communication skills of infants. Furthermore, contrary to mother-infant conversations, infant language development was not significantly associated with father-infant turn-pairs and was instead positively associated with the average duration (in seconds) of father-infant multiturn conversational episodes (no significant associations were observed between infant language development and the rate or duration [in turns] of father-infant multiturn conversational episodes). The specificity of the association between expressive communication scores and the duration of multiturn conversational episodes as measured in seconds but not turns seemingly highlights the reduced relevance of turn-transitions for the association between father-infant turn-taking and language development. This particular relevance of temporally extended turn-taking exchanges could indicate that father-infant conversations benefit infant expressive communication development through sustaining the infant's attention to ongoing activities (e.g., Masek, McMillan, et al., 2021) rather than through the provision of contingent feedback as was discussed with reference to mothers.

It is also possible that the expressive communication skills of infants may have influenced the average temporal duration of multiturn conversational episodes. Since expressive communication was not significantly associated with turn-pair rate, father or infant responsiveness, or the average duration of multiturn conversational episodes in turns, it is unlikely that infant language ability affected the temporal duration of these episodes through increasing the number of turn-transitions. Instead, infants with better expressive communication skills may have cultivated temporally longer multiturn conversational episodes through taking longer turns/and or longer pauses before responding to their fathers.

While the hypothesised association between better expressive communication skills and longer pauses may seem counterintuitive, previous research has found that children take longer to respond within verbal turn-taking exchanges when they are formulating more linguistically complex responses (Casillas et al., 2016). In addition, fathers may have similarly exhibited such lengthening of turns and pauses, either to align with the evolving temporal characteristics of their infants' speech and/or as an organic adaptation to the expressive communication skills of the infant (e.g., fathers may use longer utterances when addressing infants with more advanced expressive skills; see Snow, 1995 for a discussion of fine-tuning). Hence, infant expressive communication skills may have affected the average temporal duration of multiturn conversational episodes through shaping the temporal patterning of infant and father speech.

As outlined above, mother-infant and father-infant conversations differ with regards to the specific aspects of turn-taking which are associated with the language development of preterm-born infants. These differences suggest that distinct developmental mechanisms tie turn-taking to language development in each case. These hypothesised mechanistic divergences can be summarised on two dimensions: First, mothers and fathers may respectively support receptive and expressive communication development through mechanisms that are of unique relevance to mother-infant (provision of contingent linguistic and communicative feedback) and father-infant (scaffolding infant attention) interactions. Second, the potentially differing conversational demands associated with mother-infant and father-infant interactions may create distinct opportunities for varying features of infant communication ability to be expressed within conversational contexts. Specifically, while receptive communication skills may shape the rate of mother-infant turn-taking, expressive communication skills may shape the temporal patterning of father-infant conversations.

Although these two dimensions reflect opposite directions of effect between turn-taking and language development, they are not mutually exclusive. In line with social-interactionist (Bruner, 1983) and transactional (Fiese & Sameroff, 1989) viewpoints, these bidirectional pathways may operate in tandem to create a mutually reinforcing loop or developmental cascade (e.g., the infant's receptive communication skills may affect the rate of mother-infant turn-transitions, which in turn may affect receptive communication development through shaping the infant's exposure to contingent linguistic and communicative feedback). Should such developmental cascades exist, the abovementioned differences between mother-infant and father-infant dyads raises the possibility that unique developmental cascades may be operating within each dyadic context.

Limitations and Future Recommendations

A number of study limitations must be recognised when interpreting the current findings. With regards to the generalisability of the results, further research is needed to investigate whether similar findings may be observed among samples representing a wider range of socioeconomic status, non-English-speaking populations, and non-WEIRD countries (Western, Educated, Industrialised, Rich, and Democratic; Henrich et al., 2010). This is particularly important since what defines high-quality language learning experiences should be expected to vary across cultures and languages (MacLeod & Demers, 2023). Furthermore, as the current study included a relatively small cross-sectional preterm-born sample, statistical power was limited and causal inferences could not be made regarding the direction of effects between turn-taking and infant development. The absence of a term-born comparison sample also prevented a direct investigation of whether the observed turn-taking and developmental patterns were unique to families with preterm-born infants. Thus, future studies with longitudinal data from larger and more representative samples can attempt to replicate the current findings, elucidate the direction of influence between turn-taking and development, and directly explore the moderation of these findings by the infant's birth status (preterm/term).

Future research can also extend the current investigation through pursuing a broader conceptualisation of conversational synchrony and turn-taking. In particular, a greater understanding of multiturn conversational episodes may be fostered through examining the semantic relatedness of temporally contingent turn-transitions, as semantic connectedness could play a pivotal role in sustaining extended turn-taking exchanges. Additionally, the inclusion of non-vocal communicative behaviours (e.g., gestures) in the coding of turn-taking exchanges could allow for an examination of preterm-born infants with a wider range of developmental abilities (due to the current study's focus on vocal communication, a non-verbal infant was removed from the sample). Finally, future investigations could usefully investigate non-linear associations (e.g., quadratic) between turn-taking and infant development to explore whether there may be an optimal level of turn-taking (e.g., an optimal rate of turn-pairs or an optimal duration of conversational episodes) for each linguistic and non-linguistic developmental domain.

Conclusions

The current study adopted a dynamic systems (Spencer et al., 2011), transactional (Fiese & Sameroff, 1989), and social-interactionist (Bruner, 1983) view of child development to contextualise the language development of preterm-born infants with respect to their proximal social environments. When investigating the turn-taking exchanges of preterm-born dyads and their associations with infant development, the study adopted innovative methods to complement and extend the existing published literature. In particular, standardised observational settings were used to obtain comparable recordings of mother-infant and father-infant conversations, and a comprehensive characterisation of turn-taking was pursued through quantifying multiple aspects (turn-pairs, multiturn conversational episodes) and dimensions (rate, duration) of this construct. Through these methodological advances, the study demonstrated that the vocal exchanges of mothers and fathers with their two-year-old preterm-born infants featured limited signs of conversational synchrony (as reflected in a lack of interpersonal mutuality and co-ordination) and a developmentally atypical distribution of conversational responsibilities (as reflected in the distribution of conversation initiations).

Despite the superficial similarity of mother-infant and father-infant exchanges on linguistic and turn-taking fronts, differences were found between these dyadic contexts in the precise associations between turn-taking and infant language development. These differences highlight nuances in the interconnections between infant development and the social environment which may have been overlooked in previous studies which investigated mother-infant dyads in isolation or which pooled mother-infant and father-infant interactions. These differences may reflect the contextual variability of the infant characteristics which affect turn-taking and the pathways through which turn-taking may reciprocally affect language development. These mechanistic divergences between mother-infant and father-infant contexts may be informative for the design and delivery of parent education programmes directed toward mothers and fathers of preterm-born infants. Furthermore, at an empirical level, the methodological characteristics of the present study which delivered these novel findings can inspire and guide future studies on theoretical (e.g., operationalisation of turn-taking), design (e.g., including both mothers and fathers), and procedural (e.g., use of standardised observational settings) fronts.

Study 5.2: The Synergistic Effects of Preterm Birth and Parent Gender on the (Para)linguistic and Interactive Features of Parent-Infant Conversations

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The first author (Sarah Coughlan) was responsible for the conceptualisation, formal analysis, and writing of this paper. These responsibilities were carried out under the guidance of the second and third authors (thesis supervisors).

The data analysed in this paper were collected and curated by the research team at the Infant and Child Research Lab (Trinity College Dublin). As part of this collective effort, the first author contributed to data collection through engaging in participant recruitment, scheduling, and testing. Recordings of parent-child interactions were transcribed by research assistants and past PhD students. These transcripts were microanalytically annotated and analysed by the first author.

A revised version of this paper is in-press at Journal of Speech, Language, and Hearing Research.

Abstract

Purpose: To investigate the language environments experienced by preterm-born infants, this study compared the (para)linguistic and interactive features of parent-infant conversations involving 2-year-old preterm-/term-born infants. The study also explored how mother-infant and father-infant conversations may be differentially affected by preterm/term birth status.

Method: Twenty-two preterm-born (< 37 weeks' gestation) and 25 term-born (≥ 37 weeks' gestation) 2-year-old infants engaged in dyadic mother-/father-infant free-play interactions which were transcribed to quantify the (para)linguistic (parental volubility, speech rate, lexical diversity, morphosyntactic complexity) and interactive (infant/parent responsiveness, turn-taking, conversational balance) features of parent-infant conversations. Language, cognitive, social-emotional, and executive function skills were assessed via standardised tools.

Results: The preterm group exhibited lower parental volubility, slower maternal speech rate, and greater mother-infant conversational balance when compared to the term group. The preterm group presented poorer language and executive function skills when compared to the term group.

Conclusions: There were more preterm-term language environment similarities than differences. Similarities may be due to the partial developmental catch-up of preterm-born infants (cognitive and social-emotional skills) and parental scaffolding. Differences may reflect a parental adaptation to the language and executive function difficulties of preterm-born infants. Given the language and executive function differences between term and preterm groups, the minimal between-group differences in parent-infant conversations may suggest insufficient parental adaptations to infant characteristics. Thus, it is imperative that researchers and clinicians appraise the language environment with respect to the infants' unique developmental needs.

Keywords: preterm birth, child directed speech, turn-taking

Introduction

An infant's language development is inextricably linked to the language environment within which they are developing (e.g., Gilkerson et al., 2017; Gilkerson et al., 2018). The language environment can be characterised on (para)linguistic (e.g., number of unique words, speaking speed) and interactive (e.g., turn-taking) dimensions, which together reflect what and how language input is experienced by the infant (Preza & Hadley, 2022; Scheiber et al., 2022). While features of both dimensions of the language environment are prospectively associated with infant language development (e.g., Donnelly & Kidd, 2021; Rowe, 2012), these features are also reciprocally shaped by characteristics of the infants themselves (Bornstein et al., 2021; Snow, 1995). Thus, the language environment can be viewed as a dynamic entity which both shapes and is shaped by the characteristics of the interactants who represent the broader developmental ecology within which the language environment is situated.

An acknowledgement of the multidimensional nature of the language environment and its interface with the broader developmental ecology can provide deeper insights into the possible origins and developmental implications of the similarities/differences between the language environments experienced by clinical and non-clinical populations. Through this lens, the current study aims to better understand the language difficulties associated with preterm birth (van Noort-van der Spek et al., 2012) through comparing the (para)linguistic and interactive features of the language environments experienced by 2-year-old infants born preterm (< 37 weeks' gestation) and at term (≥ 37 weeks' gestation; World Health Organisation, 2012). Between-group similarities/differences on (para)linguistic and interactive features are interpreted with respect to the developmental ecology (reflecting infant developmental characteristics) within which they are observed.

Language Environment: A Nested Perspective

The language environment can be defined on (para)linguistic and interactive dimensions. The (para)linguistic dimension can comprise the quantitative (e.g., number of words and/or gestures, speaking speed) and qualitative (e.g., lexical diversity and morphosyntactic complexity) features of each speaker's utterances, while the interactive dimension reflects features of the dynamic interactions occurring between the two conversing individuals (e.g., temporally contingent responding, turn-taking, and conversational balance; Bang et al., 2020; Rowe & Snow, 2020). While the simultaneous characterisation of language environments across multiple dimensions or feature domains has not been standard practise in the literature, such multidimensional investigations highlight how each feature can create affordances for the nature and emergence of other features (Scheiber et al., 2022). For instance, the content of maternal utterances has been found to be associated with the interactional dynamic of the conversation within which it is produced (Spinelli et al., 2022).

While interconnections between (para)linguistic and interactive features can shape the language environment in this way, the language environment is also moulded by its interface with the broader developmental ecology. This interface occurs via the characteristics and behaviours of the interactants, as well as the mutual adaptation of these individuals. For instance, an infant's linguistic and non-linguistic development can affect the frequency, content, and context of parent-infant conversations through shaping how the infant interacts with their social (e.g., use of gestures) and non-social (e.g., object manipulation) environments. Infant development can also influence parent-infant conversations through affecting the infant's own production and comprehension of speech, as well as through eliciting parental speech adaptations which are aimed at accommodating the infant's perceived needs and competencies (Snow, 1995; Yurovsky, 2018).

The preceding discussion demonstrates how features of the language environment can be understood to be *nested* at two levels: firstly, with respect to other language environment features and secondly, with respect to the surrounding developmental ecology. This multilevel nested conceptualisation captures the complex processes underlying the variability in language environments both across dyads (e.g., clinical vs non-clinical populations) and within dyads across time (e.g., across an infant's development). This interpretive viewpoint concords with social-interactionist views of language acquisition which situate language development within co-constructed social exchanges (e.g., Bruner, 1983). This view also aligns with the more domain-general transactional perspective which acknowledges the active role of children in their own development through highlighting the bidirectional influences flowing between children and their caregivers (e.g., Fiese & Sameroff, 1989). Finally, the present nested view and the two aforementioned theoretical perspectives can be situated within dynamic systems meta-theoretical viewpoints which understand child development to be the product of iterative and bidirectional interactions between the child and his/her surrounding environment (Ibbotson, 2020; Karmiloff-Smith, 2009; Spencer et al., 2011).

Preterm Birth

The multilevel nested perspective outlined above can facilitate nuanced interpretations of the similarities/differences which can exist between the language environments experienced by clinical and non-clinical populations. Through advancing a highly contextualised understanding of language environment features, this perspective promotes an understanding of the possible origins of similarities/differences (e.g., parental speech differences rooted in parental adaptations to the infant's developmental characteristics), as well as their developmental appropriateness (e.g., are parents speaking similarly to infants with vastly different language skills?). When developmentally inappropriate language environments are identified, the nested perspective may also assist in the identification of pathways through which they may be modified. Infants born preterm are an example of a clinical population which could benefit from such a perspective. While medical advances have substantially improved the survival rates of infants born preterm (and hence the prevalence of preterm-born children in the population), they have had little impact on the neurodevelopmental difficulties experienced by this cohort (Aylward, 2014; Blencowe et al., 2012). As a result, efforts to understand the neurodevelopmental difficulties associated with preterm birth have increasingly shifted from medical explanations to more bio-ecological viewpoints (for example, see Barra & Coo, 2023).

Among the neurodevelopmental difficulties associated with preterm birth are expressive and receptive language difficulties which are observed to affect both grammatical and semantic abilities (van Noort-van der Spek et al., 2012). In line with a bio-ecological perspective, the language environment may partially account for these language difficulties. Specifically, preterm birth has been associated with unique infant characteristics which could affect the language environment in developmentally impactful ways. In addition to the aforementioned language difficulties, preterm birth is associated with an array of non-linguistic (e.g., cognitive, social-emotional; Aylward, 2014; Johnson, Matthews, et al., 2015) and neuropsychological difficulties (e.g., executive dysfunction and slower processing of heard speech; Aylward, 2014; Marchman et al., 2019). These infant characteristics may affect parent-infant conversations and thereby create a language environment that is unique to the context of preterm birth. Despite this, few studies have attempted to characterise the language environments experienced by infants born preterm.

The findings of studies which have compared the language environments of preterm- and term-born infants on (para)linguistic and interactive features are summarised below. Studies conducted during the neonatal period (e.g., in a neonatal intensive care unit) are beyond the scope of the current investigation, and are thus excluded from the following review.

(Para)linguistic Features

Among the studies investigating quantitative (para)linguistic features, some have found mothers to speak less to preterm as compared to term born infants (rate of utterances/word-types/word-tokens; Spinelli et al., 2022), while others have found no such between-group differences (frequency/rate of utterances/tokens and adult word count [per hour]; Adams et al., 2018; Salerni & Suttora, 2022; Salerni et al., 2007; Suttora et al., 2020). The author is not aware of any previously published study which has compared parental speech rate measures (i.e., speaking speed) between preterm- and term-born groups. The investigations of qualitative linguistic features have measured the lexical diversity (type-token ratio) and morphosyntactic complexity (mean length of utterance) of parental speech. No significant differences have been found between the lexical diversity of maternal speech directed to infants born preterm or at term (Salerni et al., 2007; Spinelli et al., 2022). In relation to the morphosyntactic complexity of parental speech, some studies have found no significant between-group differences (Salerni et al., 2007; Suttora et al., 2020), while others have documented significantly more complex maternal speech directed to infants born preterm as compared to term (Reissland et al., 1999; Spinelli et al., 2022).

Interactive Features

When compared to mothers in term dyads, mothers in preterm dyads have been found to be more vocally responsive (temporally contingent responding) and more likely to vocally initiate conversations following silences (Reissland & Stephenson, 1999; Salerni et al., 2007). In contrast, infants in preterm dyads have been found to be significantly less vocally responsive to their mothers and less likely to vocally initiate conversations when compared to their term-born peers (Reissland & Stephenson, 1999; Salerni et al., 2007). This combination of a highly active mother and passive preterm-born infant may reflect a transactional process whereby the activity levels of each interactant are mutually up-/down-regulated to achieve "social balance" (Crnic et al., 1983, p. 1200). Specifically, within preterm dyads, it has been proposed that parents may up-regulate their activity level (e.g., responsiveness) to balance out the inactivity in their infant and/or to elicit more activity from their infant (Crnic et al., 1983; Field, 1980). Reciprocally, the infant born preterm may seek to counterbalance this high level of parental activity through down-regulating their own activity level (Crnic et al., 1983; Field, 1980). Studies have also investigated the semantic contingency of maternal speech, and found lower levels of semantic contingency to characterise preterm as compared to term dyads (Salerni & Suttora, 2022).

Remaining Questions

Existing preterm studies have fallen short of providing a multidimensional account of the language environment. Only two of the studies reported above (Salerni & Suttora, 2022; Salerni et al., 2007) simultaneously examined linguistic and interactive dimensions of the language environment. While a multidimensional characterisation of the preterm-born infants' language environment may be achieved through synthesising the findings of multiple studies, the samples utilised by existing studies have served to systematically underrepresent critical aspects of the language environment and periods of development. Firstly, the majority of studies outlined above have focused on mother-infant interactions. In the two studies which included fathers, the mothers and fathers were pooled as "parents" (Suttora et al., 2020) or "adults" (Adams et al., 2018). A discrete investigation of paternal speech within the context of preterm birth is necessary given observations of mother-father differences in child-directed speaking styles (Shapiro et al., 2021; though see Grinberg et al., 2022 for a critical discussion) and their unique associations with language development (Tamis-LeMonda et al., 2004). Secondly, the majority of published preterm studies have investigated the language environment during the first 24 months of life. Characterising the language environment beyond the first two years is particularly important within preterm cohorts as 24 months is the age-point at which infants born preterm are tentatively suggested to developmentally catch-up to their term-born peers. Such suggestions can be found in standardised test protocols which advise practitioners to adjust an infant's age for their degree of prematurity until the age of two years (e.g., Bayley Scales of Infant and Toddler Development 3rd edition [Bayley-III]; Bayley, 2006).

Current Study

The present study compared the language environments experienced by preterm- and term-born infants during dyadic parent-infant free-play interactions. To extend the scope of existing studies, the current study observed 2-year-old term-born and preterm-born infants as they interacted with their mothers and fathers. These observations were conducted in a standardised lab environment to facilitate the comparison of mother-infant and father-infant interactions through removing the confounding influence of differing activity contexts.

Time-stamped transcripts of parent and infant speech occurring during these interactions were used to characterise the (para)linguistic and interactive dimensions of the language environment. With regards to the (para)linguistic features, quantitative (volubility [amount of speech], speech rate [speaking speed]) and qualitative (lexical diversity, morphosyntactic complexity) features of parental speech were quantified for mothers and fathers. With relation to the interactive features, the transcripts were used to compute measures of the temporal responsiveness of mothers/fathers and infants, the occurrence of temporally contingent parent-infant turn-taking, and metrics of parent-infant conversational balance (e.g., parent-infant distribution of utterances and conversation initiations). With these variables, the following research objectives were pursued:

1. To compare the (para)linguistic features of the language environment experienced by 2-year-old preterm- and term-born infants during parent-infant free-play interactions.
2. To compare the interactive features of the language environment experienced by 2-year-old preterm- and term-born infants during parent-infant free-play interactions.
3. To investigate the possible moderation of the preterm-term contrasts specified in research objectives (1) and (2) by the gender of the interacting parent (mother/father).

Due to the novelty of the study sample (with regards to infant age and the inclusion of fathers), the investigation was exploratory and there were no strong expectations to replicate the preterm-term contrasts documented in the published literature. However, on the basis of existing findings, the following predictions were made. With regards to research objective 1, when compared to mothers in term dyads, mothers in preterm dyads were expected to exhibit (i) similar or lower levels of volubility, (ii) similar levels of lexical diversity, and (iii) similar or greater levels of syntactic complexity. No predictions were made with regards to the existence of preterm-term differences in parental speech rate, as no published studies on this topic could be identified. With relation to research objective 2, in comparison to term dyads, preterm dyads were expected to demonstrate (i) higher levels of maternal responsiveness, (ii) lower levels of infant responsiveness, and (iii) lower levels of conversational balance. As the existing literature predominantly focuses on mother-infant interactions, the predictions above selectively refer to mother-infant dyads. Whether similar effects may be expected or found within father-infant dyads was unclear, and was pursued through the exploratory moderation analysis outlined in research objective 3.

Method

Participants

This study included 48 English-speaking two-parent families with 2-year-old singleton infants (23 preterm-born [< 37 weeks' gestation], 25 term-born [≥ 37 weeks' gestation]) who were recruited as part of a larger longitudinal investigation of parent-infant interaction and development. One family in the preterm group was removed from the present study's analysis as the infant was non-verbal, leaving 22 families with preterm-born (gestational age in weeks: $M = 31.19$, $SD = 3.77$, $Mdn = 31.93$, min-max = 24 ~36) and 25 families with term-born (≥ 37 weeks' gestation) infants to be included in this study.

An independent-samples t-test found that infants in the term group ($M = 24.3$ months, $Mdn = 24.47$ months, $SD = 1.41$ months) were significantly younger ($p = .005$) than infants in the preterm group ($M = 26.98$ months, $Mdn = 27.72$ months, $SD = 3.82$ months; adjusted age for those < 24 months). There was no significant difference in the proportion of male/female infants in the preterm (10 female, 12 male) and term (11 female, 14 male) groups (Chi-square test, $p = 1.000$).

Independent-samples t-tests found no significant differences between preterm and term groups in family socioeconomic status (proxied by maternal education level; $p = .411$). Mothers' age did not significantly differ between the preterm group ($M = 36.72$ years, $Mdn = 37.50$ years, $SD = 2.65$ years) and term group ($M = 33.64$ years, $Mdn = 34.00$ years, $SD = 8.56$ years; Mann-Whitney U test, $p = .079$). Fathers' age similarly did not significantly differ between the preterm group ($M = 39.31$ years, $Mdn = 38.50$ years, $SD = 3.38$ years) and term group ($M = 36.96$ years, $Mdn = 36.00$ years, $SD = 6.92$ years; independent-samples t-test, $p = .216$).

Procedure

Ethical approval was granted by the Research Ethics Committee of the Coombe Women and Infants University Hospital (Ethics ID: Study No. 6 – 2020) and the School of Psychology Research Ethics Committee in Trinity College Dublin (Ethics ID: SPREC0072021-01). Before engaging in the study, mothers and fathers provided written consent on behalf of themselves and their infants.

Consenting parents completed questionnaires regarding their infant's development (social-emotional development, executive function) and their family's sociodemographic characteristics. Participating families also visited the Infant and Child Research Lab (School of Psychology, Trinity College Dublin) where the infant was administered the cognitive and language (receptive and expressive communication) scales of the Bayley-III (Bayley, 2006) and engaged in dyadic free-play interactions with their mothers and fathers. During the mother-infant and father-infant free-play interactions, the experimenter presented the parent-infant pairs with a box of age-appropriate toys (e.g., balls, toy cars, building blocks) and encouraged parents to play with their infant as they would at home. The play sessions were video-recorded and audio-recorded with two wall-mounted cameras and a hidden audio-recorder for 5-10 minutes. The order of the dyadic interactions (mother-infant, father-infant) was counterbalanced across participants to control for growing infant fatigue. While mother-infant interactions were recorded for all participating families, father-infant interactions are missing for five preterm families and one term family as the father was unable to attend the in-person testing session (owing to a range of reasons including difficulty scheduling time off work).

Infant Development Measures

Bayley Scales of Infant and Toddler Development – 3rd Edition (Bayley, 2006). A trained investigator administered the cognitive, receptive communication, and expressive communication scales of the Bayley-III to the infants, and the mother or father completed the Bayley-III social-emotional questionnaire. Scaled scores (with a normative mean of 10 and standard deviation of 3) were used in the present analysis. Higher scaled scores (reliability in parentheses) on the cognitive (split-half reliability = .91), receptive communication (split-half reliability = .87), expressive communication (split-half reliability = .91), and social-emotional (Cronbach's alpha = .90) scales reflect higher levels of ability (Bayley, 2006).

Behavior Rating Inventory of Executive Function Preschool (BRIEF-P; Gioia et al., 2003). The mother or father completed the BRIEF-P which contains 63 items reflecting five executive function domains (inhibit, shift, emotional control, working memory, and plan/organise) which combine to form a global executive composite score (Cronbach's *a* = .95). The standardised global executive composite score was used in this analysis. This score is distributed with a normative mean of 50 and standard deviation of 10, with higher scores reflecting greater levels of executive dysfunction (scores ≥ 65 reflect potentially clinically significant degrees of executive dysfunction; Gioia et al., 2003).

Parent-Infant Interactions

Data Pre-Processing. Trained research assistants transcribed 5 minute segments of the audio-recordings of the mother-infant and father-infant free-play interactions. When audio-recordings were significantly longer than 5 minutes, the earliest uninterrupted 5 minute segment (i.e., free from interruptions including the re-entry of the investigator into the observation room) was chosen for analysis. Using the CHILDES CHAT transcription format (MacWhinney, 2000), interactions were transcribed at the utterance level whereby utterances were defined as speech units which are separated by a pause, change in intonation, and/or grammatical structure. Using the audio waveform, the start and end time of each utterance was time-stamped. A senior transcriber (Dr. Jean Quigley) reviewed and corrected all transcripts prior to analysis.

The current study aimed to investigate the language environment features which characterise the verbal conversational exchanges of parent-infant dyads. Hence, prior to analysis, the time-stamped transcripts were manually filtered to retain only vocalisations which were conversational and speech-related. Specifically, while speech segments, conversational fillers, and unintelligible utterances were kept, non-voluntary sounds and voluntary but non-conversational sounds (e.g., vegetative sounds, singing, crying, laughing) were filtered out. Utterances containing both qualifying and disqualifying characteristics (e.g., speech [qualifying characteristic] voiced while laughing [disqualifying characteristic]) were kept. This filtering procedure resulted in the removal of one mother-infant free-play interaction transcript (belonging to the term group) from the analysis as the infant produced no qualifying utterances which thereby prevented the computation of the interactive language environment features (responsiveness, turn-taking, conversational balance).

(Para)linguistic Measures. The time-stamped and filtered transcripts were analysed using the CLAN software (MacWhinney, 2000) to characterise the quantitative and qualitative features of maternal and paternal speech. The quantitative features included a measure of volubility (words per minute; number of parent words divided by the duration of the transcript in minutes) and a measure of speech rate (words per minute; number of parental words divided by the number of minutes the parent spent speaking). The qualitative features included one measure of lexical diversity (type-token ratio) and three measures of morphosyntactic complexity (mean length of utterance in morphemes [MLUm], mean length of utterance in words [MLUw], verbs per utterance).

Interactive Measures. In order to measure the interactive features of mother-infant and father-infant conversations, the following metrics of responsiveness, turn-taking, and conversational balance were manually annotated using the time-stamped transcripts (with the exception of mean length of turn ratio [MLT ratio] which was computed using CLAN). The manual coding of these features centred around analysing the interpersonal sequencing of conversational turns produced by each speaker (a turn was defined as one or more consecutive utterance(s) produced by a single speaker which were separated by pauses ≤ 2 seconds).

Responsiveness. The responsiveness of parents and infants was calculated as the proportion of interlocutor turns to which the speaker (mother/father or infant) responded within 2 seconds. This 2 second criterion draws upon previous investigations (Van Egeren et al., 2001) which suggest that temporally contingent turn-transitions involve gaps of ≤ 2 seconds between the end of one speaker's turn and the start of another speaker's turn.

Turn-Taking. Two measures of turn-taking were calculated. (1) *Turn-pairs*: Turn-pairs were defined as speaker transitions involving a gap of < 2 seconds between the end of the first speaker's turn and the start of the second speaker's turn (turn-transitions involving overlaps were included in the count of turn-pairs). The rate of turn-pairs per minute was calculated in the mother-infant and father-infant contexts by dividing the frequency of turn-pairs by the duration of the transcript (in minutes). (2) *Multiturn conversational episodes (MTCEs)*: MTCEs (Beiting et al., 2022) capture extended turn-taking sequences which involve two or more consecutive turn-pairs. MTCEs were defined as sequences of three or more alternating speaker turns (e.g., infant-parent-infant) separated by pauses of < 2 seconds (turn-transitions involving overlaps were included). The end of an MTCE was marked by a pause lasting ≥ 2 seconds. MTCEs including the first/last turn of the transcript were omitted since the MTCE may have continued beyond the time segment included in the transcript. However, the MTCE was included if the first/last turn was preceded/followed by a ≥ 2 second pause. The rate of MTCEs per minute within mother-infant and father-infant interactions was computed by dividing the corresponding frequency of MTCEs by the duration of each transcript (in minutes).

Conversational Balance. Two measures of conversational balance were computed. (1) *Conversation initiations*: The initiator of a conversation was defined as the first person (mother/father or infant) to speak during a turn-taking sequence (turn-pair or MTCE) which occurred following a conversational pause lasting ≥ 2 seconds. Within the mother-infant and father-infant interaction contexts, the proportion of conversations initiated by the mother/father was calculated. (2) *MLT ratio*: The MLT ratio was calculated to characterise the division of conversational load within mother-infant and father-infant conversations. The ratio was computed in CLAN by dividing the infant's MLT (words per turn) by the parent's MLT (words per turn). A more equal parent-infant distribution of conversational load is indicated by MLT ratios closer to 1.00. Note that "turns" in CLAN comprise sequences of consecutive utterances by one speaker with no limit on the gap between utterances. This definition of turns slightly differs from the specification used in the abovementioned manual annotations of responsiveness and turn-taking whereby turns constituted consecutive utterances separated by gaps ≤ 2 seconds. This use of a ≤ 2 second temporal cut-off in the manual annotations allowed for a more precise identification of conversational turns which was necessary for a meaningful investigation of turn-taking.

Data Analysis

All analyses were two-tailed (a = .05) and carried out in R (version 4.2.2; R Core Team, 2022).

Preliminary Analyses

Independent-samples t-tests were carried out to compare the preterm and term groups on infant development characteristics (Bayley-III and BRIEF-P scores). The parametric assumptions for distributional normality (Shapiro-Wilk test, a = .05) and homogeneity of variance (Levene's test, a = .05) were tested and met by all t-tests. The between-group comparisons were sufficiently powered (80% power, *a* = .05) to detect a large effect following Cohen's (1969) effect size indices for small (*d* = 0.2), medium (*d* = 0.5), and large (*d* = 0.8) effects.

Primary Analyses

Using the lmerTest (v3.1-3; Kuznetsova et al., 2017) package, 2x2 mixed ANOVAs were computed for each language environment feature with birth status (preterm/term) as the between-group variable and the gender of the interacting parent (mother/father) as the repeated measures variable. Of primary interest was the main effect of birth status (preterm/term) on each language environment feature and the moderation of its effect by parent gender (as reflected in the birth status*parent gender interaction term). When significant interactions between birth status and parent gender were found, Tukey HSD tests from the emmeans package (v1.8.6; Lenth, 2023) were used to examine the effect of the birth status variable across the two levels of the parent gender variable. While infant age, sex, and socioeconomic status were hypothesised to be confounding variables, only age was found to differ significantly between the preterm and term groups (see *Participants* section above). As infant age was significantly associated with the infant responsiveness and MLT ratio measures, ANCOVAs (controlling for age) were computed for these two language environment features. The ANOVAs and ANCOVAs were computed using Type III sums of squares.

The statistical assumptions which apply to both ANOVAs and ANCOVAs (henceforth, AN(C)OVAs) were assessed by testing for outliers (>1.5 times the interquartile range above/below the third/first quartile), distributional normality (Shapiro-Wilk test, *a* = .05), homogeneity of variance (Levene's test, *a* = .05), and homogeneity of covariances (Box's M test, *a* = .001). Following the removal of outliers, all AN(C)OVAs met the assumption of distributional normality, while three AN(C)OVAs violated the homogeneity of variance assumption (volubility, MLUw, parent responsiveness, MLT ratio), and one ANCOVA violated the homogeneity of covariance assumption (MLT ratio). The ANCOVA-specific assumptions of linearity (scatterplot) and homogeneity of regression lines (test of interaction terms) required of the age covariate were tested and met by both ANCOVAs.

The present ANOVA analyses were sufficiently powered (80% power, a = .05) to detect a large effect following Cohen's (1969) effect size indices for small ($\eta 2$ = .01), medium ($\eta 2$ = .06), and large ($\eta 2$ = .14) effects (Cohen's f converted to $\eta 2$ for ease of interpretation).

Results

Preliminary Analyses

Independent-samples t-tests compared the preterm and term groups on infant development characteristics (Bayley-III, BRIEF-P). As can be seen in Table 5.2.1, while infants born preterm exhibited significantly poorer receptive communication and expressive communication skills than their term-born peers, there were no significant between-group differences in cognitive or social-emotional skills (a subset of infants in the preterm group were unable to complete the receptive and expressive communication tests due to attentional difficulties, tiredness, and/or fussiness). The infants born preterm recorded significantly greater levels of executive dysfunction when compared to their term-born peers, with 12.5% and 0% of preterm- and term-born infants respectively demonstrating clinically significant levels of executive dysfunction (scores ≥ 65).

Table 5.2.1

Independent-Samples Comparisons of Bayley-III and BRIEF-P Scores

	Term-born				Preterm-born							
	n	*M*	*SD*	*Mdn*	*n*	*M*	*SD*	*Mdn*	Test statistic	*p*	95% CI	Effect size
Recep comm (Bayley)	25	12.92	2.78	13.0	19	9.95	3.54	10	$t(42) = 3.12$	**.003**	1.05, 4.89	$d = 0.95$
Express comm (Bayley)	25	12.28	2.79	12.0	19	9.95	4.33	10	$t(42) = 2.17$	**.036**	0.16, 4.50	$d = 0.66$
Cognitive (Bayley)	25	10.44	2.29	10.0	22	9.32	2.77	9	$t(45) = 1.52$	.136	-0.36, 2.61	$d = 0.44$
Social-emotion (Bayley)	22	11.86	3.12	11.0	16	9.88	2.92	10	$t(36) = 1.99$	.054	-0.04, 4.01	$d = 0.65$
GEC (BRIEF-P)	24	44.67	9.89	44.5	16	52.75	12.45	52	$t(38) = -2.28$	**.028**	-15.25, -0.91	$d = 0.74$

Note. Statistically significant effects ($p < .05$) are shown in bold. CI = confidence interval; Recep comm = Receptive communication; Express comm = Expressive communication; Social-emotion = Social-emotional; GEC = Global executive composite.

Primary Analyses

2x2 mixed AN(C)OVAs investigated the effect of birth status (preterm/term) on each (para)linguistic and interactive language environment feature displayed in Table 5.2.2, as well as the moderation of this effect by the gender of the interacting parent (mother/father). Infant age was included as a covariate (i.e., ANCOVA) for the infant responsiveness and MLT ratio variables.

Table 5.2.2

Descriptive Statistics for the (Para)linguistic and Interactive Features of Mother-/Father-Infant Interactions with Term-/Preterm-Born Infants

	Mother-infant interaction		Father-infant interaction	
	Term-born *M (SD)*	Preterm-born *M (SD)*	Term-born *M (SD)*	Preterm-born *M (SD)*
(Para)linguistic (Parent)				
Quantitative: Volubility	81.84 (22.05)	69.84 (24.46)	70.46 (24.91)	73.47 (33.59)
Quantitative: Speech rate	245.66 (28.55)	213.10 (35.22)	246.79 (37.32)	240.85 (39.76)
Qualitative (lexical): Type-token ratio	0.28 (0.05)	0.28 (0.05)	0.30 (0.06)	0.28 (0.07)
Qualitative (morphosyntactic): MLUm	4.14 (0.64)	4.20 (0.87)	3.95 (1.04)	4.16 (0.87)
Qualitative (morphosyntactic): MLUw	3.81 (0.51)	3.94 (0.80)	3.83 (1.06)	3.92 (0.80)
Qualitative (morphosyntactic): Verbs per utterance	0.72 (0.12)	0.72 (0.16)	0.73 (0.23)	0.73 (0.21)
Interactive				
Responsiveness: Parent responsiveness	0.90 (0.07)	0.89 (0.09)	0.87 (0.10)	0.90 (0.07)
Responsiveness: Infant responsiveness	0.55 (0.21)	0.52 (0.23)	0.55 (0.21)	0.50 (0.19)
Turn-taking: Turn-pairs (rate per minute)	11.81 (5.89)	9.57 (5.03)	11.81 (6.08)	9.17 (4.07)
Turn-taking: MTCE (rate per minute)	1.85 (0.82)	1.46 (0.59)	1.77 (0.65)	1.59 (0.57)
Conversational balance: Prop of conversations initiated by parent	0.55 (0.15)	0.53 (0.20)	0.53 (0.15)	0.59 (0.23)
Conversational balance: MLT ratio	0.13 (0.07)	0.24 (0.16)	0.14 (0.07)	0.14 (0.10)

Note. Descriptive statistics computed following the removal of outliers. Prop = Proportion.

(Para)linguistic Features

The results of the ANOVAs corresponding to the quantitative (volubility, speech rate) and qualitative (type-token ratio, MLUm, MLUw, verbs per utterance) measures are displayed in Table 5.2.3.

Quantitative. While there was no significant birth status*parent gender interaction effect on parent volubility, there was a significant main effect of birth status. Specifically, parents in the preterm group spoke significantly less than parents in the term group. Meanwhile, there was no significant main effect of parent gender on volubility.

In the ANOVA corresponding to parent speech rate, there was a significant birth status*parent gender interaction effect. Tukey HSD comparisons found that mothers in the preterm group spoke significantly more slowly than mothers in the term group (t[66.7] = -3.08, p = .003, d =1.02). There was no significant difference between the preterm and term groups in paternal speech rate (t[71.7] = -0.66, p = .513, d = 0.15).

Qualitative. There was no significant birth status*parent gender interaction effect on the lexical diversity (type-token ratio) or morphosyntactic complexity (MLUm, MLUw, verbs per utterance) measures. There was similarly no significant main effect of birth status or parent gender on any of these four qualitative linguistic measures.

Table 5.2.3

ANOVAs Corresponding to the (Para)linguistic Features of the Language Environment

Language environment feature	Main/Interaction effects	Test statistic	*p*	η_p^2
Quantitative: Volubility	Birth Status	$F(1, 79) = 4.08$	**.047**	.05
	Parent Gender	$F(1, 79) = 3.57$	.062	.04
	Birth Status*Parent Gender	$F(1, 79) = 0.26$	.612	< .01
Quantitative: Speech rate	Birth Status	$F(1, 44.92) = 4.55$	**.038**	.09
	Parent Gender	$F(1, 39.87) = 6.41$	**.015**	.14
	Birth Status*Parent Gender	$F(1, 39.87) = 5.33$	**.026**	.12
Qualitative (lexical): Type-token ratio	Birth Status	$F(1, 80) = 0.28$	.600	< .01
	Parent Gender	$F(1, 80) = 0.43$	.515	< .01
	Birth Status*Parent Gender	$F(1, 80) = 0.95$	.333	.01
Qualitative (morphosyntactic): MLUm	Birth Status	$F(1, 44.16) = 0.31$	.584	< .01
	Parent Gender	$F(1, 41.16) = 0.66$	.420	.02
	Birth Status*Parent Gender	$F(1, 41.16) = 0.18$	.674	< .01
Qualitative (morphosyntactic): MLUw	Birth Status	$F(1, 38.39) = 0.09$	.766	< .01
	Parent Gender	$F(1, 35.09) = 0.06$	.813	< .01
	Birth Status*Parent Gender	$F(1, 35.09) < 0.01$	.979	< .01
Qualitative (morphosyntactic): Verbs per utterance	Birth Status	$F(1, 37.76) = 0.06$	.809	< .01
	Parent Gender	$F(1, 35.29) < 0.01$	.963	< .01
	Birth Status*Parent Gender	$F(1, 35.29) = 0.01$	.915	< .01

Note. Type III sums of squares. Statistically significant effects ($p < .05$) are shown in bold.

Interactive Features

The results of the AN(C)OVAs corresponding to the responsiveness (parent responsiveness, infant responsiveness), turn-taking (turn-pairs, MTCEs), and conversational balance (proportion of conversations initiated by the parent, MLT ratio) measures are reported in Table 5.2.4.

Responsiveness. There was no significant birth status*parent gender interaction effect on either parent responsiveness or infant responsiveness. There was also no significant main effect of birth status or parent gender on either parent or infant responsiveness.

Turn-Taking. There was no significant birth status*parent gender interaction effect on either turn-pairs (rate per minute) or MTCEs (rate per minute). There was no significant main effect of birth status or parent gender on either turn-taking measure.

Conversational Balance. With regards to the proportion of conversations initiated by parents, there was no significant birth status*parent gender interaction effect. There was also no significant main effect of birth status or parent gender on this measure.

In the ANCOVA corresponding to MLT ratio, there was a significant birth status*parent gender interaction effect. Tukey HSD comparisons found that mother-infant dyads in the preterm group have significantly higher MLT ratios than mother-infant dyads in the term group (t[67.6] = 2.58, p = .01, d = 0.91). There was no significant effect of birth status on the MLT ratios of father-infant dyads (t[72.2] = 0.03, p = .976, d = 0.06).

Table 5.2.4

AN(C)OVAs Corresponding to the Interactive Features of the Language Environment

Language environment feature	Main/Interaction effects	Test statistic	p	η_p^2
Responsiveness: Parent responsiveness	Birth Status	$F(1, 42.71) = 0.92$	.344	.02
	Parent Gender	$F(1, 42.01) = 0.28$	.602	< .01
	Birth Status*Parent Gender	$F(1, 42.01) = 1.54$	.222	.04
Responsiveness: Infant responsiveness	Infant Age (covariate)	$F(1, 40.57) = 8.90$	**.005**	.18
	Birth Status	$F(1, 40.75) = 3.36$	.074	.08
	Parent Gender	$F(1, 40.80) < 0.01$	.955	< .01
	Birth Status*Parent Gender	$F(1, 40.83) = 0.02$	.897	< .01
Turn-taking: Turn-pairs (rate per minute)	Birth Status	$F(1, 43.33) = 2.97$	.092	.06
	Parent Gender	$F(1, 41.05) = 0.01$	.936	< .01
	Birth Status*Parent Gender	$F(1, 41.05) = 0.06$	.807	< .01
Turn-taking: MTCE (rate per minute)	Birth Status	$F(1, 42.27) = 1.74$	.195	.04
	Parent Gender	$F(1, 35.82) = 0.23$	.634	< .01
	Birth Status*Parent Gender	$F(1, 35.82) = 0.68$	.414	.02
Conversational balance: Prop of conversations initiated by parent	Birth Status	$F(1, 37.68) = 0.19$	.663	< .01
	Parent Gender	$F(1, 34.50) = 0.34$	.565	< .01
	Birth Status*Parent Gender	$F(1, 34.50) = 1.01$	.322	.03
Conversational balance: MLT ratio	Infant Age (covariate)	$F(1, 42.67) = 4.11$	**.049**	.09
	Birth Status	$F(1, 38.43) = 2.32$	.136	.06
	Parent Gender	$F(1, 36.88) = 2.33$	.135	.06
	Birth Status*Parent Gender	$F(1, 37.12) = 4.71$	**.036**	.11

Note. Type III sums of squares. Statistically significant effects ($p < .05$) are shown in bold. Prop = Proportion.

Discussion

The present study aimed to develop a deeper understanding of the language difficulties associated with preterm birth through comparing the (para)linguistic and interactive dimensions of the language environments experienced by infants born preterm and at term during mother-/father-infant free-play interactions. A nuanced interpretation of between-group similarities/differences in the language environment was advanced through explicitly acknowledging the nesting of each feature within the broader language environment and the nesting of the language environment itself within the wider developmental ecology. This investigation found more similarities than differences between the language environments of preterm and term groups, with the differences being found on isolated (para)linguistic (volubility, speech rate) and interactive (MLT ratio) measures. Drawing on the social-interactionist (Bruner, 1983), transactional (Fiese & Sameroff, 1989), and dynamic systems (Spencer et al., 2011) perspectives upon which the nesting view is based, the developmental and clinical implications of these findings are discussed.

(Para)linguistic Features

Preterm-term language environment differences were found on quantitative but not qualitative features. With regards to the quantitative features, parents in the preterm group were found to direct less speech to their infants (lower volubility) when compared to parents in the term group. While this finding aligns with Spinelli et al. (2022) who similarly found preterm birth to be associated with reduced maternal volubility, it conflicts with other studies which found no such between-group differences (e.g., Adams et al., 2018; Salerni & Suttora, 2022; Salerni et al., 2007; Suttora et al., 2020). Although no previous preterm-term comparison studies of parental speech rate could be identified, the current study found mothers in the preterm group to speak more slowly than mothers in the term group (i.e., slower speech rate). No corresponding preterm-term difference in father speech rate was observed. In relation to the qualitative features, the absence of preterm-term differences in parental lexical diversity aligns with previous research (Salerni et al., 2007; Spinelli et al., 2022). Meanwhile, the absence of preterm-term differences in morphosyntactic complexity aligns with some studies (Salerni et al., 2007; Suttora et al., 2020) and conflicts with others which found preterm birth to be associated with higher levels of maternal morphosyntactic complexity (Reissland et al., 1999; Spinelli et al., 2022). These discrepancies in findings may originate from between-study differences in sample characteristics (e.g., in contrast to the inclusion of infants of all degrees of prematurity in the present study, many studies constrain their sample to extremely/very preterm infants) and measurement methods (e.g., words per minute vs utterances per minute). Meta-analytic studies will be required to evaluate the moderating influence of these methodological factors.

Within the context of the present investigation, there are a number of possible explanations for the preterm-term differences in parent volubility. Previous investigations have found mothers to adapt their speech to the developmental level of both typically developing and preterm-born children (Salerni et al., 2007; Snow, 1995). Hence, the lower volubility of parents in the preterm group may reflect parental adaptations to the poorer language and executive function development of the preterm-born (as compared to term-born) infants in this study. Reciprocally, it is also possible that parent volubility is prospectively associated with the infant's language and executive function development. Similar mechanisms of parental adaptation and/or developmental influence may underlie the preterm-term difference in maternal speech rate. Whichever direction these effects may flow in (and they may flow in both directions in tandem), the differential effect of preterm/term birth status on maternal and paternal speech tentatively suggest that the interface between the language environment and the developmental ecology (infant development) may operate differently within the context of mother-infant and father-infant interactions. Such divergences may be driven by mother-father differences in familiarity with the infants' developmental characteristics and/or their level of involvement with caregiving. Future studies may evaluate these proposed pathways through investigating the concurrent and longitudinal associations between language environment features and infant development characteristics.

Interactive Features

The interactive dimension was investigated across the following three categories of features: responsiveness (infant, parent), turn-taking (turn-pairs, MTCEs), and conversational balance (proportion of conversations initiated by the parent, MLT ratio). Previous preterm studies which have investigated such interactive features have selectively examined mother-infant interactions involving infants ≤ 6 months of age. These published studies found preterm dyads to be characterised by higher levels of maternal responsiveness, higher rates of maternal conversational initiations, and lower levels of infant responsiveness when compared to term dyads (Reissland & Stephenson, 1999; Salerni et al., 2007). In contrast, the current study found no between-group differences in parental responsiveness, parental conversation initiation, or infant responsiveness. Furthermore, while there were no between-group differences in either turn-taking measure (turn-pairs, MTCEs), there was a significant preterm-term difference in MLT ratio, which was limited to the mother-infant interactions.

The lack of a preterm-term difference in either parent or infant responsiveness may be rooted in the infant's biological maturation and the parent's intentional or unintentional scaffolding of infant responsiveness. Two years is the age-point at which infants born preterm are suggested to catch-up to the development of their term-born peers. Although the preterm group demonstrated poorer language and executive function skills when compared to the term group, the non-significant between-group differences in cognitive and social-emotional skills may signify a partial catch-up. Thus, when compared to the ≤ 6 month old infants in previous preterm investigations of mother-infant vocal exchanges, the current 2-year-old preterm sample may have been better equipped to exhibit similar levels of responsiveness as their term-born counterparts. This capacity for increased responsiveness in the infant born preterm may also have transactionally down-regulated the responsiveness of the parent to a level commensurate to that of parents of term-born infants (Crnic et al., 1983; Field, 1980).

In addition, the reduced volubility of parents in the preterm group may have facilitated infants born preterm to exhibit similar levels of responsiveness as their term-born peers. Through speaking less, parents in the preterm group may have provided their infants with more opportunities to respond to their utterances and thereby participate in the conversation. Although the above explanations for the lack of preterm-term differences in parent/infant responsiveness have been advanced with respect to both mothers and fathers, preterm-term differences in these variables have thus far only been documented among mother-infant dyads, with no corresponding research existing for father-infant dyads. Therefore, the relevance of these explanations to father-infant dyads must be pursued by first examining whether the preterm-term responsiveness differences seen in the literature at ≤ 6 months of age are unique to mother-infant dyads or whether they similarly characterise both mother-infant and father-infant dyads.

With regards to the turn-taking category of features, there were no significant preterm-term differences in either turn-pair or MTCE rate. As both turn-taking measures were dependent on the responsiveness of parents/infants, the lack of significant between-group differences on these measures may be explained by the same mechanisms proposed to account for the lack of between-group differences in responsiveness (i.e., biological maturation and parental scaffolding). With regards to the features representing conversational balance, there were no significant preterm-term differences in the proportion of conversations initiated by the parent (again, possibly owing to processes of biological maturation and parental scaffolding). Meanwhile, there were significant preterm-term differences in MLT ratio which were observed in the mother-infant interactions but not the father-infant interactions. Contrary to the expectation that preterm dyads would exhibit lower MLT ratios than their term counterparts, the mother-infant dyads in the preterm group demonstrated significantly higher MLT ratios (and thus a more equal parent-infant distribution of conversational load) than those in the term group. The higher mother-infant MLT ratio of the preterm group may be a product of the slower speech rate of mothers in this group. From speaking more slowly to their infants, mothers in the preterm group may have used fewer words in each conversational turn (i.e., a shorter mean turn length, and thus a smaller parental MLT). As the MLT ratio is computed as the infant's MLT divided by the parent's MLT, the mother having a smaller MLT may have translated into a higher MLT ratio overall.

A Nested Interpretation of the Language Environment

This study found more similarities than differences between the language environments experienced by 2-year-old preterm- and term-born infants. Furthermore, some of the between-group differences manifested differently across the mother-infant and father-infant conversations. This study's adoption of a nested view of the language environment facilitated an in-depth consideration of the origins of these similarities/differences and their potential developmental implications. For instance, characterising the language environment across multiple (para)linguistic and interactive features enabled a consideration of interdependencies and mutual affordances between features which could not have been envisioned had the study been constrained to a more limited set of language environment features (e.g., parental volubility setting the context for increased infant responsiveness).

Furthermore, an awareness of the broader developmental ecology facilitated a consideration of how parental adaptations may contribute to preterm-term language environment differences. This awareness of the surrounding developmental ecology also allowed for an evaluation of the developmental appropriateness of the language environment. When considered in light of the developmental difficulties of the preterm group, the overall preterm-term language environment similarities suggest insufficient parental adaptation to the infant's needs (particularly in the case of father-infant conversations where only minimal preterm-term group differences were observed). This not only raises questions regarding the developmental appropriateness of the language environments experienced by preterm-born infants, but more broadly cautions against the indiscriminate use of the language environment of typically developing infants as a "gold standard" benchmark. In addition to appraising the language environment with respect to the specific needs of the infant (or group) in question, future studies should also investigate the opposite direction of effects to directly examine how the language environment may differentially affect the development of preterm- and term-born infants (differential susceptibility effects; e.g., Hadfield et al., 2017).

Strengths, Limitations, and Future Directions

In addition to the abovementioned strengths relating to the adoption of a nested view, the study makes substantial novel contributions through studying both mothers and fathers, and through studying infants of all degrees of prematurity at an understudied age-point at which developmental catch-up has been suggested to occur. Nonetheless, the study's insights are constrained by its cross-sectional design (limiting directional conclusions) as well as the sample's small size (limiting statistical power) and limited representativeness (English-speaking two-parent families). Future investigations should seek to address these sampling issues while also pursuing a more expanded operationalisation of the language environment through examining (para)linguistic features of infant speech and semantic features of parental speech (e.g., semantic contingency, utterance content). These expansions could respectively advance a more transactional view of the language environment (e.g., how parental responses are shaped by linguistic features of infant speech) and a greater understanding of the content of parent-infant conversations involving preterm-/term-born infants. Finally, the current study offered novel insights into the (para)linguistic and interactive conversational styles of preterm/term groups through observing parent-infant dyads in a standardised environment. Future studies may seek to complement these insights through using home observation methods to examine how these conversational styles transpire during day-to-day family activities.

Conclusions

The current study sought to better understand the language difficulties associated with preterm birth through comparing the language environment experienced by 2-year-old preterm- and term-born infants during mother-/father-infant free-play interactions. Across the (para)linguistic and interactive language environment features which were examined, preterm-term similarities outnumbered differences, with more preterm-term differences being observed in mother-infant than father-infant conversations. Drawing on insights from social-interactionist (Bruner, 1983), transactional (Fiese & Sameroff, 1989), and dynamic systems (Spencer et al., 2011) perspectives, a nested view of the language environment enabled the identification of the potential roles of infant maturation and parent-infant mutual adaptation in driving these similarities and differences.

These findings and their nested interpretations can meaningfully inform clinical practice. The preceding discussion highlights the need for clinicians to evaluate the language environment with reference to the specific developmental needs of an infant, rather than through drawing comparisons to a benchmark reflecting the language environment of typically developing infants. Furthermore, when giving advice to parents on how to enrich the language environment, clinicians should be cognizant of both the opportunities and costs associated with the networked nature of the language environment (e.g., how a change in one language environment feature could precipitate both desirable and undesirable changes in other features). In this way, it can be seen that the nested view advanced in this study may help to optimise the development of vulnerable populations through engendering a multidimensional and contextually embedded characterisation of the language environment which can meaningfully inform clinical assessment and intervention practices.

Study 5.3: Parent-Infant Conversations are Differentially Associated with the Development of Preterm- and Term-Born Infants

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Author Note

The first author (Sarah Coughlan) was responsible for the conceptualisation, formal analysis, and writing of this paper. These responsibilities were carried out under the guidance of the second and third authors (thesis supervisors).

The data analysed in this paper were collected and curated by the research team at the Infant and Child Research Lab (Trinity College Dublin). As part of this collective effort, the first author contributed to data collection through engaging in participant recruitment, scheduling, and testing. Recordings of parent-child interactions were transcribed by research assistants and past PhD students. These transcripts were microanalytically annotated and analysed by the first author.

This paper has been published in Journal of Experimental Child Psychology (https://doi.org/10.1016/j.jecp.2023.105809).

Abstract

Preterm birth is a risk factor for language difficulties. To better understand the language development of preterm-born infants, the current study investigated the concurrent associations between parent-infant conversations and the development of 22 preterm- and 25 term-born infants at 2 years of age. Conversations occurring during mother-/father-infant free-play interactions were analysed to characterise features of parental speech (volubility, speech rate, lexical diversity, morphosyntactic complexity) and parent-infant exchanges (parent responsiveness, turn-taking, conversational balance). The infants' language (receptive communication, expressive communication) and non-language (cognitive, social-emotional, executive function) development was assessed using standardised measures. Parent-infant conversations were associated with both language and non-language development. This suggests that parent-infant conversations may support language development directly and/or through advancing non-language skills which could promote language learning. The associations between parent-infant conversations and development varied as a function of birth status (preterm/term). This finding may signal the operation of different developmental processes within preterm- and term-born groups. Finally, infant development was differentially associated with mother-infant and father-infant conversations. This may point to the distinct contributions made by mothers and fathers to the development of both preterm- and term-born infants. To optimise language outcomes, these findings indicate that families should be guided to tailor parent-infant conversations to the unique developmental needs and processes of preterm-born infants. Families should also be supported to leverage the distinct developmental contributions of mothers and fathers. Future recommendations are made regarding how to investigate the proposed preterm-term differences in language development processes and the differential developmental contribution of mothers and fathers.

Keywords: preterm birth, language development, fathers, parent-infant interaction, child directed speech, turn taking

Introduction

Parent-infant conversations can play a pivotal role in shaping infant language development (Rowe & Weisleder, 2020). However, the precise nature of the associations between parent-infant conversations and infant development varies as a function of the infant's developmental needs (Rowe & Snow, 2020) and the characteristics of the caregiver (e.g., parent gender; Tamis-LeMonda et al., 2012). Such differential associations hint at variations in the developmental mechanisms which are in operation for different infants, at different stages of development, and in different interactional contexts. Based on this understanding, the current study investigated the associations between mother-/father-infant conversations and the development of preterm- and term-born infants at 2 years of age. Through this investigation, the study aimed to better understand the developmental mechanisms and needs of preterm- and term-born infants so as to generate evidence-based insights regarding how mothers and fathers may optimally support the language development of each group.

Language Environment and Infant Development

Social-interactionist (Bruner, 1983) perspectives propose that language development occurs within social interactions between an infant and a linguistically competent conversation partner. In line with this view, various paralinguistic/linguistic features (e.g., quantity, speed, lexical diversity, and morphosyntactic complexity of parental speech; Hoff & Naigles, 2002; Raneri et al., 2020) and interactive features (e.g., parental responsiveness, parent-infant turn-taking; Tamis-LeMonda et al., 2001; Wang et al., 2020) of parent-infant conversations have been found to be associated with infant language development. Importantly, the precise nature of these associations varies as a function of infant and caregiver characteristics. With regards to the role of infant characteristics, Rowe and Snow (2020) have drawn on Vygotsky's (1978) Zone of Proximal Development to underscore how the specific features of parent-infant conversations which support language development vary as a function of the infant's developmental needs and capacities. Furthermore, the moderating role of caregiver gender has been demonstrated in studies which have documented mother-infant and father-infant conversations to make unique contributions to the language development of both typically developing (Pancsofar & Vernon-Feagans, 2006; Tamis-LeMonda et al., 2012) and clinical (e.g., Down syndrome; Hilvert et al., 2022) populations.

To date, explanations for the association between parent-infant conversations and language development have invoked concepts and pathways which are relatively specific to the linguistic and communicative domains of functioning (see Masek, McMillan, et al., 2021). For example, it has been proposed that parents can help to reduce word-referent ambiguity through producing linguistically simplified utterances that are temporally and conceptually related to the infants' behaviours and focus of attention (Smith & Yu, 2008; Tamis-LeMonda et al., 2014). More recently, there has been a growth in the literature finding associations between parent-infant conversations and non-language skills (e.g., cognitive, social-emotional, executive function; Feldman, 2007; Gómez & Strasser, 2021; Romeo et al., 2021). In line with these developments, such non-language developmental domains have increasingly been recruited to explain the relationship between parent-infant conversation and language development. For instance, Masek and colleagues (Masek, McMillan, et al., 2021) discuss how parent-infant conversations may support language learning through strengthening infant attention, both in the moment and across development. Taken together, these findings and theoretical perspectives highlight how parent-infant conversations may support language development both directly and through affecting non-language skills (e.g., cognitive, social-emotional, and executive function) which can facilitate language learning (see Ibbotson, 2020 for a detailed discussion of the relationship between language and non-language development).

Preterm Birth and Infant Development

While medical advances have considerably improved the survival rates of preterm-born infants (< 37 weeks' gestation; World Health Organisation, 2012), preterm birth remains a significant risk factor for neurodevelopmental difficulties (Aylward, 2014; Blencowe et al., 2012). In comparison to their term-born peers (≥ 37 weeks' gestation; World Health Organisation, 2012), preterm-born infants exhibit poorer language skills in both receptive and expressive domains, with uncertainty regarding whether these difficulties lessen with age (van Noort-van der Spek et al., 2012). In addition to these language difficulties, preterm-born children exhibit poorer development in domain-general neuropsychological skills (e.g., executive functions; Aylward, 2014) and non-language domain-specific skills (e.g., cognitive, social-emotional; Aylward, 2014; Johnson, Matthews, et al., 2015). Nonetheless, there is considerable variability between preterm-born infants in developmental outcomes (e.g., Sansavini et al., 2011). This inter-individual variability, combined with the limited impact of medical advances on the prevalence of neurodevelopmental difficulties (Aylward, 2014), suggest the inadequacy of a purely biomedical explanation of preterm development. Instead, dynamic systems perspectives may offer a more holistic account of preterm development through viewing it as the outcome of interactions between the infant and their environment (Barra & Coo, 2023; Ibbotson, 2020; Karmiloff-Smith, 2009; Spencer et al., 2011).

As illustrated in the preceding discussion, parent-infant conversations form a pivotal element of the infant-environment interface when considering infant language development. Despite this, few studies have investigated the parent-infant conversations experienced by preterm-born infants. The majority of these existing studies have compared the parent-infant conversations of preterm- and term-born groups and have returned conflicting results regarding the presence and nature of between-group differences (e.g., both significant and non-significant between-group differences in the quantity and morphosyntactic complexity of maternal speech have been documented; Adams et al., 2018; Reissland et al., 1999; Salerni & Suttora, 2022; Salerni et al., 2007; Spinelli et al., 2022; Suttora et al., 2020).

While cumulative evidence and meta-analytic efforts may elucidate the source of these disagreements, attempts to understand the developmental implications of any preterm-term differences in parent-infant conversations are hindered by the limited research on the association between parent-infant conversations and the development of preterm-born infants. In this context, when preterm-term differences in parent-infant conversations are found, preterm conversations can be deemed "atypical" through deviating from the normative standard set by the parent-infant conversations of the term-born group. This deficit perspective of preterm parent-infant conversations reflects an implicit assumption that the conversational experiences of term-born infants (or otherwise typically developing infants) constitute a "gold-standard" benchmark which should apply to all infants. More specifically, it reflects a view that what benefits the development of term-born infants will similarly benefit the development of preterm-born infants. Yet, there are conceptual and empirical reasons to question such assumptions.

Parent-infant conversations may differentially affect the development of preterm- and term-born infants owing to their unique developmental profiles and resultingly divergent Zones of Proximal Development (Rowe & Snow, 2020; Vygotsky, 1978). Furthermore, the biopsychosocial vulnerabilities of preterm-born infants may result in a heightened sensitivity to parent-infant conversations which could manifest in a variety of ways. For instance, preterm-born infants could exhibit heightened sensitivity to positive environmental influences (vantage sensitivity), negative environmental influences (dual risk/diathesis-stress), or both (differential susceptibility), while the same environmental features could exert opposite effects on the development of preterm- and term-born infants (contrastive effects; Belsky et al., 2007; Pluess, 2015). In addition, different forms of such environmental sensitivity may be observed depending on the conversational feature and/or developmental domain under consideration. Some initial evidence has been found in support of such preterm-term differences in patterns of association between parent-infant conversations and development. While the quantity of parental speech similarly predicted the language development of both preterm- and term-born infants (Adams et al., 2018), maternal mind-related speech and maternal verbal scaffolding respectively predicted growth in the expressive language and non-verbal problem-solving skills of preterm- but not term-born children (Costantini et al., 2017; Smith et al., 2000).

Current Study

A social-interactionist and dynamic systems view of the development of preterm-born infants was adopted to gain a deeper understanding of the mechanisms underlying preterm language development and the means through which their outcomes may be optimised. To do so, the present study investigated the associations between parent-infant conversations and the development of preterm- and term-born infants at 2 years of age. A holistic account of parent-infant conversations was pursued through quantifying the (para)linguistic (parental volubility, speech rate, lexical diversity, and morphosyntactic complexity) and interactive (parental responsiveness, turn-taking, conversational balance) features of parent-infant conversations. Both mother-infant and father-infant conversations were examined given previous findings regarding the unique developmental contributions made by each. Given that language and non-language development are inter-related and are both influenced by parent-infant conversations and preterm birth, infant development was measured in both language (receptive communication, expressive communication) and non-language (cognitive, social-emotional, executive function) domains.

Due to the paucity of research on the associations between parent-infant conversations and the development of preterm-born infants, the present study constituted an exploratory investigation of the following two research objectives. The primary research objective was to investigate whether there are similarities/differences in the associations between parent-infant conversations and the development of 2-year-old preterm- and term-born infants. A secondary objective was to examine whether infant development is differentially associated with mother-infant and father-infant conversations, and whether such a mother-father contrast may be observed within preterm- and/or term-born groups. Through these investigations, the study aimed to develop deeper insights into the developmental processes underlying the language abilities of preterm-born infants and how they may be supported by both mothers and fathers.

Method

Participants

This study included 47 English-speaking two-parent families with 2-year-old verbal singleton infants who were recruited for a larger longitudinal project investigating parent-infant interaction and infant development. The present sample included 22 families with preterm-born infants (< 37 weeks' gestation, min-max = 24 ~36 weeks) and 25 families with term-born infants (≥ 37 weeks' gestation).

Table 5.3.1 displays descriptive statistics reflecting the infant and parent characteristics of the term- and preterm-born groups. While there was no significant difference in the proportion of male/female infants in the term- and preterm-born groups (Chi-square test, $p = 1.000$), the term-born infants were significantly younger than the preterm-born infants (independent samples t-test, $p = .005$). There were no significant differences between the term-born and preterm-born groups with regards to the mothers' age (Mann-Whitney U test, $p = .079$), fathers' age (independent samples t-test, $p = .216$), or household socioeconomic status (proxied by maternal education level; Mann-Whitney U test, $p = .411$).

Table 5.3.1

Demographic Characteristics of Term-born and Preterm-born Groups

	Term-born		Preterm-born	
	N	%	*N*	%
Infant sex (female)	11	44.00	10	45.45
	M (SD)	*Mdn*	*M (SD)*	*Mdn*
Infant age (months) [a]	24.30 (1.41)	24.47	26.98 (3.82)	27.72
Mother age (years)	33.64 (8.56)	34.00	36.72 (2.65)	37.50
Father age (years)	36.96 (6.92)	36.00	39.31 (3.38)	38.50
Socioeconomic status [b]	6.20 (0.82)	6.00	6.33 (0.77)	6.50

Note. [a] Age was adjusted for prematurity for preterm-born infants < 24 months of age.
[b] Proxied by maternal education which was measured on an 8-point scale ranging from “1 = no formal education” to “8 = doctoral-level education”.

Procedure

Ethical approval was received from the Research Ethics Committee of the Coombe Women and Infants University Hospital and the School of Psychology Research Ethics Committee in Trinity College Dublin. Mothers and fathers provided written informed consent on behalf of themselves and their infants.

Parents answered questionnaires relating to their family’s sociodemographic characteristics and their infant’s development (social-emotional and executive function development). At the Infant and Child Research Lab (School of Psychology, Trinity College Dublin), the infant was administered the cognitive and language scales of the Bayley Scales of Infant and Toddler Development (Bayley, 2006). In this same lab setting, mother-infant and father-infant dyadic free-play interactions were observed. During the free-play interactions, the investigator presented the mother-/father-infant pair with a box of age-appropriate toys (e.g., ball, toy car, building blocks) and asked the parent to play with their infant as they would at home. The play interactions lasted between 5 and 10 minutes and were video- and audio-recorded with two wall-mounted cameras and an audio-recorder. The order of mother-infant and father-infant interactions was counterbalanced across families to account for the gradual increase in infant fatigue. Mother-infant interactions were recorded for all consenting families, while father-infant interactions were not obtained for six families (five preterm-born, one term-born) as the father could not attend the lab (owing to reasons including difficulty taking time away from work).

Infant Development Measures

Bayley Scales of Infant and Toddler Development – 3rd Edition (Bayley, 2006)

Infants were administered the cognitive, receptive communication, and expressive communication scales of the Bayley-III by a trained examiner, while parents completed the Bayley social-emotional questionnaire. The present study's analysis used the scaled scores from this measure (normative mean of 10 and standard deviation of 3). Higher scaled scores reflect higher levels of ability on each of the following scales (reliability in parentheses): cognitive (split-half reliability = .91), receptive communication (split-half reliability = .87), expressive communication (split-half reliability = .91), social-emotional (Cronbach's alpha = .90; Bayley, 2006).

Behavior Rating Inventory of Executive Function Preschool (BRIEF-P; Gioia et al., 2003)

Parents reported on their infants' executive function difficulties using the BRIEF-P. The BRIEF-P includes 63 items encompassing five executive function domains (inhibit, shift, emotional control, working memory, plan/organise) which together comprise a global executive composite score (Cronbach's a = .95). The standardised global executive composite score (normative mean of 50 and standard deviation of 10) was used in this analysis. Higher scores indicate greater levels of executive dysfunction (scores ≥ 65 suggest clinically significant executive dysfunction; Gioia et al., 2003).

Parent-Infant Conversations

Data Pre-Processing

Trained research assistants transcribed the earliest uninterrupted 5 minute segment of the mother-infant and father-infant free-play interactions (examples of interruptions include the examiner entering the observation room mid-recording). In line with the CHILDES CHAT transcription format (MacWhinney, 2000), the recordings were transcribed at the utterance level. Utterances were defined as speech units separated by a pause, grammatical feature, and/or change in intonation. Through inspecting the audio waveform, the start and end time of each utterance was marked. A senior transcriber (Dr. Jean Quigley) corrected all transcripts prior to their inclusion in the analyses described below.

As the present study sought to investigate verbal parent-infant conversations, the time-stamped transcripts were filtered manually to only retain conversational and speech-related vocalisations. While speech segments, conversational fillers, and unintelligible utterances were retained, non-voluntary sounds and voluntary but non-conversational sounds (e.g., vegetative sounds, singing, crying, laughing) were omitted. Utterances with both qualifying and disqualifying characteristics (e.g., speech [qualifying] produced while crying [disqualifying]) were retained. This filtering process resulted in the identification of one mother-infant free-play interaction transcript (from the term-born group) where the infant did not produce any qualifying utterances. This transcript was removed from the subsequent analyses as the absence of infant utterances prevented the computation of the interactive conversational variables (e.g., responsiveness, turn-taking, conversational balance).

Paralinguistic and Linguistic Measures

Using the CLAN software (MacWhinney, 2000), the time-stamped and filtered transcripts were analysed to characterise maternal and paternal speech on the following features: volubility (words per minute; total number of parental words divided by the duration of the transcript), speech rate (words per minute; total number of parental words divided by the amount of time the parent spent speaking), lexical diversity (type-token ratio), and morphosyntactic complexity (mean length of utterance in morphemes [MLUm], mean length of utterance in words [MLUw], verbs per utterance).

Interactive Measures

Measures of responsiveness, turn-taking, and conversational balance were quantified through manual annotations (with the exception of one conversational balance measure which was computed using CLAN – further details below). These manual annotations focused on analysing the interpersonal sequencing of conversational turns (a conversational turn comprised one or more consecutive utterances produced by a single speaker which were separated by pauses no greater than 2 seconds).

Responsiveness. Parent responsiveness was calculated as the proportion of infant turns to which the mother/father responded within 2 seconds.

Turn-Taking. (1) *Turn-pairs:* Turn-pairs comprised speaker transitions in which the gap between the end of the first speaker's turn and the beginning of the second speaker's turn was less than 2 seconds (speaker-transitions involving overlaps were also classed as turn-pairs). The rate of turn-pairs per minute for each mother-/father-infant interaction was computed by dividing the count of turn-pairs by the duration (in minutes) of the corresponding transcript.

(2) *Multi-turn conversational episodes (MTCEs):* MTCEs (Beiting et al., 2022) reflected extended turn-taking sequences through comprising chains of three or more alternating speaker turns (e.g., infant-parent-infant) which were separated by pauses of less than 2 seconds (speaker-transitions including overlaps were allowed). An MTCE ended upon a conversational pause lasting 2 or more seconds. MTCEs including the first/final turn of the transcript were not counted as the turn-taking sequence may have extended beyond the time

segment captured by the transcript (however, the MTCE was counted if the first/final turn had been preceded/followed by a pause lasting 2 seconds or longer). The rate of MTCEs per minute for each mother-/father-infant interaction was computed by dividing the count of MTCEs by the duration (in minutes) of the corresponding transcript.

Conversational Balance. (1) *Conversation initiations*: The first person (mother/father or infant) to speak during a turn-taking sequence (turn-pair or MTCE) which followed a ≥ 2 second conversational pause was deemed to have initiated that conversation. For each mother-/father-infant interaction, the proportion of conversations (i.e., turn-taking sequences) initiated by the mother/father was calculated.

(2) *Mean length of turn ratio (MLT ratio)*: MLT ratio was computed to examine the parent-infant division of conversational load within mother-infant and father-infant conversations. The MLT ratio was computed using CLAN through dividing the infant's MLT by the parent's MLT, with MLT reflecting the number of words per turn. A more balanced distribution of conversational load between parent and infant is suggested by MLT ratios closer to 1.00. It is important to highlight that CLAN defines "turns" as sequences of consecutive utterances produced by one speaker with no limit on the allowable gap between utterances. This definition subtly differs from that adopted in the manual annotations of responsiveness and turn-taking in which turns were defined as utterances separated by ≤ 2 second gaps. Using a ≤ 2 second cut-off facilitated the precise identification of conversational turns in the manual annotations, thereby allowing for a rigorous investigation of turn-taking.

Data Analysis

All of the current study's analyses were two-tailed (a = .05) and carried out in R (version 4.2.2; R Core Team, 2022).

Bivariate correlations were computed between the (para)linguistic and interactive features of mother-/father-infant conversations and the language and non-language development of infants. These correlations were computed separately for the preterm- and term-born groups. The parametric assumptions for correlations were tested using scatterplots (to inspect the linearity of relationships and the presence of multivariate outliers) and the Shapiro-Wilk test (to test for distributional normality; $p < .05$). While the relationships were linear and mostly free from multivariate outliers, the normal distribution assumption was violated by some variables. Due to this violation, Spearman correlations were computed.

Infant sex, socioeconomic status (proxied by maternal education), and infant age were identified as potentially confounding variables. To examine how infant sex may confound the analyses, independent-samples t-tests compared families with male and female infants on sociodemographic characteristics, infant development, and features of mother-/father-infant conversations. As families with male and female infants did not significantly differ on any of these variables ($p > .05$), infant sex was no longer considered a covariate. The potentially confounding influences of socioeconomic status and infant age were inspected through investigating whether either variable was significantly correlated with both the conversational measures and infant development measures. While socioeconomic status was not, infant age was significantly associated with conversational measures (mother-infant turn-pairs, mother-infant MLT ratio) and infant development (expressive communication) in the term-born group. Partial correlations (Spearman) were computed to control for the influence of infant age on the association between mother-infant turn-pairs/MLT ratio and expressive communication in the term-born group. Since the inclusion and exclusion of this age covariate did not affect the significance level of these correlations ($p > .05$ in all cases), these partial correlations are not discussed any further.

Following Cohen's (1969) indices for small (0.1), medium (0.3), and large (0.5) effects, the bivariate correlations were sufficiently powered (80% power, $a = .05$) to detect a large effect. Missing data were handled with pairwise deletion.

Results

The correlations between each feature of mother-/father-infant conversations and infant development displayed in Table 5.3.2 are reported across two sections. The first section outlines the associations between mother-infant conversations and the development of preterm- and term-born infants, while the second section outlines the associations between father-infant conversations and these same developmental measures. Within each section, the correlations corresponding to the term-born and preterm-born group are discussed separately.

Table 5.3.2

Descriptive Statistics Corresponding to the Measures of Infant Development and Parent-Infant Conversation

	Term-born			Preterm-born		
	M	*SD*	*Mdn*	*M*	*SD*	*Mdn*
Infant development						
Receptive communication	12.92	2.78	13.00	9.95	3.54	10.00
Expressive communication	12.28	2.79	12.00	9.95	4.33	10.00
Cognitive	10.44	2.29	10.00	9.32	2.77	9.00
Social-emotional	11.86	3.12	11.00	9.88	2.92	10.00
Global executive composite	44.67	9.89	44.50	52.75	12.45	52.00
Mother-infant conversation						
Volubility (words per minute)	81.84	22.05	81.86	69.84	24.46	73.49
Speech rate (words per minute)	245.66	28.55	250.60	220.11	47.54	215.61
Type-token ratio	0.29	0.07	0.27	0.29	0.07	0.28
MLUm	4.25	0.83	4.16	4.20	0.87	4.33
MLUw	3.99	0.79	3.90	3.94	0.80	4.04
Verbs per utterance	0.76	0.18	0.77	0.72	0.16	0.76
Parent responsiveness	0.89	0.09	0.89	0.86	0.15	0.89
Turn-pairs (rate per minute)	11.81	5.89	12.06	10.24	5.82	10.85
MTCE (rate per minute)	1.85	0.82	1.87	1.54	0.68	1.69
Parent-initiated conv (prop)	0.57	0.17	0.53	0.53	0.20	0.50
MLT ratio	0.13	0.07	0.12	0.24	0.16	0.20
Father-infant conversation						
Volubility (words per minute)	70.46	24.91	61.98	73.47	33.59	62.70
Speech rate (words per minute)	251.31	42.68	250.26	240.85	39.76	238.24
Type-token ratio	0.31	0.07	0.32	0.28	0.07	0.29
MLUm	4.07	1.17	4.06	4.16	0.87	4.04
MLUw	3.83	1.06	3.85	3.92	0.80	3.78
Verbs per utterance	0.73	0.23	0.75	0.73	0.21	0.68
Parent responsiveness	0.85	0.13	0.86	0.90	0.07	0.90
Turn-pairs (rate per minute)	11.81	6.08	11.51	9.17	4.07	9.09
MTCE (rate per minute)	1.77	0.65	1.80	1.59	0.57	1.58
Parent-initiated conv (prop)	0.58	0.21	0.59	0.59	0.23	0.57
MLT ratio	0.17	0.13	0.15	0.19	0.16	0.18

Note. Parent-initiated conv (prop) = Proportion of conversations initiated by parent.

Mother-Infant Conversations

The Spearman coefficients and significance levels of the correlations between mother-infant conversations and the development of term-born and preterm-born infants are reported in Table 5.3.3.

Term-Born

Among the term-born group, there were no significant associations between the (para)linguistic features of maternal speech and any of the five measured domains of infant development. With respect to the interactive features, the rate of turn-pairs ($r[22] = .47$, $p = .021$) and the MLT ratio ($r[22] = .50$, $p = .014$) were positively associated with the term-born infants' cognitive scores.

Preterm-Born

Among the (para)linguistic features of maternal speech, maternal speech rate was positively associated with the preterm-born infants' level of executive dysfunction (global executive composite score; $r[14] = .60$, $p = .013$). The mothers' MLUm ($r[17] = .57$, $p = .011$) and MLUw ($r[17] = .52$, $p = .023$) were also positively associated with the receptive communication scores of preterm-born infants.

In relation to the interactive features, the rate of turn-pairs was positively associated with the preterm-born infants' receptive communication scores ($r[17] = .48$, $p = .039$), while the proportion of conversations initiated by mothers was positively associated with both the receptive communication ($r[17] = .53$, $p = .019$) and social-emotional scores ($r[14] = .57$, $p = .022$) of the preterm-born group. Finally, MLT ratio was positively associated with the expressive communication ($r[17] = .52$, $p = .024$) and cognitive ($r[20] = .51$, $p = .015$) scores of preterm-born infants.

Table 5.3.3

Spearman Correlation Coefficients for the Associations between Mother-Infant Conversations and the Development of Preterm-/Term-born Infants

	Term-born					Preterm-born				
	Recep	Express	Cog	S-em	GEC	Recep	Express	Cog	S-em	GEC
Paralinguistic and Linguistic										
Volubility (words per minute)	-0.34	0.19	-0.28	-0.41	0.21	0.03	-0.15	-0.12	0.08	0.49
Speech rate (words per minute)	-0.03	0.01	-0.21	-0.16	0.09	-0.04	-0.04	-0.08	0.34	0.60*
Lexical diversity: Type-token ratio	0.28	0.07	0.22	0.35	-0.24	0.11	0.26	0.25	0.12	-0.45
Morphosyntax complexity: MLUm	-0.07	0.03	-0.31	-0.04	0.33	0.57*	0.37	0.37	0.49	0.19
Morphosyntax complexity: MLUw	-0.08	0.03	-0.33	-0.10	0.34	0.52*	0.37	0.32	0.48	0.19
Morphosyntax complexity: Verbs per utt	-0.05	0.12	-0.34	0.02	0.25	0.35	0.37	0.16	0.43	0.32
Interactive										
Responsiveness: Parent responsiveness	0.18	0.22	0.09	-0.32	0.32	0.07	-0.05	-0.18	0.10	0.13
Turn-taking: Turn-pairs (rate per minute)	0.19	0.32	0.47*	-0.16	0.07	0.48*	0.41	0.35	0.13	0.01
Turn-taking: MTCE (rate per minute)	0.29	0.07	0.25	-0.35	-0.39	0.31	0.18	0.10	0.02	0.20
Conv balance: Parent-initiated conv (prop)	-0.10	-0.08	-0.14	-0.08	0.13	0.53*	0.14	0.15	0.57*	0.21
Conv balance: MLT ratio	0.34	0.31	0.50*	0.04	-0.11	0.27	0.52*	0.51*	0.04	-0.41

Note. *$p < .05$. Recep = Receptive communication; Express = Expressive communication; Cog = Cognitive; S-em = Social-emotional; GEC = Global executive composite; Verbs per utt = Verbs per utterance; Conv balance = Conversational balance; Parent-initiated conv (prop) = Proportion of conversations initiated by parent.

Father-Infant Conversations

The Spearman coefficients and significance levels of the correlations between father-infant conversations and the development of term-born and preterm-born infants can be found in Table 5.3.4.

Term-Born

In the term-born group, none of the (para)linguistic features of paternal speech were significantly associated with any of the five domains of development measured in this study. With respect to the interactive features, father-infant MLT ratio was positively associated with the expressive communication scores of term-born infants (r[22] = .64, p = .001).

Preterm-Born

Among the (para)linguistic features, the fathers' MLUm, MLUw, and verbs per utterance were positively associated with the preterm-born infants' receptive communication scores (MLUm: r[12] = .73, p = .003; MLUw: r[12] = .67, p = .009; verbs per utterance: r[12] = .70, p = .006) and expressive communication scores (MLUm: r[12] = .60, p = .024; MLUw: r[12] = .54, p = .047; verbs per utterance: r[12] = .56, p = .037). Paternal MLUm, MLUw, and verbs per utterance were also positively associated with the preterm-born infants' cognitive scores (MLUm: r[15] = .69, p = .002; MLUw: r[15] = .65, p = .005; verbs per utterance: r[15] = .67, p = .003) and social-emotional scores (MLUm: r[10] = .75, p = .005; MLUw: r[10] = .72, p = .008; verbs per utterance: r[10] = .77, p = .003).

Meanwhile, none of the interactive features of father-infant conversations were significantly associated with any of the five domains of development among the preterm-born group.

Table 5.3.4

Spearman Correlation Coefficients for the Associations between Father-Infant Conversations and the Development of Preterm-/Term-born Infants

	Term-born					Preterm-born				
	Recep	Express	Cog	S-em	GEC	Recep	Express	Cog	S-em	GEC
Paralinguistic and Linguistic										
Volubility (words per minute)	0.10	0.10	-0.17	-0.33	0.13	0.27	0.35	0.24	0.40	0.22
Speech rate (words per minute)	-0.05	-0.20	-0.03	-0.12	0.21	0.02	0.15	0.12	0.44	0.28
Lexical diversity: Type-token ratio	-0.05	-0.21	0.35	0.25	-0.38	-0.24	-0.22	-0.19	-0.21	0.02
Morphosyntax complexity: MLUm	0.07	0.09	-0.31	0.22	0.20	0.73**	0.60*	0.69**	0.75**	0.16
Morphosyntax complexity: MLUw	0.11	0.11	-0.29	0.18	0.23	0.67**	0.54*	0.65**	0.72**	0.14
Morphosyntax complexity: Verbs per utt	0.06	0.04	-0.20	0.13	0.23	0.70**	0.56*	0.67**	0.77**	-0.11
Interactive										
Responsiveness: Parent responsiveness	-0.20	-0.17	-0.27	-0.23	-0.11	-0.17	0.16	-0.04	0.39	0.21
Turn-taking: Turn-pairs (rate per minute)	0.08	0.12	0.03	-0.34	0.13	0.43	0.46	0.37	-0.22	0.43
Turn-taking: MTCE (rate per minute)	0.04	0.10	-0.05	-0.30	0.12	0.29	0.05	0.19	-0.25	0.08
Conv balance: Parent-initiated conv (prop)	0.13	-0.28	-0.02	-0.14	-0.24	0.15	0.03	0.05	0.16	0.04
Conv balance: MLT ratio	0.08	0.64**	0.14	< 0.01	0.19	0.15	0.23	0.12	-0.51	0.42

Note. **p* < .05, ***p* < .01. Recep = Receptive communication; Express = Expressive communication; Cog = Cognitive; S-em = Social-emotional; GEC = Global executive composite; Verbs per utt = Verbs per utterance; Conv balance = Conversational balance; Parent-initiated conv (prop) = Proportion of conversations initiated by parent.

Discussion

To advance a deeper understanding of how mothers and fathers may support the language development of preterm-born infants, the current study investigated the associations between mother-/father-infant conversations and the development of 2-year-old preterm- and term-born infants. The (para)linguistic and interactive features of parent-infant conversations were associated with language and non-language development in ways that differed both as a function of the infant's birth status (preterm/term) and the parent's gender (mother/father). These differences may reflect the unique care needs of preterm- and term-born infants (owing to potentially differing developmental mechanisms) and divergences in how mothers and fathers may satisfy these needs. Future research directions are proposed regarding how to elucidate the mechanisms underlying language development in preterm and term groups. Clinical implications are also discussed in relation to how to advance a more developmentally-sensitive approach to the evaluation and enrichment of mothers' and fathers' conversations with preterm- and term-born infants.

In line with the findings of previous research (Hoff & Naigles, 2002; Tamis-LeMonda et al., 2001; Wang et al., 2020) and the theoretical insights of dynamic systems perspectives (Barra & Coo, 2023; Ibbotson, 2020; Karmiloff-Smith, 2009; Spencer et al., 2011) and social-interactionist views (Bruner, 1983), mother-infant and father-infant conversations were associated with the language development of both preterm- and term-born infants at 2 years of age. Furthermore, adding to the growing literature on the association between parent-infant conversations and non-language development (Gómez & Strasser, 2021; Romeo et al., 2021), the current study found mother-infant and father-infant conversations to be significantly associated with cognitive, social-emotional, and executive function development. These findings indicate that efforts to optimise parent-infant conversations may have developmental benefits that extend beyond the language and communicative domains of development. Given the interrelations between language and non-language development (Ibbotson, 2020), these findings also suggest how parent-infant conversations could support language development directly and through their influence on other non-language skills which facilitate language learning (Masek, McMillan, et al., 2021).

The number and pattern of associations between parent-infant conversations and infant development differed as a function of the infants' birth status (preterm/term). These between-group differences align with prior research demonstrating differing associations between mother-infant conversations and the development of preterm- and term-born children (Costantini et al., 2017; Smith et al., 2000), and further extend these observations to include father-infant conversations. In the present study, a larger number of significant associations was found between parent-infant conversations and the development of preterm-born infants as compared to term-born infants. This difference may suggest a heightened environmental sensitivity (Belsky et al., 2007; Pluess, 2015) to caregiving (parent-infant conversations) among preterm-born infants owing to their biological vulnerability. Meanwhile, the preterm-term differences in the patterns of associations between features of parent-infant conversations and the various domains of infant development may suggest the operation of different developmental processes within the preterm- and term-born groups.

Specifically, while the interactive features of parent-infant conversations were associated with the development of both preterm- and term-born infants, the (para)linguistic features were only associated with the development of preterm-born infants. Furthermore, the interactive features occasionally exerted different influences on the development of preterm- and term-born infants (e.g., mother-infant turn-taking [turn-pairs] was positively associated with the receptive communication skills of preterm-born infants but with the cognitive development of term-born infants). In line with Rowe and Snow's (2020) discussion of the Zone of Proximal Development (Vygotsky, 1978), these differential associations may reflect that preterm- and term-born infants are at differing developmental stages which entail unique learning milestones that are affected by parent-infant conversations in disparate ways.

It is also possible that preterm- and term-born infants are at similar developmental stages, but that they undergo qualitatively different developmental processes to arrive at similar developmental outcomes. This equifinality may arise from preterm- and term-born infants having divergent learning mechanisms owing to their unique neurocognitive capacities (e.g., compared to term-born infants, preterm-born infants are slower at processing heard speech; Marchman et al., 2019). Whichever mechanism is responsible for these results, the current findings indicate that, at 2 years of age, parent-infant conversations contribute to language and non-language development in differing ways for preterm and term-born infants. In more practical terms, this indicates that what constitutes a developmentally conducive parent-infant conversation differs for preterm- and term-born 2-year-old infants.

The associations between parent-infant conversations and infant development differed not only as a function of infant birth status but also as a function of parent gender. The differential associations between mother-infant and father-infant conversations and infant development documented in the current study align with previous findings of mother-father differences among typically developing (Pancsofar & Vernon-Feagans, 2006; Tamis-LeMonda et al., 2012) and clinical (Hilvert et al., 2022) populations, and importantly extend this observation to the context of preterm birth. The pattern of mother-father differences observed in the present study could guide future investigations into the roots of the distinct developmental contributions made by mothers and fathers. For example, in the current study, the interactive features of mother-infant conversations (turn-taking and conversational balance) were associated with both language and non-language development, while the interactive features of father-infant conversations (conversational balance) were solely associated with language development.

The unique importance of the interactive features of mother-infant conversations to non-language development may tentatively suggest that the conversational engagements of mothers and fathers differ on unmeasured conceptual features (e.g., elaborative reminiscing) which have been associated with non-language skills (e.g., Salmon & Reese, 2016). While these features were beyond the scope of the current study, future research may incorporate such variables as part of an expanded characterisation of parent-infant conversations to investigate the seemingly different developmental contributions of mothers and fathers. These mother-father differences in developmental contributions may also be partially attributable to differences in the infants' routine level of exposure to each parent. This possible role of *exposure* was not captured by the present study which instead aimed to examine mother-/father-infant conversational *styles* through observing dyads within a standardised lab environment. Hence, future research may seek to investigate the role of exposure by examining the associations between infant development and mother-/father-infant conversations which occur during naturalistic home audio-recordings.

Strengths, Weaknesses, and Future Directions

The current study significantly advances our understanding of preterm-born infants' language development through researching its association with parent-infant conversations. This study also contributes to the parent-infant conversation literature more broadly through comprehensively investigating the relevance of the (para)linguistic and interactive features of both mother-infant and father-infant conversations to infant development across language and non-language domains. A number of study weaknesses must nonetheless be acknowledged. The study samples' homogeneous composition (English-speaking two-parent households residing in a WEIRD nation) and small size respectively limit the cross-cultural generalisability of the findings and statistical power of the analyses. The study's cross-sectional design additionally precludes causal inferences regarding the direction of associations between parent-infant conversations and infant development. Consider, for example, the positive association between maternal speech rate and infant executive dysfunction. While this relationship may reflect the influence of maternal speech rate on executive function development, it could also suggest that mothers speak more quickly to infants with executive function difficulties in order to keep the infant engaged with the task at hand. Similarly, the differential associations between mother-/father-infant conversations and development may also be partially attributable to differences in how mothers and fathers adapt to infant characteristics.

These points of concern could be addressed through replication studies conducted within socio-culturally diverse settings and with larger longitudinal samples. In addition to replicating the current findings, these longitudinal investigations could extend the current study through directly examining the involvement of the environmental sensitivity effects proposed here as well as their specific manifestations (e.g., are preterm-born infants more sensitive than term-born infants to positive influences, negative influences, or both?; see Belsky et al., 2007 for further details). These data could additionally allow for a more nuanced understanding of the effect of parent-infant conversations on language development through examining how the effect of conversations on language abilities may be mediated through their influence on non-language skills. With a sufficiently large sample, these studies could also examine the additive developmental contributions of mothers and fathers, and how their respective contributions may change across development. These investigations would meaningfully build on the foundation set by the current study through generating increasingly specific insights regarding the features of parent-infant conversations which are optimally suited to the neurodevelopmental profiles of preterm- and term-born infants.

Conclusions

The current study found parent-infant conversations to be associated with the language and non-language development of both preterm- and term-born infants at 2 years of age. On the basis of these findings, parent-infant conversations may be viewed as an important modifiable feature of infants' environments which have the capacity to support language development directly and possibly also through shaping other non-language skills. Nonetheless, the associations between parent-infant conversations and development were not universal and instead varied as a function of birth status and parent gender. The differential associations for preterm- and term-born infants in particular may suggest the operation of different developmental processes in each group (possibly arising out of preterm-term differences in environmental sensitivity, developmental milestones, and/or learning mechanisms). The current study's findings and future research recommendations establish a solid springboard for attempts to investigate such potential preterm-term differences in developmental processes.

These initial exploratory findings have critical implications for how the parent-infant conversations of preterm-born infants are evaluated and modified. When preterm-term differences in parent-infant conversations are observed, the parent-infant conversations of the preterm group should not be assumed to be atypical or deficient as a result of deviating from the norm set by the term-born group. Instead, both researchers and practitioners should appraise parent-infant conversations with reference to preterm-term differences in developmental needs as well as the distinct developmental relevance of parent-infant conversations for each group. By extension, when devising interventions aimed at optimising parent-infant conversations, practitioners should avoid a one-size-fits-all approach through recognising that the "target" or "goal" conversational state should vary in line with the infant's developmental profile. Finally, to maximise the development of preterm- and term-born infants, such parenting advice should be developed and implemented in a way that leverages the distinct developmental contributions of mothers and fathers.

Chapter 6: Assessing the Language Skills of Preterm-Born Infants

Study Details

The prevalence of language difficulties among preterm-born groups has spurred international recommendations to assess the language development of preterm-born children at/before 2 years of age (EFCNI, 2022a). The appropriate choice and implementation of language assessments in such clinical settings is pivotal to allow for the early identification of difficulties as well as the efficient planning and monitoring of language interventions. However, little evidence-based guidance currently exists to inform the choice and implementation of language assessments with preterm-born infants.

Study 6.1

To guide the evidence-based choice and implementation of language assessments with preterm-born infants, Study 6.1 used data collected by the Infant and Child Research Lab (see Chapter 4 for details) to compare the language abilities of preterm- and term-born 2-year-old infants using two assessment approaches (standardised testing and language sample analysis). This study additionally investigated how child characteristics (executive function) and procedural variations in standardised testing (use of clinical cut-off scores) and language sample analysis (variations in the speech sampling context) may affect the developmental insights that are obtained from these assessments.

Publication Status

After completing an initial round of peer-review, Study 6.1 has been revised and resubmitted to American Journal of Speech-Language Pathology.

Studies

Study 6.1: Assessing the Language Abilities of Preterm-Born Infants: An Examination of Standardised Testing and Language Sample Analysis

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Author Note

The first author (Sarah Coughlan) was responsible for the conceptualisation, formal analysis, and writing of this paper. These responsibilities were carried out under the guidance of the second and third authors (thesis supervisors).

The data analysed in this paper were collected and curated by the research team at the Infant and Child Research Lab (Trinity College Dublin). As part of this collective effort, the first author contributed to data collection through engaging in participant recruitment, scheduling, and testing. Recordings of parent-child interactions were transcribed by research assistants and past PhD students. These transcripts were microanalytically annotated and analysed by the first author.

After completing an initial round of peer-review, this paper has been revised and resubmitted to American Journal of Speech-Language Pathology.

Abstract

Purpose: To understand how best to assess the language abilities of preterm-born infants, this study: (i) compared preterm- and term-born infants' language skills using standardised testing and language sample analysis (LSA), (ii) investigated how executive function skills and the speech sampling context respectively affect standardised test and LSA scores, (iii) examined the pattern of associations between standardised test and LSA scores among preterm-/term-born groups.

Method: 25 term-born and 23 preterm-born 2-year-old singletons were administered the language scales of the Bayley Scales of Infant and Toddler Development 3rd edition (receptive communication, expressive communication, language composite scores). Parent-infant free-play recordings were used to quantify the (para)linguistic features of the infants' speech. Executive function was measured via parent-report.

Results: The preterm-born group obtained significantly lower scores than the term-born group on all Bayley language measures (though differences were not consistently observed when using cut-off scores). Few preterm-term differences in LSA measures were found. The preterm-term differences in Bayley scores were not explained by between-group differences in executive function. Some preterm-term differences in LSA scores were moderated by the speech sampling context. The preterm- and term-born groups exhibited different patterns of Bayley-LSA correlations.

Conclusions: Preterm language difficulties were more apparent on standardised test than LSA scores. Nonetheless, the Bayley-LSA correlations indicate that poor test performance (linked with preterm birth) is associated with functional communication difficulties. The discussion outlines the complementary utility of standardised tests and LSA while acknowledging the limited utility of cut-off scores and the confounding influence of the speech sampling context.

Keywords: preterm birth, language sample analysis, standardised testing

Introduction

Preterm birth (< 37 weeks' gestation; World Health Organisation, 2012) is a risk factor for poor language development (van Noort-van der Spek et al., 2012). As poor language skills can negatively impact school performance and later occupational outcomes (Bleses et al., 2016; Johnson et al., 2010), the early identification and mitigation of these difficulties is a public health priority. The accurate characterisation, identification, and treatment of language difficulties hinges on the use of appropriate assessment methods (Ebert & Scott, 2014) in both research settings (when investigating the mechanisms underlying the language abilities of preterm-born infants) and clinical settings (when screening for language difficulties and developing interventions). While there are many approaches to assessing language skills (e.g., standardised tests, language sample analysis [LSA]), there is a lack of consensus regarding the most appropriate method(s) to be used with preterm-born infants. To address this gap, the current study was designed to develop data-driven insights to inform how standardised testing and LSA may be used (either independently or together) in the characterisation, identification, and treatment of language difficulties following preterm birth.

Standardised Testing

In both research and clinical settings, standardised tests are commonly used to characterise the development of preterm-born infants (Johnson et al., 2008). Standardised tests are administered by trained examiners in accordance with strict administration and scoring rules which enable the calculation of norm-referenced scores which are intended to be comparable across testing settings, examiners, and time (Del Rosario et al., 2021; Johnson & Marlow, 2006; Johnson et al., 2008). These tests can be designed to assess a single developmental domain (e.g., Clinical Evaluation of Language Fundamentals Preschool [3rd edition; Wiig & Semel, 2020] which assesses various language skills) or multiple domains (e.g., Bayley Scales of Infant and Toddler Development [3rd edition; Bayley, 2006] which directly assess language, cognitive, and motor abilities). As preterm-born children are often observed to exhibit difficulties in more than one domain of functioning (Aylward, 2014), tests which assess multiple developmental domains may be particularly useful in this context.

To fully benefit from the abovementioned strengths of standardised tests, these tests must be used carefully among preterm-born cohorts. Firstly, the strict administration protocols of these tests can introduce non-specific cognitive demands (e.g., executive function demands) which can differentially affect the performance of children with differing neuropsychological profiles (Mahurin-Smith et al., 2014). In the Bayley assessment, children must follow the instructions of an unfamiliar examiner over a period of 50-90 minutes as they complete a series of language, cognitive, and motor tasks of increasing complexity. This structured assessment setting departs from the everyday experiences of children and can create attentional and self-regulatory demands which may be particularly challenging for preterm-born children who have been found to experience executive function difficulties (Sandoval et al., 2022).

Even in the absence of such cognitive demands, the use of cut-off scores to identify developmental difficulties (e.g., identifying children who score > 1 standard deviation below the normative mean level of performance; Johnson et al., 2014) may result in an underestimation of the number of preterm-born children with poor language skills. This arises from the fact that preterm-born children often exhibit subclinical levels of cognitive difficulty which fall within but at the lower end of the “average” range of performance (e.g., Lacalle et al., 2023). Therefore, these children may not consistently fall below such a prespecified clinical threshold. Finally, when language difficulties are accurately identified, the standardised test scores can be insufficient on their own to allow for the generation of targeted functional treatment goals owing to their limited ecological validity and lack of specificity (Klatte et al., 2022). The lack of specificity is particularly acute in tests which assess multiple broad developmental domains (e.g., receptive communication and expressive communication scores from the Bayley assessment).

LSA

In comparison to standardised testing, LSA embodies a more flexible and less structured assessment approach. In LSA, the speech produced by children is recorded and analysed to characterise their expressive communication skills. Speech samples may be obtained in a range of settings including naturalistic interpersonal interactions (e.g., conversation with a caregiver or examiner) as well as more structured language tasks (e.g., narrative retelling task). These speech samples can be characterised on a variety of highly specific linguistic (e.g., lexical diversity/composition and morphosyntactic complexity) and paralinguistic (e.g., productivity, intelligibility) features to gain insight into the communicative development of the child. Through using assessment settings which are more familiar to the child, LSA additionally imposes fewer non-specific cognitive burdens (when compared to standardised tests) and can thus be seen to provide more ecologically valid insights into the real-life communicative functioning of the child (Feldman et al., 1994; Mahurin-Smith et al., 2014). The ability of LSA to generate highly specific and ecologically valid characterisations of communicative development make it well suited to the setting and monitoring of functional treatment goals (Ebert & Pham, 2017; Ebert & Scott, 2014; Imgrund et al., 2023).

In contrast to standardised testing, LSA affords considerable procedural flexibility to researchers/practitioners. For instance, autonomy can be exercised over methodological factors including the speech sampling context (e.g., choosing the conversation partner) and the metrics to be analysed (e.g., lexical or morphosyntactic features of speech). While this flexibility allows for LSA to be adapted to suit the child being assessed and/or the goals of the researcher/practitioner, the insights obtained from LSA can vary according to such methodological variations (Ebert & Pham, 2017) and can thereby complicate the synthesis of findings across studies and assessment contexts. Hence, it is imperative that researchers and practitioners are cognizant of such methodological considerations when deciding on whether and how to use LSA. Furthermore, targeted investigations of the impact of such methodological choices (e.g., speech sampling context) would facilitate such decision-making processes and assist in evaluating the comparability of findings arising from existing and future studies.

Joint Use of Standardised Testing and LSA

As illustrated by the discussion so far, standardised tests and LSA address conceptually distinct yet related aspects of language development. The conceptual distinction is empirically supported by factor analytic investigations which find scores from standardised tests and LSA to form separate factors (Mahurin-Smith et al., 2014), while the conceptual relations are reflected in the correlations which nonetheless exist between the scores of these two assessment approaches (e.g., Owens & Pavelko, 2017). The conceptually distinct yet related insights of standardised tests and LSA, alongside their complementary strengths and weaknesses, indicate how the joint use of these assessments may afford the most comprehensive characterisation of language skills and thus the best chance of identifying language difficulties (Imgrund et al., 2019; Mahurin-Smith et al., 2014; Sanchez et al., 2020).

In more specific and practical terms, while LSA is constrained to measuring expressive skills, standardised tests can provide complementary insights into receptive skills. Furthermore, while standardised tests support the psychometrically rigorous identification of children with below/above average language development, LSA can provide ecologically valid and detailed descriptions of the linguistic and paralinguistic features of the child's naturalistic speech. Capturing the child's naturalistic speech patterns is particularly important as it can identify the functional difficulties routinely faced by the child and recognise how such functional difficulties may be shaping the proximal social environment of the child in developmentally impactful ways (e.g., linguistic/paralinguistic features of child speech affecting parental responses during parent-child conversations; see Warlaumont et al., 2014 for a discussion of the "social feedback loop" in parent-child conversation). In line with this view, the associations between standardised test and LSA scores (e.g., Owens & Pavelko, 2017) have been suggested to indicate how poor test performance can co-occur with functional difficulties and, therefore, how LSA may guide the identification and monitoring of functional treatment goals for children with below- (or low-) average test scores (Ebert & Pham, 2017; Ebert & Scott, 2014; Imgrund et al., 2023).

Language Assessment with Preterm-Born Children

The utility of standardised testing and LSA varies as a function of factors including the child's characteristics and the research/clinical assessment goals. Firstly, as standardised tests and LSA appraise different skills, the utility of each for the identification of language difficulties depends on the specific nature of the difficulties experienced by the cohort (e.g., primarily receptive challenges or difficulties with spontaneously producing multiword utterances). Secondly, the reliability of standardised test scores can vary as a function of the child's domain-general neuropsychological profile which can affect their ability to perform tasks within structured assessment settings. Finally, the presence, and precise nature, of associations between standardised test and LSA scores can determine the complementary utility of these approaches for setting treatment goals. In spite of the expressive and receptive language difficulties (van Noort-van der Spek et al., 2012), speech sound production difficulties (van Noort-van der Spek et al., 2022), and unique neuropsychological profile (Aylward, 2014; Sandoval et al., 2022) of preterm-born children, there is limited and inconsistent evidence relating to each of these three considerations. As a result, there is an incomplete understanding of the utility of standardised tests and LSA among this cohort.

With relation to the first consideration, the development of a comprehensive characterisation of the communicative strengths/weaknesses of preterm-born children has been hindered by the limited number of studies that have compared preterm- and term-born children using both standardised tests and LSA. Further, the studies that have adopted such a design have reported conflicting findings. Some studies have found preterm-born children to obtain lower scores than their term-born peers on both standardised tests and LSA (Grunau et al., 1990; Stipdonk et al., 2020). Meanwhile, the remaining studies have found such difficulties to manifest primarily on standardised tests but not LSA (Crosbie et al., 2011; Mahurin-Smith et al., 2014; Mahurin-Smith et al., 2021), or on LSA but not standardised tests (Imgrund et al., 2019). Identifying the source of these inconsistencies has been complicated by considerable methodological differences across studies with respect to the age of participants (ranging from 3- to 12-year-olds), the standardised test that was used (e.g., PPVT, Stanford-Binet scale, CELF-P 2nd ed., CELF-4), and the speech sampling method that was adopted (both narrative and conversational samples have been used, with variation in the latter with regards to the use of caregiver-child or examiner-child conversations).

With regards to the second consideration, there is inconsistent evidence as to whether preterm-term differences in standardised test performance may be explained by between-group differences in non-linguistic neuropsychological characteristics. For example, while Mahurin-Smith et al. (2021) found that gestational age no longer had a significant effect on standardised language scores after accounting for attentional skills, Imgrund et al. (2019) found that the effect of birth status (preterm/term) on standardised scores remained significant even after controlling for infant attention, hyperactivity, and nonverbal intelligence (each controlled separately). Finally, with regards to the third consideration, the authors are aware of only two studies which have examined preterm-term differences in the pattern of associations between standardised test and LSA scores. Both of these studies found that the number of significant correlations was larger among the preterm- as compared to the term-born sample (Sanchez et al., 2020; Stipdonk et al., 2020). While this may suggest a tighter coupling of standardised test and LSA scores among preterm-born samples, conceptual replications are needed to determine whether these findings may be specific to the samples or methods that were used.

Current Study

Effective language assessment is essential for the identification and mitigation of language difficulties. While a wide range of language assessment approaches exist, their relative utility varies as a function of the context in which they are used and the objectives they seek to address. Owing to the limited, methodologically variable, and conflicting literature, there is a lack of evidence-based guidance on the optimal use of standardised tests and LSA among preterm-born children. Since international neonatal care standards advise healthcare providers to assess the language development of preterm-born infants by/at 2 years of age (EFCNI, 2022a), it is particularly important that clearer insights are developed for this age-group. This exploratory study was designed to generate insights which could assist researchers/practitioners to make evidence-based choices regarding the use of standardised language tests and LSA among 2-year-old preterm-born children.

To achieve this goal, a comprehensive profile of the language abilities of preterm- and term-born 2-year-old infants was developed through assessing each group using both standardised testing and LSA. The standardised test comprised the language scores (receptive communication, expressive communication, language composite) from the Bayley Scales of Infant and Toddler Development (3rd edition; Bayley, 2006). Despite being used widely in research and clinical settings (Johnson et al., 2008; Wong et al., 2016), the preterm literature has not yet investigated this scale with relation to LSA. The LSA was conducted using speech samples which were recorded during mother-/father-infant free-play interactions. Through being highly familiar to infants, this speech sampling context may maximise the ecological validity of the LSA results. To achieve a holistic characterisation of the functional communicative abilities of the infants, the speech samples were analysed on both linguistic (lexical diversity/composition, morphosyntactic complexity) and paralinguistic (centring on the amount, speed, and intelligibility of speech) dimensions. With these standardised testing and LSA scores, three research objectives were addressed. Given the paucity of research and inconsistent literature, these research objectives were pursued in an exploratory capacity.

Research Objective 1

The first objective was to investigate whether preterm-term differences may be observed on mean Bayley language scores (receptive communication, expressive communication, language composite) after controlling for (i) socio-demographic characteristics (age, sex, socioeconomic status) and (ii) domain-general neuropsychological skills (executive function). This analysis also investigated the utility of developmental cut-offs through examining whether there are preterm-term differences in the proportion of infants scoring > 1 standard deviation below the normative mean for each subtest/composite score.

Research Objective 2

The second objective was to examine whether preterm-term differences may be found in the linguistic and/or paralinguistic features of infant speech after controlling for socio-demographic factors (age, sex, socioeconomic status). This analysis also considered the potentially moderating influence of the speech sampling context through investigating whether the preterm-term contrasts vary as a function of the parent with which the child was speaking (mother or father).

Research Objective 3

The third objective was to investigate the presence and pattern of associations between standardised test and LSA scores among the preterm- and term-born groups.

Method

Participants

This study involved 23 preterm-born (24-36 weeks' gestation; 10 female) and 25 term-born (≥ 37 weeks' gestation; 11 female) 2-year-old singleton infants. The infants belonged to English-speaking two-parent families who had been recruited as part of a larger longitudinal project on parent-child interaction and development. Ethical approval was granted by the research ethics committees of the Coombe Women and Infants University Hospital (Ethics ID: Study No. 6 – 2020) and the School of Psychology in Trinity College Dublin (Ethics ID: SPREC0072021-01). Parents provided written informed consent on behalf of themselves and their infants.

There was no significant difference in the proportion of male/female infants in the term- and preterm-born groups (Chi-square test, $p = 1.000$). However, the preterm-born infants ($M = 26.92$ months, $SD = 3.75$ months; adjusted age for those < 24 months) were significantly older than the term-born infants ($M = 24.30$ months, $SD = 1.41$ months; Welch's test, $p = .004$). There was no significant preterm-term difference in socioeconomic status (proxied by the mothers' education level; Mann-Whitney U test, $p = .390$).

Procedure

Standardised Testing

At the Infant and Child Research Lab (School of Psychology, Trinity College Dublin), the infant was administered the receptive communication and expressive communication subtests of the Bayley Scales of Infant and Toddler Development (3rd edition; Bayley, 2006) by a trained researcher. Scaled scores were calculated for the receptive communication (split-half reliability = .87) and expressive communication (split-half reliability = .91) subtests (normative mean of 10 and standard deviation of 3). A standardised language composite score reflecting performance on both the receptive and expressive communication subtests was also computed (split-half reliability = .93; normative mean of 100 and standard deviation of 15). For each of these three scores, the proportion of preterm- and term-born infants scoring > 1 standard deviation below the normative mean was calculated.

LSA

Speech Sample Acquisition. Speech samples were obtained from mother-infant and father-infant dyadic free-play interactions which were recorded in a standardised lab setting. During the free-play interactions, mother-/father-infant pairs were presented with a box of age-appropriate toys (e.g., building blocks, toy car, ball) and parents were requested to play with their infant as they normally would at home. The interactions were video- and audio-recorded for 5 to 10 minutes using two wall-mounted cameras and an audio-recorder. The sequencing of mother-infant and father-infant play sessions was counterbalanced to control for the gradual increase in infant fatigue. Father-infant interactions were not recorded for six families (five preterm, one term) as the father could not attend the recording session.

Transcription. Trained research assistants used the audio-recordings to transcribe the first uninterrupted 5 minute segment of each mother-infant and father-infant free-play interaction (interruptions included the investigator entering the room mid-recording). In accordance with the CHILDES CHAT transcription format (MacWhinney, 2000), the interactions were transcribed at the utterance level (utterances defined as speech units segmented by a pause, grammatical feature, and/or intonation change). Both intelligible and unintelligible words were transcribed, with every instance of the latter marked by ‘xxx’. The start and end time of each utterance was additionally marked by examining the audio waveform. To ensure the quality and standardisation of the completed transcripts, a senior transcriber (Dr. Jean Quigley) inspected and corrected all transcripts.

To facilitate the accurate computation of the linguistic and paralinguistic features of speech, the completed transcripts were manually filtered to retain only conversational and speech-related vocalisations. Specifically, speech segments, conversational fillers, and unintelligible utterances were retained. Meanwhile, non-voluntary sounds and voluntary but non-conversational sounds (e.g., vegetative sounds, singing, crying, laughing) were removed. Utterances featuring both qualifying and disqualifying characteristics were kept (e.g., speech [qualifying] produced while laughing [disqualifying]).

Analysis of Speech Samples. Two profiling commands (KIDEVAL, EVAL) and one analysis command (FREQ) from the CLAN software (MacWhinney, 2000) were used to compute the linguistic and paralinguistic features of infant speech displayed in Table 6.1.1. These metrics were computed separately for each mother-infant and father-infant transcript.

Table 6.1.1

LSA: Calculation of Linguistic and Paralinguistic Metrics

	Calculation
Linguistic	
Types	Total number of unique words
Tokens	Total number of intelligible words
Type-token ratio	(Number of types / Number of tokens)
% nouns	(Number of nouns / Total number of intelligible words) * 100
% verbs	(Number of verbs / Total number of intelligible words) * 100
% adjectives	(Number of adjectives / Total number of intelligible words) * 100
MLU (morphemes)	Mean length of utterance in morphemes
MLU (words)	Mean length of utterance in words
Verbs per utterance	(Number of verbs / Number of utterances)
Paralinguistic	
Volubility (words per minute)	(Total number of intelligible and unintelligible words / Transcript duration in minutes)
Speech rate (words per minute)	(Total number of intelligible and unintelligible words / Infant speaking time in minutes)
Intelligibility	(Number of intelligible words / Total number of intelligible and unintelligible words)
Intelligible words per minute	(Number of intelligible words / Infant speaking time in minutes)

The linguistic metrics included both lexical and morphosyntactic features. The lexical features included the number of types and tokens produced by the infant, as well as the type-token ratio which reflects the lexical diversity of infant speech. The lexical composition of the speech samples was also examined through calculating the percentage of intelligible words which could be categorised as nouns, verbs, or adjectives. The morphosyntactic complexity of infant speech was captured through measuring the mean length of utterance (MLU) in morphemes, the MLU in words, and the number of verbs per utterance.

The paralinguistic metrics reflected the overall productivity of the infant as well as the communicative effectiveness of their speech. The overall productivity was captured through the volubility and speech rate measures which respectively measured the amount of speech produced by the infant (regardless of whether the speech was intelligible or not) and the speed with which this speech was produced. The ability of infants to communicate effectively with their conversational partners was examined through the measures of intelligibility and intelligible words per minute. The intelligibility measure reflected the proportion of words produced by the infant which the transcriber could comprehend. The intelligible words per minute measure was calculated as the number of intelligible words produced per minute of speaking, and thus captured the communicative efficiency of the infant's speech (for further details, see Yorkston & Beukelman, 1981).

Executive Function

Parents rated their infant's executive function difficulties using the Behavior Rating Inventory of Executive Function – Preschool (Gioia et al., 2003). This questionnaire includes 63 items which measure difficulties on five executive function domains (inhibit, shift, emotional control, working memory, plan/organise). Together, these scales create a global executive composite score (Cronbach's a = .95) which represents the child's overall level of executive dysfunction. The current study used the standardised global executive composite score (normative mean of 50 and standard deviation of 10) in which higher scores indicate greater levels of executive dysfunction (Gioia et al., 2003).

Statistical Analyses

All of the analyses outlined below were two-tailed ($a = .05$) and conducted in R (version 4.2.2; R Core Team, 2022). Missing data were handled with pairwise deletion.

Research Objective 1

The first set of analyses investigated whether preterm-term differences in mean Bayley language scores (receptive communication, expressive communication, language composite) exist after controlling for (i) sociodemographic factors (age, sex, socioeconomic status) and (ii) neuropsychological characteristics (executive function). These proposed confounding variables (age, sex, socioeconomic status, executive function) were included in the analyses as covariates if they significantly differed between the preterm- and term-born groups (independent samples t-test/Chi-square test, $p < .05$) and were significantly correlated with the Bayley language scores ($p < .05$).

When statistically relevant covariates were identified, their influence was controlled using one-way ANCOVAs (Type III) which examined the effect of preterm/term birth-status (between-group factor) on the relevant Bayley language score. The ANCOVAs were computed using the car package (v3.1-2; Fox & Weisberg, 2019) and statistical assumptions for ANCOVAs were tested by assessing distributional normality (Shapiro-Wilk test, $a = .05$), homogeneity of variance (Levene's test, $a = .05$), the presence of outliers (> 1.5 times the interquartile range above or below the third/first quartile, respectively), linearity (scatterplot), and homogeneity of regression lines (test of interaction terms). These analyses were adequately powered (80% power, $a = .05$) to detect a large effect following Cohen's (1969) indices for small ($\eta 2 = .01$), medium ($\eta 2 = .06$), and large ($\eta 2 = .14$) effects (Cohen's f converted to $\eta 2$ for clarity).

When statistically relevant covariates were not identified, independent-samples t-tests were used to compare the preterm- and term-born infants' Bayley language scores. The parametric t-test assumptions of distributional normality (Shapiro-Wilk test, $a = .05$) and homogeneity of variance (Levene's test, $a = .05$) were tested. The t-tests were sufficiently powered (80% power, $a = .05$) to detect a large effect according to Cohen's (1969) indices for small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$) effects.

Finally, Chi-square tests were used to investigate the presence of preterm-term differences in the proportion of infants obtaining receptive communication, expressive communication, and language composite scores > 1 standard deviation below their respective normative means. As some cell counts fell below 5, Yates' continuity correction was applied.

Research Objective 2

With the lmerTest package (v3.1-3; Kuznetsova et al., 2017), 2x2 mixed ANOVAs (Type III) were computed to investigate the influence of birth status (preterm/term – between-group factor) and speech sampling context (mother-infant/father-infant conversation – repeated-measures variable) on each linguistic and paralinguistic feature of infant speech. Of key interest in each model was the main effect of birth status (preterm/term) and the moderation of its influence by the speech sampling context (birth status*speech sampling context interaction term). When a significant interaction between the two predictors was found, Tukey HSD tests (emmeans package, v1.8.6; Lenth, 2023) examined the effect of birth status within each of the two speech sampling contexts. The sociodemographic variables of age, sex, and socioeconomic status were identified as potentially confounding variables. These variables were deemed to be statistically relevant confounders if they significantly differed between the preterm- and term-born groups (independent samples t-test/Chi-square test, $p < .05$) and were significantly correlated with the Bayley language scores ($p < .05$).

When statistically relevant covariates were identified, their influence on the relevant linguistic/paralinguistic measure was controlled using ANCOVAs. The statistical assumptions applicable to both ANOVAs and ANCOVAs were tested by checking for outliers, distributional normality, homogeneity of variance, and homogeneity of covariances (Box's M test, $a = .001$). When ANCOVAs were computed, the assumptions of linearity and homogeneity of regression lines were also tested (for details on assumption-checking, see 'Statistical Analyses: Research Objective 1"). The ANOVA analyses were powered (80% power, $a = .05$) to detect a large effect according to Cohen's (1969) indices for small ($\eta 2 = .01$), medium ($\eta 2 = .06$), and large ($\eta 2 = .14$) effects (Cohen's *f* converted to $\eta 2$ for clarity).

Research Objective 3

Bivariate correlations examined the association between the Bayley language scores and LSA measures. The parametric assumptions were assessed by checking for the linearity of relationships and the absence of multivariate outliers (using scatterplots) as well as the presence of distributional normality (Shapiro-Wilk test, $p < .05$). While the scatterplots exhibited linear relationships and only minimal outliers, some variables violated the distributional normality assumption. Thus, Spearman correlations were used. The correlations were sufficiently powered (80% power, $a = .05$) to detect large effects according to Cohen's (1969) indices for small ($r = 0.1$), medium ($r = 0.3$), and large ($r = 0.5$) effects.

Results

Standardised Test

The analyses in this section compare preterm- and term-born infants on the Bayley language scores presented in Table 6.1.2. As can be seen in this table, Bayley scores for three preterm-born infants are missing as these infants were unable to complete the language scale owing to fatigue and inattention. These three infants have been excluded from all analyses in this section (including the preterm-term comparisons of sociodemographic characteristics).

Table 6.1.2

Bayley Language Scores: Descriptive Statistics

	Term (*N* = 25)				Preterm (*N* = 23)			
	n	*M*	*SD*	*Mdn*	*n*	*M*	*SD*	*Mdn*
Receptive	25	12.92	2.78	13.00	20	9.60	3.78	9.50
Expressive	25	12.28	2.79	12.00	20	9.50	4.66	10.00
Composite	25	115.52	12.88	118.00	20	97.50	23.46	97.00

Preterm-Term Comparisons Controlling for Sociodemographic Covariates

Although age, sex, and socioeconomic status were proposed to be potentially confounding sociodemographic variables, none of these variables were found to be of statistical relevance. Specifically, there were no significant preterm-term differences in sex (Chi-square, $p = 1.000$) or socioeconomic status (Mann-Whitney U test, $p = .450$). Furthermore, while statistically significant preterm-term differences in age were found (t[23.73] = 2.34, $p = .028$, Cohen's $d = 0.73$, 95% CI[0.23, 3.74]), age was not significantly correlated with the receptive, expressive, or language composite scores. As none of the sociodemographic factors were found to be statistically relevant covariates, independent-samples t-tests were used to compare the preterm- and term-born groups' Bayley language scores. While the distributional normality assumption was met for all three language scores, the homogeneity of variance assumption was violated for the expressive communication and language composite scores. Hence, a regular parametric t-test was computed for the receptive score, while Welch's t-test was computed for the expressive and language composite scores.

These independent-samples t-tests found that preterm-born children obtained significantly lower receptive (t[43] = -3.40, $p = .001$, Cohen's $d = 1.02$, 95% CI [-5.29, -1.35]), expressive (t[29.54] = -2.35, $p = .026$, Cohen's $d = 0.72$, 95% CI [-5.20, -0.36]), and language composite (t[27.99] = -3.08, $p = .005$, Cohen's $d = 0.95$, 95% CI [-29.99, -6.05]) scores than their term-born peers.

Preterm-Term Comparisons Controlling for Executive Function Skills

In comparison to term-born infants (*M* = 44.67, *SD* = 9.89), preterm-born infants (*M* = 53.20, *SD* = 10.08) obtained significantly higher executive dysfunction scores (*t*[37] = 2.60, *p* = .013, Cohen's *d* = 0.856, 95% CI[1.89, 15.18]). While these executive dysfunction scores were not significantly correlated with the expressive score (*p* = .148) or the language composite score (*p* = .131), they were significantly correlated with the receptive score (*r*[39] = -0.37, *p* = .021). Thus, a one-way ANCOVA was computed to investigate whether significant preterm-term differences in receptive scores exist after controlling for variability in executive function skills. After removing two outliers, the ANCOVA model satisfied all statistical assumptions, apart from the homogeneity of variance assumption which was violated. The ANCOVA model found that birth status (preterm/term) had a significant effect on receptive scores (*F*[1, 35] = 5.90, *p* = .020, η_p^2 = .14) after controlling for the significant effect of executive dysfunction (*F*[1, 35] = 4.55, *p* = .040, η_p^2 = .12).

Preterm-Term Comparisons Using Cut-Off Scores

Chi-square tests were used to compare the proportion of preterm- and term-born infants scoring more than one standard deviation below the normative mean for the receptive (score < 7), expressive (score < 7), and language composite (score < 85) scores. A significantly larger proportion of preterm-born (25%) than term-born (0%) infants scored greater than one standard deviation below the normative mean corresponding to the receptive communication subtest (χ2[1] = 4.73, *p* = .030). Similarly, a significantly larger proportion of preterm-born (30%) than term-born (0%) infants scored greater than one standard deviation below the normative mean corresponding to the language composite scores (χ2[1] = 6.25, *p* = .012). Meanwhile, there was no significant difference between the proportion of preterm-born (25%) and term-born (4%) infants scoring greater than one standard deviation below the normative mean for the expressive communication subtest (χ2[1] = 2.62, *p* = .106).

LSA

2x2 mixed ANOVAs were computed to investigate the effect of birth status (preterm/term), speech sampling context (mother-infant/father-infant conversation), and their interaction on each linguistic and paralinguistic feature displayed in Table 6.1.3. One preterm-born infant did not verbalise during the mother-infant or father-infant interaction and was therefore excluded from all analyses in this section (including the preliminary preterm-term comparisons of sociodemographic characteristics). One term-born infant did not verbalise during the mother-infant interaction, but did verbalise during the father-infant interaction, and was thus retained in the following analyses.

Table 6.1.3

Linguistic and Paralinguistic Features of Infant Speech: Descriptive Statistics

	Mother-infant conversation				Father-infant conversation			
	Term		Preterm		Term		Preterm	
	n	*M (SD)*	*n*	*M (SD)*	*n*	*M (SD)*	*n*	*M (SD)*
Linguistic								
Types	24	26.08 (13.52)	22	36.00 (21.94)	24	24.38 (11.71)	17	29.29 (18.23)
Tokens	24	51.00 (29.54)	22	81.73 (62.22)	24	52.67 (29.31)	17	66.35 (52.95)
Type-token ratio	24	0.57 (0.15)	22	0.51 (0.16)	24	0.51 (0.16)	17	0.52 (0.16)
% nouns	24	22.95 (13.58)	22	22.23 (12.65)	24	22.82 (17.14)	17	24.25 (12.13)
% verbs	24	10.83 (7.41)	22	12.49 (6.94)	24	10.81 (8.28)	17	13.74 (7.71)
% adjectives	24	2.66 (3.27)	22	2.89 (3.56)	24	1.86 (2.43)	17	3.97 (7.31)
MLU (morphemes)	24	1.80 (0.52)	22	2.07 (0.69)	24	1.72 (0.52)	17	1.96 (0.67)
MLU (words)	24	1.69 (0.47)	22	1.96 (0.62)	24	1.66 (0.49)	17	1.86 (0.62)
Verbs per utterance	24	0.20 (0.17)	22	0.26 (0.18)	24	0.19 (0.18)	17	0.27 (0.22)
Paralinguistic								
Volubility (words per minute)	24	13.88 (7.65)	22	15.98 (11.51)	24	14.12 (7.42)	17	13.28 (9.70)
Speech rate (words per minute)	24	122.28 (25.78)	22	112.57 (19.98)	24	118.47 (22.07)	17	112.96 (23.58)
Intelligibility	24	0.74 (0.17)	22	0.87 (0.16)	24	0.74 (0.17)	17	0.83 (0.17)
Intelligible words per minute	24	91.78 (28.33)	22	97.82 (23.80)	24	85.85 (22.65)	17	92.83 (25.13)

Age, sex, and socioeconomic status were considered as potential covariates to be controlled in these analyses. While there were no significant preterm-term differences in sex (Chi-square, $p = 1.000$) or socioeconomic status (Mann-Whitney U test, $p = .390$), there was a significant preterm-term difference in age (Welch's t-test, $t[26.03] = 3.11$, $p = .005$, Cohen's $d = 0.93$, 95% CI[0.91, 4.45]). Age was significantly correlated with nine of the 13 linguistic and paralinguistic measures ($p < .05$). Thus, ANCOVAs (controlling for age) were computed for these variables. After removing outliers, all statistical assumptions were met apart from occasional violations of distributional normality (% verbs, % adjectives, verbs per utterance, intelligibility) and homogeneity of variance (types, type-token ratio, % adjectives, intelligibility, intelligible words per minute). Full statistical reporting of the AN(C)OVAs can be found in Appendix Q.

Linguistic Features

Lexical. There was no significant birth status*speech context interaction effect on the number of types (ANCOVA) or tokens (ANCOVA). There was also no significant main effect of birth status or speech context on either variable. In contrast, there was a significant birth status*speech context interaction effect on type-token ratio (ANOVA; $F[1, 42.01] = 5.73$, $p = .021$, $\eta_p^2 = .12$). Tukey HSD comparisons found that preterm-born infants exhibited significantly smaller type-token ratios than their term-born peers during mother-infant conversations ($t[77.7] = -2.56$, $p = .0123$, $d = 0.88$). Meanwhile, there was no significant preterm-term difference in type-token ratio during father-infant conversations ($t[77.8] = 0.698$, $p = .487$, $d = 0.21$).

With regards to the lexical composition of infant speech, there was no significant birth status*speech context interaction effect on either % nouns (ANOVA) or % verbs (ANCOVA). There was similarly no significant main effect of birth status or speech context on either variable. While there was no significant birth status*speech context interaction effect on %

adjectives (ANOVA), there was a significant main effect of speech context (F[1, 30.49] = 6.34, p = .017, η_p^2 = .17). Specifically, a larger proportion of infant words were adjectives during mother-infant as compared to father-infant conversations. There was no significant main effect of birth status on % adjectives.

Morphosyntactic. In the ANCOVAs corresponding to MLU (morphemes), MLU (words), and verbs per utterance, there was no significant birth status*speech context interaction effect. There was also no significant main effect of birth status or speech context on any of these three variables.

Paralinguistic Features

Productivity. There was no significant birth status*speech context interaction effect on either volubility (ANCOVA) or speech rate (ANOVA). There was also no significant main effect of birth status or speech context on either variable.

Communicative Effectiveness. There was no significant birth status*speech context interaction effect on intelligibility (ANCOVA). However, there was a significant main effect of birth status (F[1, 40.02] = 11.79, p = .001, η_p^2 = .23) such that the speech of preterm-born infants was significantly more intelligible than that of their term-born peers. There was no significant main effect of speech context on intelligibility. There was no significant birth status*speech context interaction effect on the measure of intelligible words per minute (ANCOVA). There was also no significant main effect of birth status or speech context on this variable.

Correlations between Standardised Test and LSA Scores

Table 6.1.4 presents the bivariate associations (Spearman correlations) between the Bayley language scores and the LSA measures obtained from mother-infant and father-infant conversations (correlations were computed separately for the preterm- and term-born groups).

Table 6.1.4

Spearman Correlation Coefficients for the Associations between Bayley and LSA Scores

	Term			Preterm		
	Recep	Express	Comp	Recep	Express	Comp
Mother-infant conversation						
Types	0.32	0.56**	0.50*	0.49*	0.67**	0.61**
Tokens	0.23	0.52*	0.40	0.45	0.62**	0.56*
Type-token ratio	-0.07	-0.14	-0.08	-0.33	-0.28	-0.30
% nouns	-0.08	-0.04	-0.04	0.52*	0.52*	0.58*
% verbs	0.30	0.46*	0.44*	-0.06	0.16	0.08
% adjectives	-0.05	-0.23	-0.17	0.37	0.55*	0.47*
MLU (morphemes)	0.32	0.58**	0.51*	0.36	0.71**	0.55*
MLU (words)	0.28	0.60**	0.50*	0.27	0.69**	0.50*
Verbs per utterance	0.30	0.57**	0.49*	0.05	0.41	0.26
Volubility	0.16	0.50*	0.34	0.48*	0.66**	0.61**
Speech rate	0.00	0.04	-0.01	-0.12	0.05	-0.07
Intelligibility	0.22	-0.02	0.17	0.30	0.19	0.23
Intelligible words per min	0.11	0.01	0.08	0.12	0.27	0.17
Father-infant conversation						
Types	0.08	0.78***	0.51*	0.38	0.57*	0.49
Tokens	0.08	0.67***	0.40	0.36	0.51	0.45
Type-token ratio	-0.21	-0.01	-0.03	-0.36	-0.28	-0.30
% nouns	0.34	-0.13	0.12	0.60*	0.60*	0.72**
% verbs	0.09	0.52**	0.37	0.10	0.35	0.13
% adjectives	-0.46*	0.19	-0.16	0.54*	0.48	0.53
MLU (morphemes)	0.32	0.67***	0.54**	0.32	0.59*	0.44
MLU (words)	0.34	0.66**	0.54**	0.23	0.51	0.35
Verbs per utterance	0.26	0.61**	0.52*	0.24	0.53*	0.35
Volubility	0.15	0.65**	0.46*	0.48	0.64*	0.57*
Speech rate	-0.06	-0.09	0.01	0.00	0.24	0.03
Intelligibility	0.09	0.15	0.04	0.38	0.41	0.44
Intelligible words per min	0.14	0.27	0.20	0.27	0.52	0.36

Note. *p < .05. **p < .01. ***p < .001. Recep = Receptive communication; Express = Expressive communication; Comp = Language composite.

Bayley Receptive Scores

Term-Born. Bayley receptive scores were not significantly associated with any of the features of infant speech during mother-infant conversations. The receptive scores were significantly negatively associated with % adjectives during father-infant conversations.

Preterm-Born. Bayley receptive scores were significantly positively associated with the lexical (types, % nouns) and productive (volubility) features of infant speech during mother-infant conversations, and with the lexical (% nouns, % adjectives) features of infant speech during father-infant conversations.

Bayley Expressive Scores

Term-Born. Bayley expressive scores were significantly positively associated with the same lexical (types, tokens, % verbs), morphosyntactic (MLU morphemes, MLU words, verbs per utterance), and productive (volubility) features of infant speech during both mother-infant and father-infant conversations.

Preterm-Born. Bayley expressive scores were significantly positively associated with the lexical (types, tokens, % nouns, % adjectives), morphosyntactic (MLU morphemes, MLU words), and productive (volubility) features of infant speech during mother-infant conversations. These expressive scores were also significantly positively associated with the lexical (types, % nouns), morphosyntactic (MLU morphemes, verbs per utterance), and productive (volubility) features of infant speech during father-infant conversations.

Bayley Language Composite Scores

Term-Born. Language composite scores were significantly positively associated with the lexical (types, % verbs) and morphosyntactic (MLU morphemes, MLU words, verbs per utterance) features of infant speech during mother-infant conversations, and with the lexical (types), morphosyntactic (MLU morphemes, MLU words, verbs per utterance) and productive (volubility) features of infant speech during father-infant conversations.

Preterm-Born. Language composite scores were significantly positively associated with the lexical (types, tokens, % nouns, % adjectives), morphosyntactic (MLU morphemes, MLU words), and productive (volubility) features of infant speech during mother-infant conversations, and with the lexical (% nouns) and productive (volubility) features of speech during father-infant conversations.

Discussion

Preterm-born children are at risk of developing language difficulties (van Noort-van der Spek et al., 2012; van Noort-van der Spek et al., 2022), and are thus recommended to undergo language assessments before or at 2 years of age (EFCNI, 2022a). Such efforts are impeded by the limited understanding of how best to assess the language skills of preterm-born infants. To address this gap in knowledge, the current study compared the language abilities of preterm- and term-born 2-year-old infants using both standardised testing and LSA. In addition, this study examined how the standardised test and LSA scores may respectively be affected by domain-general neuropsychological skills and the speech sampling context. Finally, this study investigated the patterns of associations between standardised test and LSA scores among preterm- and term-born infants.

While the preterm-born infants performed significantly more poorly than their term-born peers on all standardised test scores, only minimal preterm-term differences were found on the LSA measures. The preterm-term differences in standardised scores could not be explained by differences in executive function capacities. Meanwhile, some of the preterm-term differences in LSA measures were moderated by the speech sampling context. Finally, descriptive differences were observed between the preterm- and term-born groups in the pattern of correlations linking standardised test and LSA scores. These findings are discussed with reference to how they may inform the use of standardised tests and LSA when characterising, identifying, and treating the language difficulties of preterm-born infants. The implications of the findings for the interpretation and design of existing and future language assessment studies are also explored.

In the Bayley assessment, the preterm-born infants obtained receptive communication, expressive communication, and language composite scores which were significantly lower than those of their term-born peers. These preterm-term differences could not be fully explained by sociodemographic factors (age, sex, socioeconomic status) or neuropsychological skills (executive function). In particular, while the preterm-born group obtained significantly higher executive dysfunction scores than the term-born group, this between-group difference did not fully account for the preterm-term differences in Bayley language scores.

These findings align with Imgrund et al. (2019) who found that preterm-term differences in the standardised test scores of preschool-aged children could not be wholly explained by non-verbal skills. However, they conflict with the findings of Mahurin-Smith et al. (2021) who found that the effect of gestational age on the standardised scores of school-aged children became non-significant after accounting for non-verbal skills. Since the participants in the current study and that of Imgrund et al. (2019) were younger than those in Mahurin-Smith et al. (2021), these findings may reflect age-related changes in the relevance of domain-general neuropsychological skills for standardised test performance.

Finally, in line with previous research (Lacalle et al., 2023), the preterm-born group exhibited a ‘low-average’ pattern of performance which impacted the utility of cut-off scores. While the preterm-born group obtained significantly lower receptive, expressive, and language composite scores than the term-born group, statistically significant preterm-term differences in the proportion of infants scoring > 1 standard deviation below the normative mean were found for the receptive and language composite scores, but not for the expressive communication score.

In contrast to the between-group differences in Bayley language scores, only minimal preterm-term differences were found on LSA measures. With regards to the linguistic features of infant speech, preterm-born infants exhibited significantly lower type-token ratios (reflecting a less diverse vocabulary) when compared to their term-born peers during mother-infant (but not father-infant) conversations. The moderation of this preterm-term difference by the speech sampling context illustrates how procedural variations in LSA can affect the insights that are obtained from infant speech samples (Ebert & Pham, 2017). The role of such procedural variations is further evidenced by the significant effect of the speech sampling context (mother-infant/father-infant conversation) on the % adjectives measure of lexical composition. With regards to the paralinguistic features, the speech of preterm-born infants was found to be significantly more intelligible than that of term-born infants. This conflicts with previous findings that preterm-born children are at heightened risk of experiencing speech sound production difficulties (e.g., van Noort-van der Spek et al., 2022). While it was beyond the scope of the present study, future research may seek to explore this preterm-term difference in intelligibility through measuring articulatory and phonological skills, as well as the engagement of infants with speech-language therapy.

The significant correlations between the standardised test and LSA scores align with previous research (e.g., Owens & Pavelko, 2017) and suggest how poor test performance can co-occur with functional communication difficulties. However, these correlations were not perfect (i.e., correlation coefficient < 1.00) and did not exist between every standardised test and LSA score. This importantly signals the unique and non-redundant insights which can be provided by each assessment approach. These correlations were observed among both the preterm- and term-born groups, with each group appearing to exhibit a similar number of significant associations. This latter finding conflicts with previous research conducted among older children (Sanchez et al., 2020; Stipdonk et al., 2020) which found a larger number of significant correlations (and thus, a tighter coupling of standardised test and LSA scores) among the preterm- than term-born group. These findings may indicate a preterm-term difference in the age-related differentiation of the language skills measured by standardised tests and LSA. Such a difference may be theoretically informative with regards to preterm-term differences in language development mechanisms and trajectories.

Although substantial preterm-term differences in the number of significant correlations were not found, qualitative differences in the patterns of correlations were observed. Although some of these qualitative differences may similarly suggest preterm-term differences in developmental mechanisms, others may reflect certain properties of the composition and administration of the Bayley assessment. Consider, for example, the correlations between the Bayley expressive score and the LSA lexical composition measures. While the expressive score was associated with % verbs in the term-born infants' speech, this score was associated with % nouns and % adjectives in the preterm-born infants' speech. When completing the Bayley expressive communication subtest, children continue answering test items of increasing complexity (e.g., beginning with object naming items and progressing to action-labelling items) until the examiner records five consecutive incorrect responses. Since the term-born group obtained a higher average expressive score than the preterm-born group, the term-born infants are likely to have progressed further in the expressive subtest and thus have been exposed to more verb-related items. As a result, verb-knowledge would have had a larger effect on the expressive scores of the term-born (than preterm-born) infants. This may account for why expressive communication scores were significantly associated with the percentage of verbs in the speech of term-born, but not preterm-born, infants.

Implications

When taken together, the key findings discussed so far present a seemingly paradoxical pattern of results. To summarise, preterm-term differences in standardised test scores were found, and these standardised test scores were found to be significantly associated with LSA scores. Despite this, very few preterm-term differences in LSA scores were recorded. This non-intuitive absence of substantial preterm-term differences in LSA scores is likely to be due to the greater degree of variability in LSA scores when compared to standardised test scores (see Appendix R for the coefficient of variation values corresponding to each Bayley/LSA measure). Due to this variability in LSA scores, large participant samples may be required to reliably detect preterm-term differences in LSA measures. At a more practical level, these results suggest that LSA, when taken alone, may not be well-suited to the systematic identification of preterm-term differences in language abilities.

Based on this interpretation, the current findings signal how efforts to identify language difficulties among preterm-born 2-year-old infants may be better served by standardised testing rather than LSA. Although LSA may not be suited to systematically identifying groups with language difficulties, the measures that it produces are nonetheless associated with standardised test performance among both preterm- and term-born groups. Thus, researchers and practitioners should operate with an awareness that poor standardised test scores are likely to be accompanied by functional communication difficulties which could have ramifications for the child's proximal developmental environment (Warlaumont et al., 2014). Given the non-redundant insights provided by standardised testing and LSA, using the latter when below-/low-average standardised test scores are identified could allow for a holistic characterisation of the preterm-born infant's language abilities which could inform the setting/monitoring of functional treatment goals (Ebert & Pham, 2017; Ebert & Scott, 2014; Imgrund et al., 2023).

The combined use of standardised testing and LSA outlined above is not intended to be prescriptive. Instead, this study aimed to generate insights that could guide the contextually-appropriate choice and implementation of language assessment approaches among preterm-born infants. For example, when compared to LSA, the Bayley assessment may generally be better suited to the identification of language difficulties among preterm-born infants. Nonetheless, the Bayley receptive scores were found to be negatively associated with executive function difficulties, and the developmental cut-offs were observed to be of limited utility for the expressive communication subtest. Thus, the Bayley assessment must be used cautiously with preterm-born infants who exhibit particularly high levels of executive dysfunction. Furthermore, the use of cut-off scores should be limited where possible.

The methodological insights of the present study can also inform the interpretation and design of existing and future studies which use standardised tests and LSA. Specifically, the current study found that the speech sampling context can affect the insights that are obtained from LSA, and additionally observed that the patterns of correlations between standardised test and LSA scores may be specific to the particular standardised test that was used. An acknowledgement of these methodological nuances may be central to reconciling the inconsistent findings of existing studies. Unfortunately, the standardised test-LSA contrast which has framed much of this research to date has diverted attention from the conceptually significant methodological variations which exist within each assessment approach. A move beyond this binary perspective will be essential to encourage greater sensitivity to such methodological nuances in the interpretation and design of existing and future studies.

Limitations and Future Directions

The current findings must be interpreted in light of some limitations. Owing to the small sample size (limiting statistical power) and violation of some parametric statistical assumptions, the results are preliminary and must be replicated. The Bayley language scores of the preterm-born group may be inflated as three preterm-born infants were unable to complete the language scale owing to inattention/fatigue. The current study was conducted within the English-speaking community in Ireland, and hence further research is needed to investigate whether the findings may generalise to other linguistic/cultural contexts. For instance, there is evidence that standardised language tests can be of varying validity among linguistically-diverse (Lowe et al., 2013; Mendoza et al., 2023) and culturally-diverse (De Lamo White & Jin, 2011) populations. Furthermore, the dyadic speech sampling context used here may be unfamiliar to infants in cultures where child-directed speech is less common or where multiparty interactions are the norm (e.g., Cristia et al., 2019).

In addition to repeating this study with a larger sample and in different linguistic and cultural settings, the current study could be extended through adopting a longitudinal design. A longitudinal study could investigate how preterm-term differences in standardised test and LSA scores may change across infancy. For example, while preterm-term differences in the linguistic features of infant speech were only found on lexical features (type-token ratio) in the current study, preterm-term differences in morphosyntactic features may be observed in later infancy as children begin to produce more complex linguistic constructions. A longitudinal design would also allow for the correlations between standardised test and LSA scores to be tracked across multiple developmental timepoints. This would allow for an investigation of the aforementioned hypothesis that language skills may differentiate in distinct ways among preterm- and term-born groups. Future studies could additionally examine parental speech samples to investigate how caregivers may adapt their speech when preterm-born infants exhibit signs of both poorer (smaller type-token ratio indicating a less diverse vocabulary) and more sophisticated (greater intelligibility) language abilities. Future research may also acknowledge such parental perceptions through investigating how parent-report instruments may complement the insights obtained from standardised tests and LSA.

Conclusions

The current study used standardised testing and LSA to develop a holistic characterisation of the language development of preterm-born infants. This investigation was designed to guide the use of these assessments at 2 years of age when preterm-born infants are advised to undergo language assessments (EFCNI, 2022a). In comparison to LSA, the standardised test was found to be better suited to identifying preterm-term differences in language abilities. Nonetheless, LSA was found to provide non-redundant insights which could complement standardised test scores in developing an ecologically valid characterisation of language skills which could guide functional treatment goals. Beyond these broad conclusions, researchers and practitioners are encouraged to tailor the language assessment approach to their particular preterm cohort and assessment objectives through leveraging this study's insights regarding the influence of neuropsychological skills, the utility of standardised testing cut-off scores, and the effect of procedural variations in LSA. In doing so, researchers and practitioners must move away from the binary view of standardised testing and LSA to recognise the wide range of methods falling within each category.

These insights are timely given recent social and technological changes which are inspiring innovations in language assessment. The need for social distancing during the COVID-19 pandemic led to the trialling of remotely administered language assessments including substitutions for the Bayley assessment as well as its administration using video-conferencing platforms (Komanchuk et al., 2023; Ross & Perlman, 2022). Furthermore, the introduction of automatic speech recognition software (e.g., Batchalign; Liu et al., 2023) is increasing the accessibility of LSA through reducing (though not obviating) the time required for manual transcription. Given these expanded possibilities for language assessment, it is more important than ever that researchers and practitioners are equipped with the necessary information to make evidence-guided assessment choices. This study hopes to provide insights which can help those working with preterm-born cohorts to confidently navigate this evolving assessment landscape.

Chapter 7: General Discussion

7.1 Introduction

Preterm birth affects approximately 10% of births worldwide (World Health Organisation, 2023) and is a considerable public health concern given the medical and neurodevelopmental risks that it poses (Saigal & Doyle, 2008). Language difficulties have been identified to be among the neurodevelopmental sequelae which are associated with preterm birth (van Noort-van der Spek et al., 2012). As poor language skills in childhood can have negative ramifications for both proximal and distal life outcomes (Bleses et al., 2016; Johnson et al., 2010), the prevention and management of language difficulties is a clinical and societal imperative.

Although preterm birth is recognised as a risk factor for language development, the literature has been populated with inconsistent findings regarding the presence and nature of preterm-term differences in language abilities (see Chapter 1). Understanding the source of this variability is critical to advance the identification of developmentally at-risk preterm-born groups as well as the prevention and mitigation of preterm language difficulties. The fact that preterm language difficulties have persisted in spite of perinatal medical advances suggests that biomedical factors alone are insufficient to account for the variability in the association between preterm birth and language development. Furthermore, while biomedical indicators (e.g., brain injury) can assist in the identification of developmentally at-risk children, they can be of limited utility in interventional settings due to their relatively intractable nature. Hence, the current thesis adopted a developmental systems view (Barra & Coo, 2023; Spencer et al., 2011) to investigate how an understanding of the reciprocal interplay of factors characterising the child and their surrounding ecology could afford a more holistic and practicable account of preterm language development.

In particular, the studies in Chapters 3 and 5 of this thesis explored how modifiable features of the parent, child, and parent-child relationship may independently and synergistically contribute to the association between preterm birth and language development. Chapter 6 further bridged the research-to-clinic divide through generating data-driven insights which could guide the choice and implementation of language assessments with preterm-born infants.

In Section 7.2 of this final chapter, the findings of these studies are synthesised and discussed with reference to developmental theory. The practical implications of these findings are then outlined in Section 7.3. Following this, Section 7.4 and Section 7.5 respectively discuss the strengths and weaknesses of this thesis. Finally, Section 7.6 discusses how future research may extend the methodology and findings of the current thesis to develop an increasingly nuanced understanding of preterm language development.

7.2 Key Findings

The empirical investigations constituting this thesis were undertaken in three parts. The first line of investigation was presented in Chapter 3 and used nationally-representative longitudinal data to examine how parent, child, and parent-child relationship factors may synergistically mediate the association between preterm birth and language development at 3 and 5 years of age.

The second line of investigation was presented in Chapter 5 and reflected a more targeted examination of the role of parent-child relationships. Using observational data from the Infant and Child Research Lab, the studies in Chapter 5 analysed parent-child conversations to characterise the language environments of 2-year-old preterm- and term-born infants. This chapter additionally investigated how these language environment features associate with language development.

The third and final line of investigation was presented in Chapter 6. Chapter 6 used data collected in the Infant and Child Research Lab to explore the utility of commonly-used (standardised tests) and less commonly-used (language sample analysis) approaches to language assessment when ascertaining the language skills of preterm-born infants.

Across the following subsections, the key findings from each line of investigation are synthesised in turn and discussed with reference to broader developmental theory. The insights from each subsection are then integrated in a final summary. In the course of this synthesis, the practical implications of the findings and future directions for research are briefly mentioned. Such practical implications and future directions are discussed in further depth in Sections 7.3 and 7.6, respectively.

Part 1. Multiple Avenues Linking Preterm Birth to Language Development (Chapter 3)

Study 3.1 used nationally representative longitudinal cohort data (from the Growing Up in Ireland Study) to explore the developmental cascades linking preterm birth to language development. The path models in this study identified a dynamic web of developmental effects which interlinked the child's developmental domains and enmeshed the child in their broader social ecology.

In particular, preterm birth was found to be associated with developmental difficulties spanning both linguistic and non-linguistic (cognitive, social-personal, motor) domains. Critically, certain non-linguistic difficulties (cognitive, social-personal) at 9 months of age were found to mediate the association between preterm birth and expressive language development at 3 years of age. These mediational effects align with the developmental cognitive linguistic view which highlights how non-linguistic skills can affect language development through shaping the child's ability to learn from and engage with their surrounding environment (Ibbotson, 2020). More broadly, these mediational findings reflect the embodied nature of child development (Tamis-LeMonda & Masek, 2023) and the associated importance of adopting a holistic view of the child's developmental profile. Such an embodied and holistic view of development has previously been noted by neuroconstructivist perspectives to be of particular importance in the study of biologically vulnerable cohorts such as those born preterm (Guarini et al., 2016; Guarini et al., 2009; Karmiloff-Smith, 2009).

The path models in Study 3.1 additionally identified how the development of preterm-born children is intertwined with their broader social ecology. Preterm birth was found to influence the quality of parent-child relationships at 3 years of age through affecting the infant's temperament and the parent's wellbeing at 9 months of age. These mediational effects align with transactional views of development which recognise the child as an active agent in shaping their own developmental environments and trajectories (Fiese & Sameroff, 1989; Sameroff & Mackenzie, 2003).

These path models thereby illustrate how the association between preterm birth and language development may reflect the dynamic interplay of factors both internal and external to the child. Such findings highlight how efforts to screen for at-risk children and to identify intervention targets should look at both the linguistic and non-linguistic abilities of the preterm-born child as well as features of their surrounding developmental ecology. With respect to the social ecology, the observation that preterm birth affects the quality of parent-child relationships highlights the need to consider how the influence of preterm birth may reverberate beyond the child and into the broader family unit.

The developmental implication of the effect of preterm birth on the quality of parent-child relationships was nonetheless unclear. In the path models, the quality of the parent-child relationship was not significantly associated with later language development. This finding contrasts with the literature in Chapter 1 which had indicated that parent-child relationships form a key setting for the development of early language skills. These non-significant findings are tentative given the concerns about the scope and reliability of the parent-reported measures of parent-child relationship quality which were used by the longitudinal national cohort study (see Study 3.1 for further details). A more in-depth investigation of parent-child relationships was pursued in Chapter 5.

Part 2. Constructing a Language Environment in the Context of Preterm Birth (Chapter 5)

While Chapter 3 used parent-report measures to characterise the quality of parent-child relationships, the three studies in Chapter 5 used observational data to capture the dynamics of parent-child play interactions. In particular, parent-infant conversations occurring during mother-infant/father-infant dyadic free-play were microanalytically coded to characterise the linguistic (e.g., volubility, lexical diversity, morphosyntactic complexity) and dyadic conversational (e.g., responsiveness, turn-taking) features of the language environments experienced by 2-year-old preterm- and term-born infants. With these observational measures, Chapter 5 examined the manifestation of conversational synchrony in the context of preterm birth (Study 5.1), the differences between the language environments of preterm- and term-born groups (Study 5.2), and the association of these language environment features with the development of preterm- and term-born infants (Study 5.3).

Study 5.1 initially examined the dyadic features of parent-infant conversations (responsiveness, conversation initiations, and turn-taking) among the observational sample of preterm-born infants (no term-born comparison sample was included in this study). This investigation found limited signs of conversational synchrony among this cohort and tentatively concluded that preterm-born dyads may be characterised by a developmentally atypical conversational dynamic. This interpretation was importantly qualified by the findings of Study 5.2.

Study 5.2 compared the language environments of preterm- and term-born infants. In line with Study 3.1 which found preterm birth to significantly influence the quality of parent-child relationships, preterm birth was significantly associated with a subset of the language environment features which were investigated. Specifically, Study 5.2 found significant preterm-term differences in maternal speech rate, maternal/paternal volubility, and the degree of mother-infant conversational balance (mean length of turn ratio). Meanwhile, this study did not find significant preterm-term differences in the lexical or morphosyntactic features of parental speech nor in the dyadic features of parent/infant responsiveness, conversational initiation, and turn-taking. These preterm-term contrasts have a number of important theoretical implications.

Firstly, the preterm-term differences in language environment features were more apparent in the context of mother-infant than father-infant conversations. This suggests that the preterm literature that has predominantly focused on mother-infant conversations to date may not generalise to father-infant conversations. More broadly, the differential influence of preterm birth on mother-infant and father-infant conversations indicates how mothers and fathers may respond differently to the experience of preterm birth.

Secondly, the lack of a significant preterm-term difference in parent/child responsiveness, conversation initiation, or turn-taking significantly enriched the interpretation of the findings of Study 5.1. Although the findings of Study 5.1 had initially suggested that a developmentally atypical dynamic (limited conversational synchrony) characterises the conversations of preterm-born dyads, Study 5.2 questioned this conclusion through demonstrating the absence of significant preterm-term differences in the underlying dyadic conversational features (responsiveness, conversation initiation, turn-taking). In this way, Study 5.2 illustrated how these signs of “limited” conversational synchrony were not unique to preterm-born children and were observed irrespective of birth status.

This lack of a significant preterm-term difference in the dyadic features of responsiveness, conversation initiation, and turn-taking critically diverge from the findings of previous literature. Specifically, previous studies involving ≤ 6-month-old preverbal infants had found lower levels of synchrony to characterise the mother-infant conversations of preterm-born groups when compared to term-born groups (Reissland & Stephenson, 1999; Salerni et al., 2007). Such preterm-term differences were not found to characterise either the mother-infant or father-infant conversations of the current sample of verbal 2-year-old infants. These divergent findings may be attributable to the biological maturation (and associated developmental catch-up) of the preterm-born infants as well as qualitative differences between the mechanisms underlying preverbal and verbal parent-child turn-taking. The differential findings may also be the result of parental scaffolding. Further investigation will be required to elucidate the relevance of each proposed explanation.

To understand the developmental significance of these preterm-term contrasts in language environment features, Study 5.3 examined how these features associate with the development of preterm- and term-born infants. In contrast to Study 3.1 which did not find a significant association between parent-reported parent-child relationship quality (at 9 months and 3 years) and language development (at 3 years and 5 years, respectively), Study 5.3 found significant concurrent associations between parent-infant conversations and the development of preterm- and term-born 2-year-old infants. Interestingly, the pattern of associations differed as a function of both birth status and parental gender. These variations have a number of theoretical implications.

Firstly, a larger number of significant associations were found among the preterm- as compared to the term-born group. This may be suggestive of a heightened environmental sensitivity of preterm-born children to the language environment. Secondly, preterm-term differences were found in the nature of the significant associations between the language environment and development (e.g., mother-infant turn-taking was associated with the language scores of preterm- but not term-born infants). These differences may indicate that 2-year-old preterm- and term-born infants are at different developmental stages and/or that their development is underpinned by divergent developmental systems and learning mechanisms. These divergences may additionally highlight how there may be differences between preterm- and term-born groups in what constitutes a developmentally conducive environment.

Thirdly, mother-infant and father-infant conversations were differentially associated with infant development in both the preterm- and term-born groups (e.g., the interactive features of mother-infant conversations [turn-taking and conversational balance] were associated with both language and non-language development, while the interactive features of father-infant conversations [conversational balance] were solely associated with language development). This may indicate how mothers and fathers can differentially support the divergent care needs of preterm- and term-born infants.

Part 3. Assessing the Language Skills of Preterm-Born Infants (Chapter 6)

Study 6.1 was designed to generate data-driven insights which could guide the use of language assessments with preterm-born infants. Specifically, this study empirically investigated the utility of standardised assessments (Bayley-III) and language sample analysis by comparing the performance of 2-year-old preterm- and term-born infants on each. The influence of procedural factors (e.g., child neuropsychological profile, use of cut-off scores, speech sampling context) on the developmental insights offered by each assessment approach were also explored.

This study found preterm-born infants to perform significantly more poorly than their term-born peers on the receptive communication, expressive communication, and language composite scores of the Bayley-III assessment. Importantly, these between-group differences in test scores could not be fully explained by preterm-term differences in executive function scores (which could have affected standardised test performance). While minimal preterm-term differences were observed in the spontaneous speech of these infants (as ascertained through language sample analysis), significant correlations were nonetheless found between the standardised test scores and language sample analysis measures. These correlations were found among both the preterm- and term-born groups and indicated the complementary utility of standardised tests and language sample analysis. Specifically, while standardised tests may facilitate the identification of preterm language difficulties, language sample analysis may aid the setting and monitoring of functional treatment goals. The findings additionally provided nuanced guidance for the implementation of standardised testing and language sample analysis through cautioning the use of clinical cut-off scores and through highlighting the importance of being aware of the speech sampling context.

With further reference to the speech sampling context, this methodological characteristic may help to explain why the findings of Study 6.1 diverged from that of a subset of previous studies. While previous studies had found preterm-term differences in the lexical and morphosyntactic features of the spontaneous speech produced by preschool-aged children (Grunau et al., 1990; Imgrund et al., 2019), only limited signs of such preterm-term differences were found in Study 6.1. As outlined in Study 6.1, the general lack of preterm-term differences in the language sample analysis measures may be attributable to the amount of variability in the measures of infant speech. Importantly, the degree of variability in the infant speech measures analysed in Study 6.1 may have been greater than that of the aforementioned studies of preschool-aged children owing to differences in the speech sampling context. While Study 6.1 sampled infant speech from parent-child conversations, the previous studies of preschool-aged children sampled infant speech from examiner-child conversations. Through reducing the amount of between-dyad variability in conversational contexts, examiner-child conversations may have increased the likelihood of detecting preterm-term differences in infant speech patterns.

Summary

The studies in this thesis drew upon two disparate datasets to better understand the language development of preterm-born children. A finding common to both the nationally-representative dataset and the observational dataset was that preterm-born children exhibited poorer language skills than their term-born peers during infancy and toddlerhood (though see Study 3.1 for a discussion of a potential catch-up in expressive language skills at 5 years of age). These findings highlight the need for the continued clinical monitoring of the language development of preterm-born children. The effectiveness of such clinical efforts will hinge upon the appropriate choice and implementation of language assessment tools. These clinical decisions may be usefully guided by the findings of Study 6.1.

The observational dataset in particular demonstrated that the preterm-term differences in language abilities persist in spite of adjusting age for prematurity. This finding suggests that these preterm language difficulties are not simply the result of maturational lags and instead may signify the operation of unique developmental processes. Nuanced insights into these developmental processes were obtained through leveraging the two data sources to examine the synergistic developmental contributions of parent and child factors at a range of developmental timepoints (9 months, 2 years, 3 years, and 5 years of age), across multiple timescales (longitudinal and cross-sectional), and using an array of measurement methods (e.g., parent-report measures, standardised testing, observational methods).

These investigations illustrated how the language abilities of preterm-born children are underpinned by a complex network of developmental influences which flow between the child's linguistic and non-linguistic development as well as between the child and their proximal social partners. Through highlighting the embodied and embedded nature of child development, these findings underscore the importance of acknowledging the holistic developmental profile of the preterm-born child and the bidirectional influences which flow between the child and their surrounding developmental environment. More broadly, these cumulative findings illustrate how developmental systems perspectives can facilitate a more dynamic and nuanced understanding of preterm language development.

This chapter has thus far synthesised the findings of Chapters 3, 5, and 6 to demonstrate their collective theoretical significance. In addition to these theoretical implications, this thesis has considerable practical implications owing to its focus on investigating how modifiable factors contribute to the association between preterm birth and language development. These practical applications are outlined in the following section.

7.3 Practical Implications

The findings of this thesis illustrate how preterm language development can be affected by a number of modifiable postnatal factors. This critically highlights how variations in the clinical follow-up care of preterm-born cohorts could affect the development and life-long outcomes of these children. Given the great deal of heterogeneity both within and across nations in the care provided to preterm-born children, these findings demonstrate the importance of developing standardised evidence-based care guidelines. Co-ordinated efforts to standardise the follow-up care of preterm-born children are underway (e.g., EFCNI, 2022a), and the findings of this thesis can assist in the development and refinement of such standards.

A key aspect of the clinical management of preterm language development involves the identification and monitoring of language difficulties. The EFCNI (2022a) has recommended that preterm-born children undergo language assessments at/before 2 years of age. While standardised tests are commonly used in such settings (Johnson et al., 2008), the findings of Study 6.1 provide data-driven insights to guide the choice and implementation of language assessments with 2-year-old preterm-born infants. In particular, Study 6.1 highlights that while standardised tests can facilitate the identification of language difficulties, language sample analysis can provide complementary developmental insights which can aid in the setting and monitoring of functional treatment goals. Furthermore, through flagging the often "low-average" standardised test performance of preterm-born children, this study cautions against exclusively relying on clinical cut-off scores. The sole reliance on clinical cut-offs would overlook these subclinical levels of difficulty which may worsen without appropriate therapeutic attention. This study additionally emphasises the importance of recognising how procedural variations in language sample analysis (speech sampling context) can affect the developmental insights that are obtained from this assessment approach.

A critical insight of Study 6.1 was that although preterm-born infants exhibit poorer standardised language test performance than their term-born peers, only minimal systematic differences are observed between the spontaneous speech of preterm- and term-born infants within naturalistic conversational contexts. This highlights how families with preterm-born children should be encouraged to attend such follow-up language assessments regardless of whether the infants are perceived to have communicative difficulties in day-to-day conversational contexts. In addition, efforts to identify preterm-born children who are "at-risk" of developing language difficulties should make use of screening tools which extend beyond the linguistic domain of development. Specifically, screening should be extended to consider the child's non-linguistic development as well as their broader developmental ecology. As identified below, this embodied and embedded view of development could also usefully guide interventions which are aimed at preventing and mitigating language difficulties.

With respect to the embodied nature of child development, Study 3.1 identified how the association between preterm birth and language development is longitudinally mediated by non-linguistic skills. This highlights the importance of taking a holistic view of the preterm-born child's developmental profile and adopting a multidisciplinary approach to their follow-up care. Nonetheless, the involvement of multiple healthcare disciplines can create logistical challenges both for healthcare providers and patient families (Phillips et al., 2013). For instance, the duplication of developmental assessments across healthcare teams (e.g., physiotherapy team, speech-language therapy team) can lead to the inefficient use of practitioner time and resources. Furthermore, the need to attend multiple clinical appointments can be an unnecessary source of strain for families. With this in mind, the establishment of co-ordinated multidisciplinary healthcare teams which offer continuity of care to preterm-born children is vital (see Phillips et al., 2013 for a discussion).

The socially embedded nature of child development highlights how such multidisciplinary healthcare teams should additionally acknowledge the caregiving experiences and developmental contributions of parents. Specifically, the studies in Chapters 3 and 5 illustrated the developmental importance of the broader social ecology through exploring the reciprocal and transactional influences which unfold between the parent and child. Study 3.1 identified how infant temperament and parental mental wellbeing mediate the association between preterm birth and parent-child relationship quality. Such findings indicate how healthcare providers (such as those in the neonatal intensive care unit) should actively include and support parents in the care of their infants from the first days of life. Through involving parents in basic caregiving tasks, medical staff can help parents to become familiar with the behavioural characteristics of their child (e.g., temperament) and to develop the skills which are necessary to sensitively respond to such behavioural cues (Craig et al., 2015). Healthcare providers should also seek to offer mental health screening to parents of preterm-born infants (EFCNI, 2022b). Such screening should be accompanied by follow-on emotional support which can accommodate the varying amount and nature of assistance required by differing parents and at differing stages of the child's development (Hynan et al., 2015).

Beyond facilitating the transition to parenthood, parents can also be supported to take a proactive role in scaffolding their infant's language development through enriching the language environment. Study 5.3 identified how parent-child conversations are associated with language development, and how such conversations may be particularly important in the context of preterm birth given the seemingly heightened environmental sensitivity of this developmentally vulnerable cohort. Study 5.3 additionally identified how different features of parent-child conversations can support the development of preterm- and term-born infants.

These finding could guide the development of psychoeducational programs which help parents to create language environments which are specifically conducive to the development of preterm-born children. Importantly, parents can implement the insights obtained from such psychoeducational programs in the safety of their own homes and in a way that accords with their family's routines and customs. Furthermore, since parent-child conversations do not require the use of specialised educational materials, such psychoeducational guidance can be implemented with minimal financial cost. In this way, enriching the language environment can be seen as an inclusive approach to optimising preterm language development.

In the course of discussing the practical implications of this thesis, the gender-neutral term of "parents" has been used in order to encompass the caregiving experiences and developmental contributions of both mothers and fathers. This approach aligns with family-centred care approaches which seek to support and encourage the involvement of both parents in the care of preterm-born children (EFCNI, 2022b). An important insight of this thesis, however, was that mothers and fathers have unique parenting experiences with each parent making distinct developmental contributions. These findings highlight how family-centred care approaches should respect the unique needs of mothers and fathers and seek to leverage their differential influences on child development. A particularly sensitive approach to the support and involvement of fathers is needed as fathers have often been excluded from clinical caregiving contexts to date (Fisher et al., 2018). Given the dearth of literature on the caregiving experiences and developmental contributions of fathers (in both the preterm and non-preterm literature), further research into this topic is needed to drive the evidence-guided advancement of family-centred care.

7.4 Strengths

The studies comprising this thesis are characterised by a number of methodological strengths. These strengths are thematically organised below.

Design and Sample Characteristics

The studies in this thesis drew on nationally representative cohort data (Growing Up in Ireland) and observational data (Infant and Child Research Lab) to develop rich insights into the association between preterm birth and language development. The use of these two data sources allowed for this association to be investigated at two time scales (longitudinal and cross-sectional), at multiple points in development (between 9 months and 5 years of age), and using a wide range of measurement methods (parent-report, standardised assessment, observational methods). The studies in this thesis additionally addressed the lack of research on moderate-to-late preterm birth through studying infants of all degrees of prematurity. Furthermore, to address the predominant focus of the existing literature on mothers of preterm-born infants, this thesis considered the parenting experiences and developmental contributions of both mothers and fathers. Importantly, rather than relying on maternal reports of father characteristics, paternal characteristics were ascertained through father-report and direct observation. Finally, this thesis explored the developmental mechanisms and outcomes of a contemporary sample of preterm-born children. The use of such a contemporary sample is critical given that medical advances are continually altering the survival rates and developmental profiles of preterm-born children.

Methodological Rigour

Beyond these sample characteristics, each study in this thesis is characterised by a high level of methodological rigour. In Study 3.1, the nationally-representative cohort data was weighted to account for differential attrition between data collection waves. Furthermore, the quality of the observational data which was used in Chapters 5 and 6 was bolstered by the approaches that were taken to recording, transcribing, and coding parent-child interactions. In particular, the use of the purpose-built observation facility at the Infant and Child Research Lab allowed for the unobtrusive recording of parent-child dyads within a standardised environment. While the recorded interactions were transcribed by multiple individuals, all of the transcripts were audited and corrected by a single senior transcriber to ensure the standardisation of the transcription process. The manual coding of these resulting transcripts also allowed for a high level of precision in the identification of turn-taking exchanges.

Methodological Innovations

In addition to these methodological safeguards, the studies in this thesis pursued a number of methodological innovations. At the time of writing Study 3.1, no previously published study had used path analysis to investigate how non-linguistic abilities and parenting may contribute to the association between preterm birth and language development. Furthermore, the studies in Chapter 5 investigated multiple operationalisations of turn-taking to develop a more comprehensive understanding of the mechanisms through which such conversational engagements may support language development. Such mechanistic insights into the association between the language environment and language development were also pursued through investigating how parent-child conversations associate with both language and non-language development.

Continuity with Future Research

The conduct and reporting of the studies in this thesis lay the foundation for future extensions of this research effort. With regard to Study 3.1, the detailed reporting of the path analyses lend considerable transparency to the statistical methods that were used. Furthermore, as these path analyses were conducted in R, future researchers may extend these R scripts through including additional variables or waves of data from the Growing Up in Ireland study. The R scripts may also serve as a template for similar investigations using nationally representative cohort data from other countries.

Continuity with future research efforts is also afforded by the manner in which the parent-child interactions of Chapters 5 and 6 were recorded and coded. While home-based interaction recordings may be affected by temporal changes in home environments (e.g., technology), interactions observed in a standardised environment can be immune to such environmental changes. Since the interactions in this thesis were recorded within a standardised lab environment, these observations may be confidently compared to those which may be recorded at a later date. Finally, the transcripts of the parent-child interactions were manually annotated to identify instances of temporally contingent turn-taking. These annotated transcripts may be investigated by future researchers to examine the semantic relatedness of these speaker transitions.

7.5 Weaknesses

In spite of the numerous strengths of this thesis, a number of methodological weaknesses must be recognised.

Heterogeneity of the Preterm Experience

The studies in this thesis compared preterm-born and term-born children, and did not directly explore the variability that may exist within each group. In particular, this conceptual and statistical approach prevented a direct investigation of how the experience of preterm birth may vary considerably among both parents and children. For instance, differences in the preterm-born child's degree of prematurity, medical diagnoses, and neurodevelopmental characteristics (e.g., symptoms of attention deficit hyperactivity disorder and autism spectrum disorder – both of which tend to be elevated among preterm-born samples; Fitzallen et al., 2020) could significantly alter parenting experiences (e.g., caregiving responsibilities, mental wellbeing, and perceptions of the child) and thus parenting behaviours. Differences in these same child characteristics could additionally shape how the child engages with and processes such parenting behaviours. In line with the developmental systems perspective which frames this thesis, such transactional parent-child processes could have implications for the language development of preterm-born children.

This thesis opted for between-groups comparisons of preterm- and term-born children over such within-groups investigations for a number of reasons. First, a primary objective of this thesis was to address the lack of foundational research on the developmental differences of preterm- and term-born groups. Second, the observational data (underlying the studies in Chapters 5 and 6) contained limited information on child characteristics (e.g., autism spectrum disorder symptoms/diagnoses) and a small sample size (limiting statistical power) which together precluded such detailed multivariate within-group analyses. To extend the foundational insights of the current thesis, future studies should investigate the within-group variation seen among preterm-born children in order to develop a more individualised understanding of the experience of preterm birth and development. The findings of such studies would have theoretical implications through elucidating the various paths to language development which may be travelled by different preterm-born children. These insights could also be of clinical significance as they may allow for a more personalised approach to the care of preterm-born children.

Multiple Statistical Comparisons

In many of the studies in this thesis (particularly those in Chapters 5 and 6), multiple null hypothesis significance tests were carried out without statistically correcting for multiple comparisons. Such multiple comparisons (in the absence of statistical corrections) can inflate the family-wise error rate and thereby elevate the likelihood of finding false positive results (i.e., Type 1 error; Bretz et al., 2011). Due to the failure to correct for multiple comparisons, the exploratory findings of this thesis must be understood to primarily serve a descriptive and hypothesis-generating function (Bender & Lange, 2001). To ascertain the reliability of these results, these findings must first be replicated by more statistically rigorous confirmatory studies. A priority for these confirmatory studies will be to adequately control for multiple comparisons. This may be achieved in a number of ways.

Future confirmatory studies may control the family-wise error rate by adjusting for multiple comparisons using one of many single-step (e.g., Bonferroni procedure) and step-wise (e.g., Holm procedure) correction procedures (see Bretz et al. 2011 for a discussion). When choosing among these correction techniques, researchers must consider the assumptions required by each, as well as the trade-offs they carry with respect to the Type 1 (false positive) and Type 2 (false negative) error rates that they maintain (e.g., when correcting for a large number of comparisons, the Bonferroni procedure can be overly conservative and lacking in statistical power; Bender & Lange, 2001; Bretz et al., 2011).

In addition to retroactively correcting for multiple comparisons, future studies may seek to limit the number of comparisons that are conducted in the first instance. The exploratory nature of the studies in this thesis resulted in a large number of variables being tested (e.g., language environment variables, LSA variables), with this translating into a large number of comparisons being carried out (e.g., preterm-term comparisons on each language environment feature). Building on the insights derived from this thesis, future studies may limit the number of comparisons that are carried out through pursuing a targeted investigation of a subset of the variables investigated here.

Future studies could also limit the number of required comparisons by recruiting statistical methods which reduce the dimensionality of the dataset. Variable-centred dimension reduction techniques (e.g., principal components analysis) can allow for a large number of correlated variables (e.g., language environment features) to be summarised in a smaller number of composite variables (e.g., a composite measure of morphosyntactic complexity; Greenacre et al., 2023). These composite variables can then be entered into statistical analyses (e.g., preterm-term comparison of this composite measure of morphosyntactic complexity; Greenacre et al., 2023). Through reducing the number of variables under investigation in this way, the number of statistical tests can also be minimised.

Person-centred dimension reduction techniques (e.g., mixture modelling methods including latent class/profile analysis; see Bauer, 2022 and Oberski, 2016 for overviews of these methods) could also be used to limit the number of comparisons that are required. Such methods group individuals according to their scores on a set of thematically-related variables (e.g., LSA variables). The groupings seek to maximise the similarity of individuals within groups and minimise their similarity across groups. These groupings (e.g., groups of children with similar constellations of LSA scores) can then be investigated with relation to external variables (e.g., birth status). In this hypothetical example, testing the association between birth status and such LSA profile group membership requires considerably fewer tests than investigating the association between birth status and each individual LSA variable. In addition to the statistical benefit of limiting the number of tests that are required, this person-centred analytical method allows for a holistic approach to the study of individual differences (e.g., identifying children with similar constellations of developmental characteristics and/or environmental experiences). This statistical and conceptual approach may therefore be well-suited to probing the aforementioned heterogeneity in the experiences of parents/children following preterm birth (see the “Weaknesses – Heterogeneity of the Preterm Experience” section of this chapter).

Comprehensiveness of the Path Models

Study 3.1 used data from the Growing Up in Ireland project to model the direct and indirect paths between preterm birth and expressive language development. Since this dataset did not include information on the receptive language skills of these children, corresponding paths between preterm birth and receptive language abilities could not be tested. Hence, further research is required to examine whether the pathways identified to link preterm birth and expressive language development may similarly underlie the association between preterm birth and receptive skills.

Furthermore, two path models were used to separately investigate the parenting experiences and developmental contributions of mothers and fathers. Separate mother and father models were constructed to ensure the statistical parsimony and theoretical interpretability of the findings. Nonetheless, this modelling decision prevented an examination of how mothers and fathers may mutually influence one another’s parenting experiences and behaviours. Future research which jointly models maternal and paternal variables could boost the explanatory power of the path models in Study 3.1 through more comprehensively accounting for the operation of the family system (see Kerig, 2019 for a discussion of family systems approaches to parenting research).

Observational Data: Representativeness of Recordings

There has been little systematic investigation of whether human behaviours which are observed in a standardised laboratory environment are representative of behaviours which are seen in more naturalistic contexts (Gardner, 2000). Furthermore, few studies have investigated whether behaviours which are coded from brief observational recordings (e.g., 5 minutes) are reflective of those which would be coded from more prolonged periods of observation (see Murphy & Hall, 2021 for a review).

While manual annotation methods were chosen to allow for the precise coding of parent-child conversations, the time-intensive nature of this practice limited the number of parent-child interactions which could be analysed. Through limiting the number of available datapoints, this decision to use manual annotation constrained the statistical power of the analyses in Chapters 5 and 6. The time constraints also limited the range of interactions which could be analysed. While the participating infants had been observed as they engaged in free-play and structured-play within dyadic and triadic contexts, only the dyadic free-play interactions could be analysed. As parent-child conversations have been found to vary across interactional contexts (e.g., Nandy et al., 2021), future research should examine whether the findings of this thesis generalise beyond the dyadic free-play setting.

Observational Data: Sample Composition

The infants in the preterm-born and term-born samples belonged to two-parent households with highly-educated parents of White ethnicity. Thus, future work is required to investigate whether the findings of Chapters 5 and 6 may generalise to cohorts with different sociodemographic characteristics. A factor which is likely to have contributed to this sociodemographic profile is the voluntary and unpaid nature of participation in the underlying preterm-born and typically developing cohort studies. Some additional factors may have affected the sociodemographic composition of the preterm-born cohort in particular. Part of the preterm-born cohort was recruited from a medical study. Thus, these families may have had a heightened awareness of and interest in academic research. The preterm-born cohort was also recruited and tested during the COVID-19 pandemic. The following dedicated subsection details the impact that COVID-19 may have had on the data that was collected in the preterm-born cohort study.

Observational Data: COVID-19

As mentioned above, the preterm-born cohort was recruited and tested during the COVID-19 pandemic. This situational context may have attenuated the participation of families with medical vulnerabilities as well as those who were experiencing significant lifestyle changes associated with the pandemic (e.g., loss of a family member, loss of employment). The COVID-19 pandemic may have also boosted the participation of families who had been offered limited opportunities to engage with developmental professionals. Specifically, COVID-19 had severely curtailed the scheduling of clinical follow-up appointments for preterm-born children. Hence, families who had not had the opportunity to discuss their child's development with a developmental professional may have been particularly likely to participate in child psychology research.

The COVID-19 pandemic had a number of other methodological implications. The precautions that were taken to curb the spread of the virus while testing the preterm-born cohort resulted in procedural deviations from the testing protocol which had been used with the typically developing cohort. Furthermore, the social distancing regulations and lockdowns which began in 2020 led to the indefinite postponement of fieldwork involving the preterm-born cohort. Thus, while it was intended that two waves of data collection would be completed before finishing this thesis, only one wave of data collection could be executed. As a result, the analyses in Chapters 5 and 6 of this thesis rely upon cross-sectional data from which causal and directional conclusions cannot be drawn.

Finally, the influence that COVID-19 may have had on the developmental characteristics and the parent-child dynamics of the preterm-born cohort must be considered. There are a multitude of pathways through which COVID-19 may have affected these variables. For instance, there is ongoing research into whether COVID-19 infection during pregnancy could affect pregnancy outcomes (Wei et al., 2021) and infant neurodevelopmental characteristics (Firestein et al., 2023). There is also a body of research investigating how restricted access to neonatal intensive care units during the pandemic may have affected the caregiving experiences of families with medically vulnerable infants (Deindl et al., 2023).

The fieldwork for the preterm-born cohort was carried out in the midst of the pandemic when health regulations regarding neonatal care as well as everyday living were in constant flux. Hence, the abovementioned factors (e.g., hospital visitation regulations) which could disambiguate the influence of COVID-19 on child development and parent-child dynamics could not be anticipated or accounted for in the design of the preterm-born cohort study. The future synthesis of ongoing research into the influence of COVID-19 on pregnancy, neurodevelopment, and parent-child relations will allow for an evaluation of how the pandemic may have affected the data pertaining to the preterm-born cohort.

7.6 Future Research Directions

To better understand the language development of preterm-born children, this thesis investigated the developmental contributions of a wide range of factors relating to the parent, child, and parent-child relationship. Nonetheless, language development is a complex and multifaceted process, and capturing all contributing factors and mechanistic pathways was beyond the scope of this thesis. As outlined in Section 7.4, the methodological approach and comprehensive reporting of the studies in this thesis lay the foundation for future extensions of the current research effort. To guide such future endeavours, a number of important avenues for further research are highlighted below.

Characterising the Developmental Ecology

Future research should seek to investigate the developmental relevance of a wider range of parental variables. While parental wellbeing was investigated in Study 3.1, the inclusion of such variables in the observational studies of Chapters 5 and 6 was curtailed by limited statistical power. Future studies should thus investigate how parent-child conversations (parental speech, parent-infant turn-taking, and infant speech) may be affected by maternal/paternal wellbeing in the context of both preterm and term birth. In addition to investigating the individual wellbeing of mothers and fathers, future research should examine how preterm birth may shape the coparenting relationship (i.e., how parents take a cooperative and coordinated approach to caring for their child; Feinberg, 2003). With the increasing focus on advancing family-centred care approaches, it is pertinent to develop a deeper understanding of how mothers and fathers form a harmonious parenting team in the context of preterm birth (see Fisher et al., 2018 for a discussion). As mentioned in the "Weaknesses – Heterogeneity of the Preterm Experience" section of this chapter, such parental variables (parental wellbeing and coparenting relationship) should also be investigated with respect to how they may be shaped by the unique characteristics of each preterm-born child.

To investigate the coparenting relationship in action, future investigators may extend the dyadic insights of this thesis through investigating similar conversational constructs in the context of triadic mother-father-infant interactions. Through examining these interactions in both free-play and structured-play settings, researchers could additionally study how the interactional context affects the coparenting dynamics and broader parent-child conversations of families with preterm-born children. In the course of such observational investigations, researchers should seek to extend the findings of Chapter 5 through examining a broader range of language environment features. For instance, future studies could consider the conceptual features (e.g., use of decontextualised language) and communicative functions (e.g., use of *Wh-* questions) of parental speech as well as the semantic relatedness of temporally contingent turn-taking. While the addition of such variables will enhance the comprehensiveness of future studies, these studies must take precautions to ensure that this expanded range of variables can be statistically analysed without inflating the Type 1 error rate (for a more detailed discussion, see the "Weaknesses – Multiple Statistical Comparisons" section of this chapter).

Researchers may also seek to investigate the non-vocal communicative behaviours of parents and children. In particular, an examination of the coordinated use of vocal and non-vocal communicative modalities could facilitate a deeper understanding of how parent-infant turn-taking exchanges evolve as children transition from preverbal to verbal communication (see Rohlfing et al., 2020 for a discussion of multimodal turn-taking). Through investigating multimodal turn-taking, these studies could develop a more comprehensive understanding of how conversational synchrony in preterm-born dyads evolves across development.

Tracing the Associations between the Ecology and the Child

In addition to advancing a more expansive characterisation of the developmental ecology, innovations can also be pursued when parsing the association between the child's ecology and their language development. For instance, future studies could investigate the additive influence of maternal and paternal characteristics (e.g., maternal and paternal speech patterns) on preterm language development. Longitudinal studies could additionally elucidate the pathways linking such language environment features to preterm language development through considering the mediational role of non-linguistic abilities. When pursuing these research topics, the inclusion of a term-born comparison sample would importantly allow for a continuation of research into the potential differential susceptibility of preterm- and term-born infants to language environment features. Furthermore, through collecting detailed information about the medical/neurodevelopmental characteristics of larger samples of preterm-born children, future studies could additionally explore how such language environment features may differentially affect preterm-born children with differing medical/neurodevelopmental profiles.

Characterising the Developing Child

The mechanisms underlying such between-group and within-group differences in sensitivity to the language environment could be elucidated through developing a deeper understanding of the neuropsychological profiles of preterm- and term-born children. In particular, experimental eye-tracking methods which characterise how infants visually process audio-visual speech stimuli (e.g., a speaking face) could engender a better understanding of how preterm- and term-born infants experience and learn from their parents' speech (see Imafuku et al., 2019 for an investigation of the audiovisual speech processing abilities of preterm-born infants). Such insights could be supplemented by more linguistically-oriented eye-tracking tasks, such as the Looking-While-Listening task, which provide insights into the real-time language processing abilities of infants (see Chapter 1 for details). Through capturing how neuropsychological skills can shape language development, these experimental eye-tracking methods would additionally allow for a richer characterisation of the embodied nature of preterm language development.

In addition to characterising the broader neuropsychological profile of preterm-born cohorts, future research should construct a more holistic picture of the communicative development of preterm-born children through jointly examining their linguistic and phonological abilities. In Study 6.1, preterm-born infants exhibited significantly poorer linguistic skills than their term-born peers (Bayley-III). However, in this same study, the spontaneous speech of the preterm-born group was found to be significantly more intelligible than that of the term-born group. These findings may be indicative of a dissociation between the linguistic and phonological development of preterm-born infants, and thus may reflect preterm-term differences in language development mechanisms. As few studies to date have investigated the interrelations of the linguistic and phonological skills of preterm-born children (though see Guarini et al., 2009 and Imgrund et al., 2023), further research on this topic is a priority.

Stepping Outside of the Laboratory

The empirical investigations comprising this thesis were carried out among English-speaking samples of preterm- and term-born children in Ireland. Thus, without further conceptual replications of this work, it cannot be assumed that the findings of this thesis will generalise to other developmental contexts. In particular, the developmental trajectories and mechanisms of preterm-born children are likely to vary depending on the linguistic features of the language being acquired (Berman, 2014). Furthermore, as language and communication are socially-enmeshed processes (Casillas, 2023), the cultural practices of the child's community are likely to affect the contexts in which language is used and thus acquired (Cristia et al., 2019; MacLeod & Demers, 2023).

Given the dearth of research which has investigated preterm language development from a developmental systems perspective, the current thesis aimed to stimulate research in this domain through characterising the "core" of this dynamic system. Specifically, this thesis focused on the reciprocal influences occurring within the child (e.g., between linguistic and non-linguistic developmental domains) as well as between the child and their proximal social environment (e.g., parent-child interactions). To pursue an empirically rigorous investigation of the latter, parent-child interactions were observed in an experimentally controlled and standardised laboratory setting. Nonetheless, the linguistic-cultural variations outlined above highlight how future research should seek to build outwards from this "core" to develop a more contextually-enmeshed understanding of preterm language development.

A key element of this research agenda will be to understand the everyday experiences of preterm-born children within a range of naturalistic contexts (e.g., home environment).

Through harnessing technological advancements which make it possible to obtain ecologically valid ego-centric audio (LENA system – a small audio-recorder carried in a purpose-built vest worn by the child; Gilkerson & Richards, 2020) and visual (e.g., BabyView camera - a head-mounted camera worn by the child; Long et al., 2023) recordings of children's daily experiences, researchers can acquire a more holistic understanding of the child's broader developmental ecology.

Specifically, such technological advancements make it possible for researchers to step outside of the laboratory to unobtrusively capture the moment-by-moment engagements that children have with the social partners and physical objects which populate their surroundings. Through characterising the social partners (e.g., involvement of extended family in caregiving), physical objects (e.g., cultural artefacts), and play activities (e.g., object-centred play) experienced by the child, such naturalistic recordings can provide a richer understanding of the cultural context within which the child is developing (see Tamis-LeMonda & Masek, 2023 for a discussion of the social and physical embeddedness of child development).

Through characterising the naturalistic ebb-and-flow of the preterm-born child's everyday experiences, the child and the parent-child dyad (which were studied in this thesis) can be situated within the broader developmental ecology. These insights will allow for an increasingly robust understanding of the reciprocal and transactional effects which unfold between the preterm-born child and their environment over the course of development. Thus, through melding the foundational insights of the present thesis with the ever-evolving capabilities of research technologies, future research has the opportunity to mitigate the language difficulties of preterm-born children through advancing an increasingly embodied and embedded understanding of preterm development.

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Appendices

Appendix A

Attrition Analysis

Appendix A reports on the t-tests and chi-square tests which were used to compare the families from the GUI Infant Cohort who were included (families that participated at waves 1, 2, and 3 of the GUI study; *N* = 8,712) and excluded (families that only participated at waves 1 and/or 2; *N* = 2,422) from the analysis in Study 3.1.

This study's analysis was restricted to a subset of families who participated at waves 1, 2, and 3 of the Growing Up in Ireland study (see 'Participants' section of Study 3.1). Chi-square tests and t-tests were used to examine whether significant differences on key study variables may exist between these included families (families that participated at waves 1, 2, and 3; *N* = 8,712) and excluded families (families that only participated at waves 1 and/or 2; *N* = 2,422).

As can be seen in Table A1, there were no significant differences between the groups in the proportion of male/female children, while there was a smaller proportion of infants born preterm in the included families. The included families had significantly larger values than the excluded families on the following variables: Equivalised household income (rescaled), 9-month social-personal ability, 3-year language ability, 3-year motor ability, 3-year social-personal ability, and 3-year mother-child relationship. The included families had significantly smaller values than the excluded families on the following variables: 9-month fussy-difficult temperament, 9-month language ability, 9-month maternal stress, and 9-month maternal depression.

Table A1

Attrition Analysis: Comparison of Included and Excluded Families on Path Model Variables

	Included Families		Excluded Families					
	N	%	*N*	%	χ^2	*df*	*p*	
Birth Status - % preterm	8686	6.16	2408	8.39	14.75	1	< **.001**	
Child Sex - % female	8712	49.36	2422	47.69	2.05	1	.153	
	N	*M (SE)*	*N*	*M (SE)*	*t*	*df*	*p*	*d*
Wave 1 (9 month old)								
Equivalised household income (rescaled) [a]	8093	221.51 (1.49)	2177	189.10 (2.91)	9.92	3413.9	< **.001**	0.24
Fussy-difficult temperament [a]	8688	14.76 (0.05)	2414	15.22 (0.11)	- 3.86	3642.5	< **.001**	0.09
Language ability	8658	44.42 (0.12)	2406	45.16(0.24)	-2.83	11062	**.005**	0.07
Cognitive ability	8218	46.12 (0.14)	2286	46.15 (0.28)	-0.09	10502	.932	< 0.01
Motor ability [a]	8437	84.67 (0.24)	2343	85.63 (0.48)	-1.78	3572.6	.075	0.04
Social-personal ability	8599	43.68 (0.13)	2403	43.06 (0.25)	2.22	11000	**.026**	0.05
Maternal parental stress	8643	31.90 (0.07)	2390	32.85 (0.14)	-6.00	11031	< **.001**	0.14
Paternal parental stress	6968	30.84 (0.08)	1621	31.16 (0.16)	-1.88	8587	.060	0.05
Maternal depression [a]	8594	2.35 (0.04)	2346	2.84 (0.08)	-5.25	3357.1	< **.001**	0.13
Paternal depression	6889	1.32 (0.03)	1570	1.42 (0.07)	-1.40	8457	.163	0.04
Mother-child relationship [a]	8687	42.55 (0.03)	2410	42.43 (0.06)	1.96	3694.6	.050	0.05
Father-child relationship	6990	24.09 (0.02)	1633	24.09 (0.04)	0.16	8621	.869	0.01
Wave 2 (3 year old)								
Language ability [a]	8215	75.07 (0.22)	964	71.90 (0.70)	4.34	1156.1	< **.001**	0.15
Cognitive ability [a]	8518	60.88 (0.15)	1031	60.10 (0.48)	1.54	1248.1	.125	0.05
Motor ability	8603	3.26 (0.01)	1066	3.18 (0.03)	2.98	9667	**.003**	0.10
Social-personal ability [a]	8706	32.29 (0.05)	1080	31.53 (0.15)	4.82	1310.8	< **.001**	0.16
Mother-child relationship [a]	8689	33.82 (0.02)	1075	33.58 (0.07)	3.21	1257.6	**.001**	0.11

	Included Families		Excluded Families					
	N	*M (SE)*	*N*	*M (SE)*	*t*	*df*	*p*	*d*
Father-child relationship	6852	32.95 (0.03)	711	32.88 (0.10)	0.74	7561	.458	0.03
Wave 3 (5 year old)								
Language ability	8602	110.93 (0.20)	284	109.49 (1.03)	1.32	8884	.187	0.08

Note. Statistically significant between-group differences ($p < .05$) are shown in bold.
[a] Welch's t-test (when homogeneity of variance was not found).

Appendix B

Pearson Correlations between Continuous Path Model Variables

Table B1

Correlations between Continuous Path Model Variables

	9 months												3 years						5 years
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Income	-																		
2. Mother stress (9mo)	-.11***	-																	
3. Father stress (9mo)	-.06***	.36***	-																
4. Mother depress (9mo)	-.12***	.33***	.12***	-															
5. Father depress (9mo)	-.03**	.11***	.22***	.14***	-														
6. Fussy-difficult (9mo)	-.06***	.33***	.15***	.18***	.06***	-													
7. Mother-child rel (9mo)	-.03**	-.44***	-.19***	-.26***	-.08***	-.30***	-												
8. Father-child rel (9mo)	-.04***	-.16***	-.36***	-.04**	-.14***	-.10***	.16***	-											
9. Language (9mo)	-.09***	-.07***	-.04**	-.02	.00	-.06***	.08***	.07***	-										
10. Cognitive (9mo)	.02	-.07***	-.03*	-.01	-.01	-.05***	.05***	.02	.30***	-									
11. Motor (9mo)	.00	-.01	.03**	-.01	.02	.01	-.02	.01	.32***	.36***	-								
12. Social-personal (9mo)	.03**	-.08***	-.04***	-.02*	-.01	-.03**	.05***	.03*	.34***	.31***	.34***	-							
13. Mother-child rel (3yr)	.02	-.15***	-.06***	-.07***	-.04**	-.12***	.14***	.08***	.10***	.12***	.05***	.09***	-						
14. Father-child rel (3yr)	.00	-.09***	-.17***	-.03**	-.06***	-.06***	.06***	.16***	.06***	.07***	.04***	.06***	.26***	-					
15. Language (3yr)	.18***	-.06***	-.03*	-.04***	-.01	-.05***	.01	.03*	.10***	.09***	.06***	.12***	.11***	.06***	-				
16. Cognitive (3yr)	.08***	-.07***	-.04***	-.04***	-.04**	-.04***	.03**	.03*	.05***	.07***	.10***	.10***	.11***	.08***	.40***	-			
17. Motor (3yr)	.03**	-.05***	-.04***	-.04**	-.02*	-.02*	.03**	.02	.09***	.10***	.10***	.09***	.14***	.11***	.17***	.18***	-		
18. Social-personal (3yr)	.13***	-.26***	-.12***	-.18***	-.07***	-.25***	.20***	.06***	.07***	.08***	.05***	.09***	.28***	.17***	.16***	.16***	.13***	-	
19. Language (5yr)	.18***	-.05***	-.05***	-.02	-.01	-.04***	.02	.01	.05***	.06***	.01	.08***	.10***	.07***	.52***	.24***	.10***	.14***	-

Note. Pearson correlation coefficients. mo = months; depress = depression; Fussy-difficult = Fussy-difficult temperament; rel = relationship; Language = Language ability; Cognitive = Cognitive ability; Motor = Motor ability; Social-personal = Social-personal ability; yr = year.
**p* < .05. ***p* < .01. ****p* < .001.

Appendix C

Path Analysis Methods

This document supplements the analysis methods outlined in Study 3.1 by providing further detailed information regarding the path analysis approach which was adopted. Path analyses were conducted using a subset of longitudinal data from the Growing Up in Ireland research project (see 'Method: Design' and 'Method: Participants' sections of Study 3.1 for further information regarding the included subsample). Path models were fitted in place of structural equation models as the authors did not have access to item-level response data for the included scales. In the absence of item-level response data, latent variables (required for structural equation modelling) cannot be derived. All of the analyses described here and in Study 3.1 were conducted using R (version 4.1.2; R Core Team, 2021).

Model Specification

The original model specification is depicted in Figure 3.1.1 (see Study 3.1). This diagram includes direct longitudinal paths of theoretical interest (i.e., relating to the core research questions), as well as within-wave correlations and auto-regressive paths between repeated-measure variables to shield against biased longitudinal parameter estimates (MacCallum & Austin, 2000). In addition to the paths depicted in Figure 3.1.1, the confounding influences of household income and Study Child sex were accounted for by regressing birth status and language ability (9-month, 3-year, 5-year) on household income and child sex, and by regressing parent-child relationship (9-month, 3-year), stress (9-month), and depression (9-month) on household income. To avoid issues associated with multicollinearity, pairs of variables exhibiting moderate-large correlations ($r \geq 0.3$; Cohen, 1988) in the correlation matrix reported in Appendix B were allowed to covary in the model specification.

Finally, the following 10 indirect paths were specified and estimated:

Birth Status → Parent-Child relationship (9-months) → Language ability (3-years)

Birth Status → Cognitive ability (9-months) → Language ability (3-years)

Birth Status → Motor ability (9-months) → Language ability (3-years)

Birth Status → Social-Personal ability (9-months) → Language ability (3-years)

Birth Status → Parent Stress (9-months) → Parent-Child relationship (3-years)

Birth Status → Parent Depression (9-months) → Parent-Child relationship (3-years)

Birth Status → Fussy-Difficult Temperament (9-months) → Parent-Child relationship (3-years)

Birth Status → Parent Stress (9-months) → Parent-Child relationship (3-years) → Language ability (5-years)

Birth Status → Parent Depression (9-months) → Parent-Child relationship (3-years) → Language ability (5-years)

Birth Status → Fussy-Difficult Temperament (9-months) → Parent-Child relationship (3-years) → Language ability (5-years)

As outlined in Study 3.1, two versions of this path model were fit. One with parental variables (stress, depression, parent-child relationship) related to the child's mother ('Mother model'), and the other with corresponding variables related to the child's father ('Father model'). The following description of the model estimation, evaluation, and respecification approach applies to both models.

Model Estimation

The model outlined above was fitted using the lavaan package (v0.6-9; Rosseel, 2012). The lavaan package applies diagonally-weighted least squares estimation when the model specification includes categorical variables (there were two categorical variables in the model: Birth Status and Child Sex). When using diagonally-weighted least squares estimation, missing data can be handled through either pairwise deletion or listwise deletion. Pairwise deletion was chosen to preserve as much of the original data as possible and thereby boost statistical power. Further details on the amount of missing data and the missingness mechanisms can be found in Study 3.1. When fitting the models, a sample weighting factor generated by the GUI study team was applied. This weighting factor adjusts for differential response and inter-wave attrition (Murray et al., 2015) to make the sample representative of the population in the Republic of Ireland. This weight was computed by the GUI study team by considering variables relating to the mother (e.g., age, educational attainment, marital status, mental wellbeing, body-mass index), the household (e.g., family structure, family income), and childcare practices (e.g., whether the Study Child was breastfed).

Model Evaluation and Respecification

Given the exploratory nature of the current study, a model generation strategy was adopted whereby the original model specification (outlined above) was modified (‘respecified’) to improve the global fit of the model through addressing areas of local misfit (further details below). Importantly, prior to checking the global/local fit indices, the model degrees of freedom were examined to determine whether the model was under-identified (degrees of freedom < 0), just-identified (degrees of freedom = 0), or over-identified (degrees of freedom > 0). Furthermore, the statistical power of the analysis was considered by assessing whether the sample size was sufficiently large to provide at least 20 cases per parameter (criteria suggested by Kline, 2011).

In accordance with the published literature, the path models were deemed to have achieved satisfactory global fit when a root-mean square error of approximation of < 0.06 and a standardised root mean square residual of < 0.08 was achieved (Hu & Bentler, 1999). Cumulative fit indices (Tucker-Lewis index and comparative fit index) were not interpreted as they can problematically indicate poor model fit when the model contains small between-variable correlations (which was the case in the current study).

Areas of local misfit were identified by inspecting non-significant paths, as well as modification indices and expected parameter change values. In combination with the global fit indices, these statistics were examined to explore the possible addition/removal of paths which could increase the model's parsimony and explanatory power. When using a model generation approach, the data-driven model modifications run the risk of capitalising on chance patterns that are unique to the particular dataset under investigation (see MacCallum & Austin, 2000 for a discussion). To minimise such issues, the following a priori constraints were placed on the modifications which could be made to the models. Non-significant paths could be removed from the model unless they constituted the direct prospective paths in Figure 3.1.1 or the explicitly specified indirect paths. These non-significant direct/indirect paths were to be retained as they relate to the central research questions and thus their non-significance is of considerable theoretical interest. When possible path additions were suggested by the modification indices, their inclusion was dependent on their theoretical relevance to the core research aims and questions. When changes were to be made, paths were to be modified iteratively, with path additions to precede deletions (MacCallum, 1986). The impact of these modifications were examined by inspecting changes in the parameter estimates of the retained paths, the global fit indices of the model, and by comparing the resulting nested models using ANOVA comparisons (a = .05).

After selecting the most parsimonious respecified model, the selected model was interpreted by examining standardised and unstandardised parameter estimates, p-values, and bootstrapped 95% confidence intervals for the direct and indirect paths.

Details of the application of these path analysis methods to the Mother model and Father model are documented in Appendix D and E, respectively.

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Appendix D

Mother Model: Model Estimation, Evaluation, and Respecification

The estimation, evaluation, and respecification of the Mother model was conducted in line with the reasoning and methods outlined in Appendix C.

The originally hypothesised model (see Appendix C) was fitted using parental variables relating to the child's mother (i.e., parent stress, parent depression, parent-child relationship). As can be observed from the model summary statistics reported in Table D1 , the model converged, was over-identified (degrees of freedom > 0), and had sufficient statistical power (exceeding 20 cases per estimated parameter; Kline, 2011). While the model obtained an acceptable standardised root mean square residual value (SRMR < 0.08), the root-mean square error of approximation exceeded the recommended threshold of 0.06 (Hu & Bentler, 1999). Given this unsatisfactory global fit index, model modifications were considered by examining the model's non-significant paths, modification indices, and expected parameter change values.

Table D1

Original Model (Model-1) Statistics

	Original model (model-1)
Converged?	Yes
Model parameters	99
Observations	8712
Missing patterns	173
Degrees of freedom	70
RMSEA	0.068
SRMR	0.053

While no theoretically relevant path additions were suggested by these local fit indices, three non-significant paths were identified for removal. These paths were removed iteratively from the model in the following order, starting with the path that had the highest p-value and was thus the least statistically significant: (i) child sex → language ability (5-years), (ii) correlation between mother-child relationship (9-months) and motor ability (9-months), (iii) income → mother-child relationship (3-years). After each path was removed, the resulting model was examined to check whether any other paths which are eligible for removal (i.e., not direct / indirect paths of theoretical interest) may have become non-significant (they had not).

After iteratively removing these three non-significant paths, four nested path models resulted – the original path model (model-1), model-2 (original model with path (i) removed), model-3 (original model with paths (i) and (ii) removed), and model-4 (original model with paths (i), (ii), and (iii) removed). These models were compared using ANOVAs to investigate whether the inclusion/exclusion of these paths significantly affected the model's explanatory power. As none of these model comparisons were statistically significant (see Table D2), model-4 was chosen for further consideration as it offered the most parsimonious model specification.

Table D2

ANOVA Comparisons of Nested Models

	df	χ^2	χ^2 difference	*p*
		Model 1 – Model 2		
Model 1	70	2844.1		
Model 2	71	2844.6	0.84	.360
		Model 2 – Model 3		
Model 2	71	2844.6		
Model 3	72	2845.8	1.27	.259
		Model 3 – Model 4		
Model 3	72	2845.8		
Model 4	73	2848.6	3.26	.071
		Model 1 – Model 4		
Model 1	70	2844.1		
Model 4	73	2848.6	5.54	.136

Model-4 converged and was over-identified (degrees of freedom > 0). As seen in the model summary statistics reported in Table D3, the model had sufficient statistical power (exceeding 20 cases per estimated parameter; Kline, 2011). The SRMR value was acceptable, while the RMSEA value still slightly exceeded the recommended threshold of 0.06 (Hu & Bentler, 1999). Since no further meaningful modifications to the model could be identified, model-4 was accepted as the final model (model-4 is henceforth referred to as 'Mother model').

Table D3

Model-4 ('Mother Model') Statistics

	Model-4
Converged?	Yes
Model parameters	96
Observations	8712
Missing patterns	173
Degrees of freedom	73
RMSEA	0.066
SRMR	0.054

Full statistical output corresponding to the Mother model (model-4) can be found below. This statistical output consists of five tables. The first and second of which report the covariance matrix (Table D4) and means (Table D5), respectively. The third, fourth, and fifth each contain standardised regression coefficients, standard errors, z-scores, p-values, and bootstrapped 95% confidence intervals corresponding to the direct paths (Table D6), within-wave covariances (Table D7), and indirect paths (Table D8).

Table D4

Mother Model Sample Covariance Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Language (5yr)	301.84																
2. Mother-Child rel (3yr)	3.72	3.70															
3. Language (3yr)	179.02	5.31	373.81														
4. Cognitive (3yr)	66.86	3.65	118.22	202.46													
5. Motor (3yr)	1.51	0.23	2.93	2.30	0.73												
6. Social-personal (3yr)	10.71	2.67	14.11	10.17	0.46	21.20											
7. Mother stress (9mo)	-7.03	-2.05	-7.85	-5.53	-0.23	-8.16	46.53										
8. Mother depress (9mo)	-1.56	-0.54	-3.06	-2.27	-0.09	-3.45	9.03	13.22									
9. Fussy-difficult (9mo)	-2.44	-1.27	-3.63	-3.67	-0.08	-5.72	11.17	3.69	24.29								
10. Mother-child rel (9mo)	0.36	0.78	-0.18	0.62	0.04	2.20	-7.83	-2.62	-3.82	6.65							
11. Language (9mo)	7.19	2.37	19.48	6.15	0.87	3.13	-4.94	-0.79	-3.49	2.18	129.49						
12. Cognitive (9mo)	15.25	3.76	24.18	12.86	1.10	4.41	-5.57	-0.09	-3.10	1.87	45.21	174.41					
13. Motor (9mo)	4.87	2.25	27.29	30.91	2.04	5.21	-1.15	-2.38	1.11	-1.52	78.09	104.22	483.13				
14. Social-personal (9mo)	18.02	2.02	29.29	17.94	1.07	4.56	-5.27	-1.12	-2.08	1.24	45.10	50.03	87.29	141.66			
15. Birth Status	-0.54	-0.08	-1.40	-1.18	-0.06	-0.28	0.37	0.17	0.09	0.01	-2.93	-2.43	-6.39	-2.45	1.00		
16. Income	381.80	8.80	464.73	247.10	3.40	110.27	-125.21	-88.95	-53.29	-16.72	-193.15	47.15	24.20	70.64	-16.27	17627.50	
17. Child sex	-0.41	-0.10	-1.18	-0.75	-0.07	-0.19	0.06	0.03	0.06	0.00	-0.43	-0.20	-0.01	-0.26	0.01	2.48	0.25

Note. Covariance matrix computed with pairwise deletion. Language = Language ability; yr = year; rel = relationship; Cognitive = Cognitive ability; Motor = Motor ability; Social-personal = Social-personal ability; mo = months; depress = depression; Fussy-difficult = Fussy-difficult temperament.

Table D5

Mother Model Means

	M
Language ability (5-years)	111.33
Mother-child relationship (3-years)	33.80
Language ability (3-years)	74.79
Cognitive ability (3-years)	60.34
Motor ability (3-years)	3.25
Social-personal ability (3-years)	32.03
Mother stress (9-months)	31.95
Mother depression (9-months)	2.46
Fussy-difficult temperament (9-months)	14.79
Mother-child relationship (9-months)	42.57
Language ability (9-months)	44.64
Cognitive ability (9-months)	46.05
Motor ability (9-months)	83.82
Social-personal ability (9-months)	43.71
Income	216.07

Table D6

Mother Model: Regression Paths

Regression paths			ß	*SE*	*z*	*p*	Bootstrapped 95% CI	
							lower	upper
Birth status	→	Language (5yr)	0.011	0.38	0.52	.601	-0.543	0.896
Mother-child rel (3yr)	→	Language (5yr)	0.028	0.14	1.79	.074	-0.016	0.556
Language (3yr)	→	Language (5yr)	0.489	0.02	23.24	.000	0.390	0.470
Cognitive (3yr)	→	Language (5yr)	0.052	0.02	3.16	.002	0.024	0.104
Motor (3yr)	→	Language (5yr)	-0.007	0.27	-0.51	.611	-0.656	0.399
Social-personal (3yr)	→	Language (5yr)	0.041	0.05	3.28	.001	0.062	0.251
Income	→	Language (5yr)	0.078	0.00	2.50	.012	0.004	0.018
Mother stress (9mo)	→	Mother-child rel (3yr)	-0.097	0.01	-4.22	.000	-0.041	-0.015
Mother depress (9mo)	→	Mother-child rel (3yr)	0.002	0.01	0.09	.932	-0.025	0.026
Fussy-difficult (9mo)	→	Mother-child rel (3yr)	-0.079	0.01	-4.10	.000	-0.045	-0.016
Mother-child rel (9mo)	→	Mother-child rel (3yr)	0.103	0.02	4.62	.000	0.046	0.112
Birth status	→	Language (3yr)	-0.004	0.60	-0.12	.906	-0.887	1.450
Mother-child rel (9mo)	→	Language (3yr)	0.01	0.11	0.69	.489	-0.155	0.290
Language (9mo)	→	Language (3yr)	0.064	0.03	3.36	.001	0.068	0.191
Cognitive (9mo)	→	Language (3yr)	0.047	0.02	2.86	.004	0.018	0.112
Motor (9mo)	→	Language (3yr)	-0.026	0.01	-1.58	.114	-0.054	0.003
Social-personal (9mo)	→	Language (3yr)	0.092	0.03	5.51	.000	0.093	0.201

Regression paths							Bootstrapped 95% CI	
			ß	*SE*	*z*	*p*	lower	upper
Income	→	Language (3yr)	0.189	0.00	9.25	.000	0.027	0.041
Child sex	→	Language (3yr)	-0.117	0.51	-8.93	.000	-5.566	-3.660
Cognitive (9mo)	→	Cognitive (3yr)	0.134	0.02	7.19	.000	0.106	0.186
Motor (9mo)	→	Motor (3yr)	0.161	0.00	9.36	.000	0.005	0.008
Social-personal (9mo)	→	Social-personal (3yr)	0.158	0.01	6.92	.000	0.046	0.082
Birth status	→	Mother stress (9mo)	0.164	0.20	5.59	.000	0.761	1.530
Income	→	Mother stress (9mo)	-0.111	0.00	-6.40	.000	-0.007	-0.004
Birth status	→	Mother depress (9mo)	0.075	0.11	2.58	.010	0.073	0.491
Income	→	Mother depress (9mo)	-0.169	0.00	-6.07	.000	-0.006	-0.002
Birth status	→	Fussy-difficult (9mo)	0.136	0.13	5.35	.000	0.442	0.943
Birth status	→	Mother-child rel (9mo)	-0.000	0.06	0	1.000	-0.125	0.122
Income	→	Mother-child rel (9mo)	-0.051	0.00	-3.00	.003	-0.002	-0.000
Birth status	→	Language (9mo)	-0.304	0.28	-12.26	.000	-4.150	-3.051
Income	→	Language (9mo)	-0.175	0.00	-8.91	.000	-0.018	-0.011
Child sex	→	Language (9mo)	-0.041	0.27	-3.49	.000	-1.410	-0.360
Birth status	→	Cognitive (9mo)	-0.231	0.30	-10.13	.000	-3.748	-2.515
Birth status	→	Motor (9mo)	-0.248	0.58	-9.26	.000	-6.669	-4.395
Birth status	→	Social-personal (9mo)	-0.288	0.32	-10.43	.000	-4.181	-2.909
Income	→	Birth status	-0.177	0.00	-5.52	.000	-0.002	-0.001
Child sex	→	Birth status	0.103	0.04	4.74	.000	0.119	0.289

Note. mo = months; yr = years; rel = relationship; Language = Language ability; Cognitive = Cognitive ability; Motor = Motor ability; Social-personal = Social-personal ability; Income = Equivalised household income (rescaled).

Table D7

Mother Model: Covariances

Covariances							Bootstrapped 95% CI	
			ß	*SE*	*z*	*p*	lower	upper
Mother stress (9mo)	~~	Mother-child rel (9mo)	-0.462	0.33	-23.95	.000	-8.561	-7.258
Mother depress (9mo)	~~	Mother-child rel (9mo)	-0.295	0.20	-13.42	.000	-3.079	-2.262
Fussy-difficult (9mo)	~~	Mother-child rel (9mo)	-0.303	0.22	-17.67	.000	-4.227	-3.402
Mother-child rel (9mo)	~~	Language (9mo)	0.084	0.41	5.69	.000	1.541	3.151
Mother-child rel (9mo)	~~	Cognitive (9mo)	0.078	0.50	5.14	.000	1.554	3.522
Mother-child rel (9mo)	~~	Social-personal (9mo)	0.083	0.49	4.90	.000	1.411	3.443
Language (9mo)	~~	Cognitive (9mo)	0.258	2.48	14.17	.000	29.604	39.417
Language (9mo)	~~	Motor (9mo)	0.275	3.91	15.91	.000	54.039	69.202
Language (9mo)	~~	Social-personal (9mo)	0.283	2.10	16.27	.000	29.337	37.539
Cognitive (9mo)	~~	Motor (9mo)	0.340	5.07	17.99	.000	80.648	100.746
Cognitive (9mo)	~~	Social-personal (9mo)	0.287	2.73	15.08	.000	35.370	46.146
Motor (9mo)	~~	Social-personal (9mo)	0.298	4.38	16.11	.000	61.442	78.207
Mother stress (9mo)	~~	Fussy-difficult (9mo)	0.316	0.55	18.61	.000	9.154	11.311
Mother depress (9mo)	~~	Fussy-difficult (9mo)	0.197	0.36	9.52	.000	2.710	4.152
Mother stress (9mo)	~~	Mother depress (9mo)	0.341	0.54	15.10	.000	6.850	9.119
Mother-child rel (3yr)	~~	Language (3yr)	0.141	0.67	7.43	.000	3.553	6.182
Language (3yr)	~~	Cognitive (3yr)	0.436	4.42	25.91	.000	105.676	123.490

Covariances							Bootstrapped 95% CI	
			ß	*SE*	*z*	*p*	lower	upper
Language (3yr)	~~	Motor (3yr)	0.179	0.25	11.12	.000	2.329	3.330
Language (3yr)	~~	Social-personal (3yr)	0.144	1.25	9.80	.000	9.833	14.753
Cognitive (3yr)	~~	Motor (3yr)	0.185	0.20	10.98	.000	1.809	2.594
Cognitive (3yr)	~~	Social-personal (3yr)	0.151	0.97	9.97	.000	7.962	11.621
Motor (3yr)	~~	Social-personal (3yr)	0.111	0.06	7.06	.000	0.319	0.554
Mother-child rel (3yr)	~~	Cognitive (3yr)	0.135	0.55	6.57	.000	2.412	4.528
Mother-child rel (3yr)	~~	Motor (3yr)	0.143	0.03	7.75	.000	0.170	0.288
Mother-child rel (3yr)	~~	Social-personal (3yr)	2.239	0.21	12.58	.000	3.031	0.310
Income	~~	Child sex	0.392	0.93	2.39	.017	4.007	0.033

Note. mo = months; yr = years; rel = relationship; depress = depression; Fussy-difficult = Fussy-difficult temperament; Language = Language ability; Cognitive = Cognitive ability; Social-personal = Social-personal ability; Motor = Motor ability; Income = Equivalised household income (rescaled).

Table D8

Mother Model: Indirect Effects

Indirect effects					Bootstrapped 95% CI	
	ß	*SE*	*z*	*p*	lower	upper
BS ⟶ Mother stress (9mo) ⟶ Mother-child rel (3yr) ⟶ Language (5yr)	-0.000	0.01	-1.34	.181	-0.022	0.000
BS ⟶ Mother depress (9mo) ⟶ Mother-child rel (3yr) ⟶ Language (5yr)	0.000	0.00	0.07	.945	-0.003	0.002
BS ⟶ Fussy-difficult (9mo) ⟶ Mother-child rel (3yr) ⟶ Language (5yr)	-0.000	0.00	-1.35	.176	-0.015	0.000
BS ⟶ Mother-child rel (9mo) ⟶ Language (3yr)	-0.000	0.00	< 0.01	1.000	-0.018	0.018
BS ⟶ Cognitive (9mo) ⟶ Language (3yr)	-0.011	0.08	-2.58	.010	-0.372	-0.055
BS ⟶ Motor (9mo) ⟶ Language (3yr)	0.007	0.08	1.50	.133	-0.017	0.309
BS ⟶ Social-personal (9mo) ⟶ Language (3yr)	-0.026	0.11	-4.63	.000	-0.739	-0.311
BS ⟶ Mother stress (9mo) ⟶ Mother-child rel (3yr)	-0.016	0.01	-2.72	.007	-0.059	-0.013
BS ⟶ Mother depress (9mo) ⟶ Mother-child rel (3yr)	0.000	0.00	0.08	.939	-0.010	0.006
BS ⟶ Fussy-difficult (9mo) ⟶ Mother-child rel (3yr)	-0.011	0.01	-2.70	.007	-0.039	-0.008

Note. BS = Birth status; mo = months; yr = years; rel = relationship; Language = Language ability; depress = depression; Fussy-difficult = Fussy-difficult temperament; Cognitive = Cognitive ability; Motor = Motor ability; Social-personal = Social-personal ability.

References

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Appendix E

Father Model: Model Estimation, Evaluation, and Respecification

The estimation, evaluation, and respecification of the Father model was conducted in line with the reasoning and methods outlined in Appendix C.

The originally hypothesised model (see Appendix C) was fitted using parental variables relating to the child's father (i.e., parent stress, parent depression, parent-child relationship). As can be observed from the model summary statistics reported in Table E1 , the model converged, was over-identified (degrees of freedom > 0), and had sufficient statistical power (exceeding 20 cases per estimated parameter; Kline, 2011). Both the standardised root mean square residual (SRMR < 0.08) and the root-mean square error of approximation (< 0.06) indicated satisfactory global model fit (Hu & Bentler, 1999).

Table E1

Original Model (Model-1) Statistics

	Original model (model-1)
Converged?	Yes
Model parameters	99
Observations	8712
Missing patterns	232
Degrees of freedom	70
RMSEA	0.054
SRMR	0.043

An inspection of local fit indices did not identify any theoretically relevant paths to be added to the model. However, three non-significant paths (same as those identified in the Mother model) were identified for removal. The paths were removed iteratively from the model in the following order, starting with the path that had the highest p-value and was thus the least statistically significant (i) child sex → language ability (5-years), (ii) correlation between father-child relationship (9-months) and motor ability (9-months), (iii) income → father-child relationship (3-years). After each path was removed, the resulting model was examined to check whether any other paths which were eligible for removal (i.e., not the direct / indirect paths of theoretical interest) may have become non-significant (they had not).

After iteratively removing the non-significant paths, four nested path models resulted – the original path model (model-1), model-2 (original model with path (i) removed), model-3 (original model with paths (i) and (ii) removed), and model-4 (original model with paths (i), (ii), and (iii) removed). These models were compared using ANOVAs to investigate whether the inclusion/exclusion of these paths significantly affected the model's explanatory power. As none of these model comparisons were statistically significant (see Table E2), model-4 was chosen for further consideration as it offered the most parsimonious model specification.

Table E2

ANOVA Comparisons of Nested Models

	df	χ^2	χ^2 difference	*p*
		Model 1 – Model 2		
Model 1	70	1817.3		
Model 2	71	1817.8	0.77	.381
		Model 2 – Model 3		
Model 2	71	1817.8		
Model 3	72	1818.4	0.63	.427
		Model 3 – Model 4		
Model 3	72	1818.4		
Model 4	73	1821.1	2.87	.090
		Model 1 – Model 4		
Model 1	70	1817.3		
Model 4	73	1821.1	4.46	.216

Model-4 converged and was over-identified (degrees of freedom > 0). As can be seen in the model summary statistics reported in Table E3, the model had sufficient statistical power (exceeding 20 cases per estimated parameter; Kline, 2011). The SRMR and RMSEA global fit indices were satisfactory. Since no further meaningful modifications to the model could be identified, model-4 was accepted as the final model (model-4 is henceforth referred to as ‘Father model’).

Table E3

Model-4 ('Father Model') Summary Statistics

	Model-4
Converged?	Yes
Model parameters	96
Observations	8712
Missing patterns	232
Degrees of freedom	73
RMSEA	0.053
SRMR	0.043

Full statistical output corresponding to the Father model (model-4) can be found below. This statistical output consists of five tables. The first and second of which report the covariance matrix (Table E4) and means (Table E5), respectively. The third, fourth, and fifth each contain standardised regression coefficients, standard errors, z-scores, p-values, and bootstrapped 95% confidence intervals corresponding to the direct paths (Table E6), within-wave covariances (Table E7), and indirect paths (Table E8).

Table E4

Father Model Sample Covariance Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Language (5yr)	301.84																
2. Father-child rel (3yr)	1.97	6.07															
3. Language (3yr)	179.02	2.60	373.81														
4. Cognitive (3yr)	66.86	2.80	118.22	202.46													
5. Motor (3yr)	1.51	0.26	2.93	2.30	0.73												
6. Social-personal (3yr)	10.71	2.03	14.11	10.17	0.46	21.20											
7. Father stress (9mo)	-5.23	-2.89	-2.40	-3.09	-0.24	-3.67	39.40										
8. Father depress (9mo)	0.70	-0.64	0.49	-1.41	0.02	-1.30	4.63	5.57									
9. Fussy-difficult (9mo)	-2.44	-1.00	-3.63	-3.67	-0.08	-5.72	4.85	1.46	24.29								
10. Father-child rel (9mo)	0.08	0.69	0.59	0.44	0.01	0.33	-3.39	-0.51	-0.80	2.08							
11. Language (9mo)	7.19	1.89	19.48	6.15	0.87	3.13	-2.75	-0.11	-3.49	1.14	129.49						
12. Cognitive (9mo)	15.25	2.24	24.18	12.86	1.10	4.41	-1.67	-0.29	-3.10	0.42	45.21	174.41					
13. Motor (9mo)	4.87	2.33	27.29	30.91	2.04	5.21	5.11	0.91	1.11	-0.25	78.09	104.22	483.13				
14. Social-personal (9mo)	18.02	1.54	29.29	17.94	1.07	4.56	-2.67	0.48	-2.08	0.43	45.10	50.03	87.29	141.66			
15. Birth Status	-0.54	0.24	-1.40	-1.18	-0.06	-0.28	0.39	0.09	0.09	0.06	-2.93	-2.43	-6.39	-2.45	1.00		
16. Income	381.80	-4.30	464.73	247.10	3.40	110.27	-53.65	-14.69	-53.29	-8.38	-193.15	47.15	24.20	70.64	-16.27	17627.50	
17. Child sex	-0.41	-0.06	-1.18	-0.75	-0.07	-0.19	0.08	-0.02	0.06	-0.01	-0.43	-0.20	-0.01	-0.26	0.01	2.48	0.25

Note. Covariance matrix computed with pairwise deletion. Language = Language ability; yr = year; rel = relationship; Cognitive = Cognitive ability; Motor = Motor ability; Social-personal = Social-personal ability; mo = months; depress = depression; Fussy-difficult = Fussy-difficult temperament.

Table E5

Father Model Means

	M
Language ability (5-years)	111.33
Father-child relationship (3-years)	32.96
Language ability (3-years)	74.79
Cognitive ability (3-years)	60.34
Motor ability (3-years)	3.25
Social-personal ability (3-years)	32.03
Father stress (9-months)	30.69
Father depression (9-months)	1.27
Fussy-difficult temperament (9-months)	14.79
Father-child relationship (9-months)	24.13
Language ability (9-months)	44.64
Cognitive ability (9-months)	46.05
Motor ability (9-months)	83.82
Social-personal ability (9-months)	43.71
Income	216.07

Table E6

Father Model: Regression Paths

Regression paths			ß	*SE*	*z*	*p*	Bootstrapped 95% CI lower	Bootstrapped 95% CI upper
Birth status	→	Language (5yr)	0.011	0.39	0.50	.617	-0.581	0.924
Father-child rel (3yr)	→	Language (5yr)	0.011	0.11	0.69	.493	-0.127	0.300
Language (3yr)	→	Language (5yr)	0.490	0.02	23.29	.000	0.392	0.472
Cognitive (3yr)	→	Language (5yr)	0.053	0.02	3.20	.001	0.025	0.106
Motor (3yr)	→	Language (5yr)	-0.005	0.27	-0.38	.702	-0.624	0.444
Social-personal (3yr)	→	Language (5yr)	0.047	0.05	3.90	.000	0.093	0.271
Income	→	Language (5yr)	0.079	0.00	2.50	.013	0.004	0.018
Father stress (9mo)	→	Father-child rel (3yr)	-0.106	0.01	-5.13	.000	-0.060	-0.027
Father depress (9mo)	→	Father-child rel (3yr)	-0.049	0.03	-1.57	.116	-0.099	0.024
Fussy-difficult (9mo)	→	Father-child rel (3yr)	-0.046	0.01	-2.59	.010	-0.043	-0.007
Father-child rel (9mo)	→	Father-child rel (3yr)	0.149	0.04	6.87	.000	0.172	0.319
Birth status	→	Language (3yr)	0.008	0.62	0.25	.803	-0.816	1.640
Father-child rel (9mo)	→	Language (3yr)	0.020	0.22	1.20	.228	-0.144	0.690
Language (9mo)	→	Language (3yr)	0.066	0.03	3.52	.000	0.073	0.196
Cognitive (9mo)	→	Language (3yr)	0.050	0.02	3.05	.002	0.022	0.116
Motor (9mo)	→	Language (3yr)	-0.028	0.01	-1.66	.098	-0.056	0.002
Social-personal (9mo)	→	Language (3yr)	0.096	0.03	5.89	.000	0.099	0.202

Regression paths			ß	*SE*	*z*	*p*	Bootstrapped 95% CI	
							lower	upper
Income	→	Language (3yr)	0.191	0.00	9.24	.000	0.028	0.042
Child sex	→	Language (3yr)	-0.119	0.51	-9.12	.000	-5.670	-3.758
Cognitive (9mo)	→	Cognitive (3yr)	0.131	0.02	7.06	.000	0.104	0.183
Motor (9mo)	→	Motor (3yr)	0.160	0.00	9.27	.000	0.005	0.008
Social-personal (9mo)	→	Social-personal (3yr)	0.131	0.01	7.00	.000	0.038	0.067
Birth status	→	Father stress (9mo)	0.078	0.18	2.81	.005	0.144	0.865
Income	→	Father stress (9mo)	-0.047	0.00	-2.69	.007	-0.004	-0.000
Birth status	→	Father depress (9mo)	0.016	0.11	0.35	.726	-0.119	0.198
Income	→	Father depress (9mo)	-0.034	0.00	-1.21	.226	-0.002	0.000
Birth status	→	Fussy-difficult (9mo)	0.118	0.12	4.77	.000	0.360	0.837
Birth status	→	Father-child rel (9mo)	0.029	0.04	0.94	.345	-0.045	0.130
Income	→	Father-child rel (9mo)	-0.042	0.00	-2.32	.020	-0.001	-0.000
Birth status	→	Language (9mo)	-0.289	0.29	-11.28	.000	-3.971	-2.855
Income	→	Language (9mo)	-0.177	0.00	-9.25	.000	-0.018	-0.012
Child sex	→	Language (9mo)	-0.043	0.27	-3.63	.000	-1.458	-0.395
Birth status	→	Cognitive (9mo)	-0.213	0.3	-9.32	.000	-3.512	-2.323
Birth status	→	Motor (9mo)	-0.249	0.64	-8.45	.000	-6.849	-4.296
Birth status	→	Social-personal (9mo)	-0.250	0.31	-9.50	.000	-3.700	-2.496
Income	→	Birth status	-0.183	0.00	-5.55	.000	-0.002	-0.001
Child sex	→	Birth status	0.098	0.05	4.21	.000	0.102	0.284

Note. mo = months; yr = years; rel = relationship; Language = Language ability; Cognitive = Cognitive ability; Motor = Motor ability; Social-personal = Social-personal ability; Income = Equivalised household income (rescaled).

Table E7

Father Model: Covariances

Covariances			ß	*SE*	*z*	*p*	Bootstrapped 95% CI	
							lower	upper
Father stress (9mo)	~~	Father-child rel (9mo)	-0.382	0.17	-20.05	.000	-3.763	-3.087
Father depress (9mo)	~~	Father-child rel (9mo)	-0.152	0.11	-4.65	.000	-0.819	-0.392
Fussy-difficult (9mo)	~~	Father-child rel (9mo)	-0.117	0.12	-7.00	.000	-1.055	-0.595
Father-child rel (9mo)	~~	Language (9mo)	0.085	0.24	5.49	.000	0.856	1.806
Father-child rel (9mo)	~~	Cognitive (9mo)	0.044	0.3	2.65	.008	0.242	1.440
Father-child rel (9mo)	~~	Social-personal (9mo)	0.049	0.26	3.13	.002	0.273	1.310
Language (9mo)	~~	Cognitive (9mo)	0.265	2.49	14.66	.000	30.921	40.615
Language (9mo)	~~	Motor (9mo)	0.279	3.98	15.88	.000	54.816	70.015
Language (9mo)	~~	Social-personal (9mo)	0.294	2.00	18.15	.000	31.734	39.684
Cognitive (9mo)	~~	Motor (9mo)	0.344	5.11	18.10	.000	81.904	102.063
cognitive (9mo)	~~	Social-personal (9mo)	0.295	2.65	16.28	.000	37.733	48.420
Motor (9mo)	~~	Social-personal (9mo)	0.304	4.36	16.79	.000	63.941	81.138
Father stress (9mo)	~~	Fussy-difficult (9mo)	0.148	0.51	8.92	.000	3.551	5.529
Father depress (9mo)	~~	Fussy-difficult (9mo)	0.123	0.29	4.92	.000	0.645	1.799
Father stress (9mo)	~~	Father depress (9mo)	0.311	0.54	8.48	.000	3.106	5.256
Father-child rel (3yr)	~~	Language (3yr)	0.049	0.84	2.61	.009	0.485	3.908
Language (3yr)	~~	Cognitive (3yr)	0.436	4.42	25.91	.000	105.680	123.527

Covariances							Bootstrapped 95% CI	
			ß	*SE*	*z*	*p*	lower	upper
Language (3yr)	~~	Motor (3yr)	0.179	0.25	11.13	.000	2.329	3.334
Language (3yr)	~~	Social-personal (3yr)	0.147	1.24	10.08	.000	10.196	15.015
Cognitive (3yr)	~~	Motor (3yr)	0.186	0.20	10.99	.000	1.812	2.598
Cognitive (3yr)	~~	Social-personal (3yr)	0.152	0.97	10.05	.000	8.048	11.711
Motor (3yr)	~~	Social-personal (3yr)	0.113	0.06	7.15	.000	0.325	0.562
Father-child rel (3yr)	~~	Cognitive (3yr)	0.082	0.62	4.47	.000	1.553	3.960
Father-child rel (3yr)	~~	Motor (3yr)	0.127	0.04	6.50	.000	0.181	0.339
Father-child rel (3yr)	~~	Social-personal (3yr)	0.184	0.22	9.09	.000	1.610	2.486
Income	~~	Child sex	0.038	0.94	2.69	.007	0.626	4.298

Note. mo = months; yr = years; rel = relationship; depress = depression; Fussy-difficult = Fussy-difficult temperament; Language = Language ability; Cognitive = Cognitive ability; Social-personal = Social-personal ability; Motor = Motor ability; Income = Equivalised household income (rescaled).

Table E8

Father Model: Indirect Effects

Indirect effects					Bootstrapped 95% CI	
	ß	*SE*	*z*	*p*	lower	upper
BS ⟶ Father stress (9mo) ⟶ Father-child rel (3yr) ⟶ Language (5yr)	-0.000	0.00	-0.54	.588	-0.008	0.003
BS ⟶ Father depress (9mo) ⟶ Father-child rel (3yr) ⟶ Language (5yr)	-0.000	0.00	-0.21	.831	-0.002	0.001
BS ⟶ Fussy-difficult (9mo) ⟶ Father-child rel (3yr) ⟶ Language (5yr)	-0.000	0.00	-0.57	.571	-0.006	0.002
BS ⟶ Father-child rel (9mo) ⟶ Language (3yr)	0.001	0.02	0.58	.560	-0.016	0.062
BS ⟶ Cognitive (9mo) ⟶ Language (3yr)	-0.011	0.08	-2.73	.006	-0.355	-0.060
BS ⟶ Motor (9mo) ⟶ Language (3yr)	0.007	0.09	1.56	.120	-0.014	0.317
BS ⟶ Social-personal (9mo) ⟶ Language (3yr)	-0.024	0.10	-4.79	.000	-0.661	-0.288
BS ⟶ Father stress (9mo) ⟶ Father-child rel (3yr)	-0.008	0.01	-2.19	.029	-0.041	-0.006
BS ⟶ Father depress (9mo) ⟶ Father-child rel (3yr)	-0.001	0.01	-0.29	.769	-0.014	0.005
BS ⟶ Fussy-difficult (9mo) ⟶ Father-child rel (3yr)	-0.005	0.01	-2.06	.039	-0.029	-0.004

Note. BS = Birth status; mo = months; yr = years; rel = relationship; Language = Language ability; depress = depression; Fussy-difficult = Fussy-difficult temperament; Cognitive = Cognitive ability; Motor = Motor ability; Social-personal = Social-personal ability.

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Appendix F

Distributional Characteristics (Skewness, Kurtosis, and Anderson-Darling Test for Normality) of Continuous Path Model Variables

Table F1

Distributional Characteristics of (Continuous) Path Model Variables

	Preterm							Term-born						
	N	*M*	*SD*	*Mdn*	Skew	Kurtosis	*p*	*N*	*M*	*SD*	*Mdn*	Skew	Kurtosis	*p*
Wave 1														
Income (rescaled)	499	197.21	112.97	179.52	1.34	3.2	< .001	7573	223.37	135.62	201.01	2.92	24.49	< .001
Mother stress	530	32.59	7.28	32	0.44	0.01	< .001	8097	31.86	6.71	31	0.45	0.39	< .001
Father stress	419	31.49	6.77	31	0.38	0.26	.002	6537	30.8	6.24	30	0.41	0.15	< .001
Mother depression	524	2.81	3.96	1	2.13	5.08	< .001	8052	2.32	3.47	1	2.58	8.43	< .001
Father depression	414	1.6	2.85	1	3.65	17.63	< .001	6464	1.3	2.39	0	4.05	25.03	< .001
Fussy-difficult	534	15	5.09	14	0.7	0.74	< .001	8131	14.74	4.86	14	0.68	0.71	< .001
Mother-child rel	534	42.52	2.76	43.6	-1.56	2.85	< .001	8129	42.55	2.59	43.6	-1.52	4.86	< .001
Father-child rel	420	24.2	1.44	25	-3.04	15.34	< .001	6557	24.09	1.46	25	-1.96	4.68	< .001
Language ability	531	38.61	14.81	40	-0.72	0.05	< .001	8101	44.8	10.97	45	-0.68	0.55	< .001
Cognitive ability	510	40.37	15.9	45	-0.9	0.03	< .001	7685	46.5	12.79	50	-1.27	1.68	< .001
Motor ability	522	71.21	24.84	70	-0.44	0.26	< .001	7892	85.56	21.5	85	-0.29	-0.13	< .001
Social-personal ability	525	38.53	14.42	40	-0.67	0.09	< .001	8051	44.03	11.6	45	-0.81	0.67	< .001
Wave 2														
Mother-child rel	532	33.74	2.23	35	-3.26	15.49	< .001	8133	33.83	1.9	35	-2.94	14.83	< .001
Father-child rel	407	33.23	2.28	34	-2.76	13.21	< .001	6428	32.94	2.51	34	-2.41	11.56	< .001
Language ability	497	72.36	19.58	74	-0.45	0.28	< .001	7703	75.27	19.59	78	-0.44	0.79	< .001
Cognitive ability	513	58.06	14.45	59	-0.62	1.53	< .001	7983	61.05	14.19	62	-0.37	1.75	< .001
Motor ability	523	3.12	0.94	3	-1.3	1.9	< .001	8055	3.27	0.85	3	-1.35	2.21	< .001
Social-personal ability	534	31.5	4.9	32	-0.85	0.91	< .001	8146	32.35	4.47	33	-0.77	0.69	< .001

	Preterm							Term-born						
	N	*M*	*SD*	*Mdn*	Skew	Kurtosis	*p*	*N*	*M*	*SD*	*Mdn*	Skew	Kurtosis	*p*
							Wave 3							
Language ability	521	109.52	19.06	112	-0.64	1.88	< .001	8057	111.1	17.99	112	-0.46	1.68	< .001

Note. p-values correspond to the Anderson-Darling test for normality. Fussy-difficult = Fussy-difficult temperament; rel = relationship.

Appendix G

Preterm-Born Cohort: Ethical Approval Letter (School of Psychology Research Ethics Committee)

Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

F.A.O. Jean Quigley and Liz Nixon
Merve Attaman, Sarah Coughlan

Approval ID: SPREC0072021-01

School of Psychology Research Ethics Committee

16th July 2021

The School of Psychology Research Ethics Committee has reviewed your application entitled "PETIT: PrETerm Infant InTeraction and development", and I am pleased to inform you that it was approved.

Please note that you will be required to submit a completed **Project Annual Report Form** on each anniversary of this approval, until such time as an **End of Project Report Form is submitted** upon completion of the research. Copies of both forms are available for download from the Ethics section of the School website.

Please note that you must be familiar with and adhere to the attached 'Safety Protocol for Adults'.
Adverse events associated with the conduct of this research must be reported immediately to the Chair of the Ethics Committee.

Yours sincerely,

Richard Carson
Chair,
School of Psychology Research Ethics Committee

Scoil na Siceolaíochta
Dámh na nEolaíochtaí Sóisialta agus Daonna,
Áras an Phiarsaigh,
Coláiste na Tríonóide,
Baile Átha Cliath,
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Appendix H

Preterm-Born Cohort: Ethical Approval Letter (Coombe Women and Infants University Hospital)

Coombe Women & Infants University Hospital

Excellence in the Care of Women and Babies

Foirfeacht i gCuram Ban agus Naionan

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fax +353·1·453 6033
www.coombe.ie

Dr Elizabeth Nixon
Assistant Professor in Developmental Psychology
Trinity College Dublin
(enixon@tcd.ie)

22nd June 2021

Re: **Study No. 6 – 2020 – PETIT: Preterm Infant Interaction and Development – a Follow-up of the GENIE Study**

Dear Dr Nixon,

thanks for the final communication in relation to your study '**PETIT: Preterm Infant Interaction and Development – a Follow-up of the GENIE Study'.** Your study is now fully approved by the Research Ethics Committee in the Coombe Women and Infants University Hospital

Yours sincerely

Professor Jan Miletin (IMC 241348)
Consultant Neonatologist
Chairman of the Research Ethics Committee
Coombe Women and Infants University Hospital (jmiletin@coombe.ie)

Cc.: *Prof Eleanor Molloy (eleanor.molloy@tcd.ie), Chair and Professor of Paediatrics and Child Health, Trinity College Dublin*
Dr John Kelleher (jkelleher@coombe.ie), Consultant Neonatologist, Coombe Women and Infants University Hospital
Dr Jean Quigley (quigleyj@tcd.ie), Assistant Professor, Trinity College Dublin

Appendix I

Preterm-Born Cohort: Information Leaflet, Consent Form, and Debriefing Sheet (for Families Recruited from the Community)

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Infant and Child Research Lab
Trinity College Dublin

Participant Information Leaflet

PETIT Project: Preterm Infant Interaction and Development

You and your child are invited to join a research study to help understand the development of children who are born preterm or prematurely. Babies born pre-term and at full-term are being invited to participate. The study is being conducted by researchers at the School of Psychology and Medicine at Trinity College Dublin. Please read this information leaflet carefully and get in touch with us if you have any questions about participating in the research. The decision for yourself and your child to join, or not to join, is totally up to you.

Contact us at:
Merve Ataman or Sarah Coughlan infres@tcd.ie
Dr Elizabeth Nixon enixon@tcd.ie – 01 896 2867
Dr Jean Quigley quigleyj@tcd.ie- 01 896 2697

Site	Trinity College Dublin (TCD)
Principal Investigator(s) and Co-Investigator(s) (insert names, titles and contact details)	Dr. Elizabeth Nixon & Dr. Jean Quigley, Associate & Assistant Professor in Psychology, TCD. Prof. Eleanor Molloy, Professor of Pediatrics, School of Medicine, TCD. Merve Ataman and Sarah Coughlan, Postgraduate Students, TCD
Study Organiser/ Sponsor	Trinity College Dublin

Data Controllers	Trinity College Dublin
Data Protection Officer	Data Protection Officer Secretary's Office Trinity College Dublin, Dublin 2

This leaflet provides information on the research study and aims to answer any questions you may have

Part 1 – The Study

Who are we and what do we do?
We are a team of lecturers, researchers and psychology students at the School of Psychology, Trinity College Dublin. We do research in our Infant and Child Lab on child development and parenting.

What is the study about?
We are carrying out a study of families whose babies are born preterm. We want to investigate the effects of being born preterm on children's later development and on how parents interact with their babies. To do this, we are inviting families of babies born pre-term and full-term to participate. We have called the project the PETIT project. **Pre****t**erm **I**nfant In**t**eraction and Development. Trinity College Dublin has funded the project.

What is involved in the taking part in the study?
Your child will complete a standard developmental test (we measure children's language, thinking skills, and motor skills (by this we mean being able to crawl, walk, pick up objects, etc). Some of the tasks that we ask your child to do will be very easy for them and some will be very hard – this assessment will take approximately 90 minutes to complete but we make sure that you and your child get a lot of breaks so that your child does not get too tired.

We will also video-record you and your child playing with each other, as you ordinarily would at home. We will provide specific toys at certain times, and at other times you will be given a box of toys where you and your child can choose what to play with and how to play. In total, the developmental test and observation will last 3 hours. You will be present with your child at all times.

Before we invite you in for the assessment, we will send you a series of questionnaires that we will ask you to complete online. The questionnaires will include questions about yourself, your child, and your partner. These questions will ask about things including your stress levels, your mood, the quality of your relationship with your partner (if relevant), and your child's personality and behaviour.

We will want to follow-up with you and your child to see how things are progressing, after one year. We will re-contact you after the data collection to see if you would be interested in taking part in another assessment. However, just because you took part in one stage of the study does not means that you have to take part in a later stage – you can change your mind about taking part at any time.

We will also ask you to complete a screening questionnaire 24 hours prior to and on the morning of your visit to ensure you or your child are not experiencing any symptoms of COVID-19. We will also store your contact details for 28 days for the purpose of contact tracing and we require you to download the HSE contact tracing app. During the assessment you will be required to wear an FFP2 mask (which we will provide for you). Your child is not required to wear a face covering.

Are there any risks involved in taking part in the study?

No risk is foreseen for you and your child's participation in the study beyond those experienced in everyday life. The room in which we conduct the study is a child-friendly space. There is a risk your child may become tired and frustrated with some of the tasks – we can stop at any time and you can take breaks whenever you need. Some of the questionnaires may seek information that is personal and sensitive – you do not have to answer any questions that you do not wish to.

In light of the COVID-19 Pandemic, we have introduced a number of new measures to ensure the safety of you and your child throughout the study. We will send you questionnaires to complete online at home (rather than in our lab as we usually do), to reduce the amount of time you will be with us. We will require you to complete a COVID-19 questionnaire the day before and the day of your visit to our lab, and we will take the temperature of you and your child, upon arrival to the lab, using an infra-red thermometer. Our researchers will also have their temperatures checked. Our lab room and all of our materials and toys are thoroughly cleaned and sanitised in between families visiting us. Our researchers will maintain a two meter social distance between you and your child, for the majority of your visit, but where this is not possible, he/she will wear a face mask. Hands will be sanitised regularly throughout the process.

Do I have to take part?

You don't have to take part in this study. It is entirely voluntary – it is entirely your choice whether or not to participate. You can leave the study at any time without giving a reason and without consequence.

What if I change my mind about taking part?

To leave the study you just need to inform the researchers involved in the study, either while the study is taking place or after it has finished. Our contact information is included on this form. If you decide to leave the study, we will delete all information we store about you.

What will happen to the findings of the study?
All information which we collect will be treated in the strictest of confidence and will be stored safely and securely (see the next section for details on what we do with your data). The results arising from the study will be included in a thesis and will be used in publications and presentations. Names and other personally identifiable information will not be used in any outputs arising from the research.

Will I get feedback about the study?
When the study is completed, we will provide an update to participants on the results of the study, which will be in summary (average) form. If there is a sign of any developmental issues based on the assessment of your child, we will let parents know.

Will the research benefit me and my child?
You or your child will not benefit directly from taking part in this research project.

Part 2 – Data Protection

What information about me (personal data) will be used as part of this study?
For this study, we will gather personal information such as your name, your email address and phone number. We will also video-record you and your child interacting and playing with each other – this is classified as personal data because your and your child's voice and your face will be recorded. Before you come in for your appointment we will also ask you to complete questionnaires about yourself and your child, relating to things such as your stress levels, your mood, the quality of your relationship with your partner (if relevant), your child's personality and behaviour.

What will happen to my personal data?
We will use the personal information (names and contact details) to keep in touch with you about the study and to contact you regarding follow-up meetings. We will retain personal data and the video recordings for a period of seven years after collection. This ensures that we have enough time to analyse the very rich data that we have collected and can continue to use the data in our follow-up studies.

We will also keep your personal data (names, addresses, phone number) in hard copy for the purpose of contact tracing relating to COVID-19 for 28 days. We will store this information separately from all the other data and it will be destroyed after 28 days.

Who will access and use my personal data?
Only the members of the study team listed on the information sheet and TCD students who have been recruited to work under their supervision listed will have access to your personal data. Anybody who works with the data will be Garda Vetted and have undergone training in ethics and data protection. No personal information will ever be shared with individuals outside the institution of TCD.

Will my personal data be kept confidential? How will my data be kept safe?
Your privacy is very important to us. We take many steps to make sure that we protect your confidentiality and keep your data safe.

- Any information we collect from you is entirely confidential and is used only for the purpose of the research. A unique study ID code will be assigned to you and your study information will be gathered, stored, and accessed using this ID code only. Personal data (names, postal addresses, email address, phone numbers and video-recordings) will be stored separately in a password-protected and encrypted database. Only researchers who are part of this study team will have access to these data. Signed consent forms will be stored in a locked cabinet in a locked office.
- It is not possible for us to anonymise the data – we do not want to delete your names and contact details because we will want to be able to contact you about follow-up in the future (you are not obligated to take part in any follow-up, unless you want to). Also, it is not possible to anonymise the video-recordings of your data because your voice and face will be heard/seen.
- However, we will pseudo-anonymise the data – that is, we will separately store the file that links your unique study ID code with participant identity.
- Analyses will be conducted on aggregate or anonymised data – no information that could potentially identify you will be included in any reports or presentations.
- We will never share data with researchers at any institution other than TCD.
- Training in data protection law and practice has been provided to those individuals who are responsible for the research (Dr. Elizabeth Nixon and Dr. Jean Quigley).

Will the confidentiality of my data ever be breached or shared with a third party?
There are certain circumstances under which confidentiality may be breached. First, if you tell us something or behave in a way that indicates you or your child are at risk, we will need to let the appropriate services know (e.g., Tusla, the Gardaí). This is required by law. We will not do this without informing you first.

Another circumstance is where disclosure is required as part of a legal process or Garda investigation. In such instances, information may be disclosed to appropriate third parties without permission being sought. Where possible, a full explanation will be given to you regarding the necessary procedures and the actions that may need to be taken.

What is the lawful basis to use my personal data?
Under Articles 6 and 9 of the EU General Data Protection Regulation (GDPR) your personal data and your child's personal data will be processed for scientific research in the public interest. We also ask for your explicit consent to process your data and your child's personal data as a requirement of the Irish Health Research Regulations 2018.

What are my rights in relation to my data?
You are entitled to:

- Access to your data and receive a copy of it.
- Restrict or object to processing of your data.
- Object to any further processing of the information we hold about you (except where it is fully anonymised).
- To have inaccurate information about you corrected or deleted.
- Receive your data in a portable format and to have it transferred to another data controller.
- Request deletion of your data.

You can exercise these rights by contacting the study team or the Trinity College Data Protection Officer, Secretary's Office, Trinity College Dublin, Dublin 2, Ireland. Email: dataprotection@tcd.ie . Website: www.tcd.ie/privacy.

Part 3 – Costs, Funding and Approval

Has this study been approved by a research ethics committee?
This study has been approved by the School of Psychology Research Ethics Committee (SPREC) at Trinity College Dublin on 16th July 2021 and by the ethics committee of the Coombe Women and Infants University Hospital on 22nd June 2021.

Who is organising and funding this study? Will the results be used for commercial purposes?
The study is funded by Trinity College Dublin and is conducted by the team of researchers at Trinity College Dublin. The results will not be used for commercial purposes.

Will I be paid for taking part? Will it cost anything to take part?
There is no payment for participation in this study, nor are there any costs, aside from any costs incurred in travelling to Trinity College.

Part 4 – Future Research

Will my personal data be used in future studies?

No, not without your explicit consent. As stated above, the research we do involves tracking children and their families over time, so that we can understand how children's early circumstances influence how they get on at a later age. Thus, we may want to contact you in the future to see how your child is getting on. We will never use any of your data for future studies without contacting you and seeking your permission first.

Part 5 – Further Information

Who should I contact for information or complaints?

If you have any concerns or questions, you can contact:

- *Principal Investigators:* **Dr. Elizabeth Nixon,** School of Psychology, Trinity College, Dublin 2. Email: enixon@tcd.ie. Phone: 01 896 2867; **Dr. Jean Quigley,** School of Psychology, Trinity College, Dublin 2. Email: quigleyj@tcd.ie. Phone: 01 896 2697.
- *Data Protection Officer, Trinity College Dublin:* Data Protection Officer, Secretary's office, Trinity College Dublin, Dublin 2, Ireland. Email: dataprotection@tcd.ie. Website: www.tcd.ie/privacy

Under GDPR, if you are not satisfied with your how data is being processed, you have the right to lodge a complaint with the Office of the Data Protection Commission, 21 Fitzwilliam Square South, Dublin 2, Ireland. Website: www.dataprotection.ie

What should I do now?

Within a few days of receiving this information sheet, we will be in touch with you to discuss your potential participation. If you wish to contact us before then, you can email us at infres@tcd.ie or call the study Principal Investigators (Dr Elizabeth Nixon or Dr Jean Quigley) on 01 896 2867.

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Infant and Child Research Lab
Trinity College Dublin

Consent Form

PETIT Project: Preterm Infant Interaction and Development

Site	Trinity College Dublin
Principal Investigator and Co-Investigators	Dr. Elizabeth Nixon & Dr. Jean Quigley, *Associate & Assistant Professor in Psychology,* Trinity College Dublin Prof. Eleanor Molloy, *Professor of Pediatrics,* Trinity College Dublin Merve Ataman & Sarah Coughlan, *Postgraduate Students,* Trinity College Dublin
Data Controller	Trinity College Dublin
Data Protection Officer	Data Protection Officer Secretary's Office Trinity College Dublin Dublin 2

There are 4 sections in this form. Each section contains a number of statements. You are asked to write your initials in the box beside the statement if you agree. If you do not agree with a statement, please leave the box blank. The end of this form is for the researchers to complete.

If you have any questions, please don't hesitate to call or email the lead researchers – Elizabeth Nixon (01 8962867; enixon@tcd.ie) or Jean Quigley (01 896 2697; quigleyj@tcd.ie). Thank you for participating.

GENERAL	**Initials**
I confirm I have read and understood the **Information Leaflet** for the above-named study. I have been given the contact details of the lead researcher to ask questions. Where I had questions, they have all been answered to my satisfaction.	

I understand that participating in this study **is entirely voluntary, and if I decide that we do not want to take part, we can stop taking part in this study at any time without giving a reason**.	
I understand that we **will not be paid for taking part in this study** and that there will be no direct benefits to us from taking part in the study.	
I know how to **contact the research team** if I need to.	
I agree to take part in this study with my child having been fully informed of the **risks, benefits and alternatives** which are set out in full in the information leaflet with which **I have been provided.** This includes risk associated with the COVID-19 pandemic, including the transmission of the virus. However, every effort will be made to mitigate these risks, including temperature checking, physical distancing, FFP2 mask-wearing and hand-sanitising.	
I agree that I and my child can be **contacted by researchers by email and phone** as part of this research study.	
I agree to be video-recorded playing with my child.	

DATA PROCESSING	**Initials**
I give my permission for my own and my child's data, including video recordings, to be processed in line with the aims of the research study, as outlined in the information leaflet.	
I understand that I am entitled to access any data that is held about me or my child.	
I understand that **personal data will be collected and stored as part of this research project.** The consent forms, my contact data, the video-recordings, and the completed questionnaires/medical data (if applicable) will be stored separately from each other, and a unique study ID to which only the lead researchers have access will be used to link the different pieces of data.	
I understand that the personal information collected in the study will be kept **strictly confidentia**l and will only be made available to researchers who are part of the study team and **used only for the purpose of research approved by a Research Ethics Committee**.	
I understand that **confidentiality may be breached in circumstances in which**: 1. The research team has a strong belief or evidence exists that there is a serious risk of harm or danger to either the participant or another individual. This may relate to issues surrounding physical, emotional and/or sexual	

abuse, concerns for child protection, rape, self-harm, suicidal intent or criminal activity. 2. Disclosure is required as part of a legal process or Garda investigation. In such instances, information may be disclosed to significant others or appropriate third parties without permission being sought. Where possible, a full explanation will be given to the participant regarding the necessary procedures and also the intended actions that may need to be taken.	
I understand that **I can withdraw my permission for me/my child to take part in this study** at any time without giving a reason. I understand that in this case, the researchers will delete all information related to us and we will be removed from the study.	

RETENTION OF INFORMATION	
I understand that my data may be retained by the study team for seven years.	
I understand we may be contacted within the seven years about follow-up stages of the research.	

SHARING OF INFORMATION	
Data will not be shared with researchers outside of the study team. The data will only be used for research projects related to the goals of this study.	

Child Name (Block Capitals)

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Parent/Guardian Name (Block Capitals)   Parent/Guardian Signature   Date

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Lead Researcher Name (Block Capitals)   Lead Researcher Signature   Date

To be completed by the Principal Investigator or nominee and retained by parent/guardian

I, the undersigned, have taken the time to fully explain to the above participant the nature and purpose of this study in a way that they could understand. I have explained the risks and possible benefits involved. I have invited them to ask questions on any aspect of the study that concerned them.
I have given a copy of the information leaflet and consent form to the participant with contacts of the study team.

Researcher name:

Title and qualifications:

Signature:

Date:

Tel: 01 8962867

Email: infres@tcd.ie

This sheet to be retained by guardian/parent of participant

PETIT PROJECT: **Pre**term **I**nfant In**t**eraction and Development

Debriefing Form

Thank you for your help!

Many thanks for giving us your time to participate in our study. Remember that the information which you have shared with us is **confidential** will be used **only for the purpose of the research.**

Any identifying details will be changed to protect your anonymity.

If the lab visit has raised any issues which have been upsetting or distressing for you, we recommend that you get in touch with your GP or your local health centre.

Also, please find below the contact details of some relevant organisations which you may find useful.

Barnardos
CallSave 1850 222300 email info@barnardos.ie www.barnardos.ie

Parentline: Helpline for parents under stress
LoCall 1890 927277 email info@parentline.ie www.parentline.ie

If you require further information about the research or want to contact the research team, our details are:

Dr Jean Quigley quigleyj@tcd.ie 01 896 2697
Dr Elizabeth Nixon enixon@tcd.ie 01 896 2867
School of Psychology, Áras an Phiarsaigh, Trinity College, Dublin 2

Appendix J

Preterm-Born Cohort: Information Leaflet, Consent Form, and Debriefing Sheet (for Families Recruited from the Medical Study)

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Infant and Child Research Lab
Trinity College Dublin

Participant Information Leaflet

PETIT Project: Preterm Infant Interaction and Development

You and your child are invited to join a research study to help understand the development of children who are born preterm or prematurely. Babies born pre-term and at full-term are being invited to participate. The study is being conducted by researchers at the School of Psychology and Medicine at Trinity College Dublin. Please read this information leaflet carefully and get in touch with us if you have any questions about participating in the research. The decision for yourself and your child to join, or not to join, is totally up to you.

Contact us at:
Merve Ataman or Sarah Coughlan infres@tcd.ie
Dr Elizabeth Nixon enixon@tcd.ie – 01 896 2867
Dr Jean Quigley quigleyj@tcd.ie- 01 896 2697

Site	Trinity College Dublin (TCD)
Principal Investigator(s) and Co-Investigator(s) (insert names, titles and contact details)	Dr. Elizabeth Nixon & Dr. Jean Quigley, Associate & Assistant Professor in Psychology, TCD. Prof. Eleanor Molloy, Professor of Pediatrics, School of Medicine, TCD. Merve Ataman and Sarah Coughlan, Postgraduate Students, TCD
Study Organiser/ Sponsor	Trinity College Dublin

Data Controllers	Trinity College Dublin
Data Protection Officer	Data Protection Officer Secretary's Office Trinity College Dublin, Dublin 2

This leaflet provides information on the research study and aims to answer any questions you may have

Part 1 – The Study

Who are we and what do we do?

We are a team of lecturers, researchers and psychology students at the School of Psychology, Trinity College Dublin. We do research in our Infant and Child Lab on child development and parenting.

What is the study about?

We are carrying out a study of families whose babies are born preterm. We want to investigate the effects of being born preterm on children's later development and on how parents interact with their babies. To do this, we are inviting families of babies born pre-term and full-term to participate. We have called the project the PETIT project. **Pret**erm **I**nfant In**t**eraction and Development. Trinity College Dublin has funded the project.

What is involved in the taking part in the study?

Your child will complete a standard developmental test (we measure children's language, thinking skills, and motor skills (by this we mean being able to crawl, walk, pick up objects, etc). Some of the tasks that we ask your child to do will be very easy for them and some will be very hard – this assessment will take approximately 90 minutes to complete but we make sure that you and your child get a lot of breaks so that your child does not get too tired.

We will also video-record you and your child playing with each other, as you ordinarily would at home. We will provide specific toys at certain times, and at other times you will be given a box of toys where you and your child can choose what to play with and how to play. In total, the developmental test and observation will last 1.5 to 2 hours. You will be present with your child at all times.

Before we invite you in for the assessment, we will send you a series of questionnaires that we will ask you to complete online. The questionnaires will include questions about yourself, your child, and your partner. These questions will ask about things including your stress levels, your mood, the quality of your relationship with your partner (if relevant), and your child's personality and behaviour.

We will want to follow-up with you and your child to see how things are progressing, after one year. We will re-contact you after the data collection to see if you would be interested in taking part in another assessment. However, just because you took part in one stage of the study does not means that you have to take part in a later stage – you can change your mind about taking part at any time. We will also ask permission to access medical records held on your child including data collected as part of the GENIE study (in which you have been previously involved).

We will also ask you to complete a screening questionnaire 24 hours prior to and on the morning of your visit to ensure you or your child are not experiencing any symptoms of COVID-19. We will also store your contact details for 28 days for the purpose of contact tracing and we require you to download the HSE contact tracing app. During the assessment you will be required to wear an FFP2 mask (which we will provide for you). Your child is not required to wear a face covering.

Are there any risks involved in taking part in the study?

No risk is foreseen for you and your child's participation in the study beyond those experienced in everyday life. The room in which we conduct the study is a child-friendly space. There is a risk your child may become tired and frustrated with some of the tasks – we can stop at any time and you can take breaks whenever you need. Some of the questionnaires may seek information that is personal and sensitive – you do not have to answer any questions that you do not wish to.

In light of the COVID-19 Pandemic, we have introduced a number of new measures to ensure the safety of you and your child throughout the study. We will send you questionnaires to complete online at home (rather than in our lab as we usually do), to reduce the amount of time you will be with us. We will require you to complete a COVID-19 questionnaire the day before and the day of your visit to our lab, and we will take the temperature of you and your child, upon arrival to the lab, using an infra-red thermometer. Our researchers will also have their temperatures checked. Our lab room and all of our materials and toys are thoroughly cleaned and sanitised in between families visiting us. Our researchers will maintain a two meter social distance between you and your child, for the majority of your visit, but where this is not possible, he/she will wear a face mask. Hands will be sanitised regularly throughout the process.

Do I have to take part?

You don't have to take part in this study. It is entirely voluntary – it is entirely your choice whether or not to participate. You can leave the study at any time without giving a reason and without consequence.

<u>What if I change my mind about taking part?</u>

To leave the study you just need to inform the researchers involved in the study, either while the study is taking place or after it has finished. Our contact information is included on this form. If you decide to leave the study, we will delete all information we store about you.

<u>What will happen to the findings of the study?</u>

All information which we collect will be treated in the strictest of confidence and will be stored safely and securely (see the next section for details on what we do with your data). The results arising from the study will be included in a thesis and will be used in publications and presentations. Names and other personally identifiable information will not be used in any outputs arising from the research.

<u>Will I get feedback about the study?</u>

When the study is completed, we will provide an update to participants on the results of the study, which will be in summary (average) form. If there is a sign of any developmental issues based on the assessment of your child, we will let parents know.

<u>Will the research benefit me and my child?</u>

You or your child will not benefit directly from taking part in this research project.

Part 2 – Data Protection

<u>What information about me (personal data) will be used as part of this study?</u>

For this study, we will gather personal information such as your name, your email address and phone number. We will also video-record you and your child interacting and playing with each other – this is classified as personal data because your and your child's voice and your face will be recorded. Before you come in for your appointment we will also ask you to complete questionnaires about yourself and your child, relating to things such as your stress levels, your mood, the quality of your relationship with your partner (if relevant), your child's personality and behaviour.

<u>What will happen to my personal data?</u>

We will use the personal information (names and contact details) to keep in touch with you about the study and to contact you regarding follow-up meetings. We will retain personal data and the video recordings for a period of seven years after collection. This ensures that we have enough time to analyse the very rich data that we have collected and can continue to use the data in our follow-up studies.

We will also keep your personal data (names, addresses, phone number) in hard copy for the purpose of contact tracing relating to COVID-19 for 28 days. We will store this information separately from all the other data and it will be destroyed after 28 days.

Who will access and use my personal data?

Only the members of the study team listed on the information sheet and TCD students who have been recruited to work under their supervision listed will have access to your personal data. Anybody who works with the data will be Garda Vetted and have undergone training in ethics and data protection. No personal information will ever be shared with individuals outside the institution of TCD.

Will my personal data be kept confidential? How will my data be kept safe?

Your privacy is very important to us. We take many steps to make sure that we protect your confidentiality and keep your data safe.

- Any information we collect from you is entirely confidential and is used only for the purpose of the research. A unique study ID code will be assigned to you and your study information will be gathered, stored, and accessed using this ID code only. Personal data (names, postal addresses, email address, phone numbers and video-recordings) will be stored separately in a password-protected and encrypted database. Only researchers who are part of this study team will have access to these data. Signed consent forms will be stored in a locked cabinet in a locked office.
- It is not possible for us to anonymise the data – we do not want to delete your names and contact details because we will want to be able to contact you about follow-up in the future (you are not obligated to take part in any follow-up, unless you want to). Also, it is not possible to anonymise the video-recordings of your data because your voice and face will be heard/seen.
- However, we will pseudo-anonymise the data – that is, we will separately store the file that links your unique study ID code with participant identity.
- Analyses will be conducted on aggregate or anonymised data – no information that could potentially identify you will be included in any reports or presentations.
- We will never share data with researchers at any institution other than TCD.
- Training in data protection law and practice has been provided to those individuals who are responsible for the research (Dr. Elizabeth Nixon and Dr. Jean Quigley).

Will the confidentiality of my data ever be breached or shared with a third party?

There are certain circumstances under which confidentiality may be breached. First, if you tell us something or behave in a way that indicates you or your child are at risk, we will need to let the appropriate services know (e.g., Tusla, the Gardaí). This is required by law. We will not do this without informing you first.

Another circumstance is where disclosure is required as part of a legal process or Garda investigation. In such instances, information may be disclosed to appropriate third parties without permission being sought. Where possible, a full explanation will be given to you regarding the necessary procedures and the actions that may need to be taken.

What is the lawful basis to use my personal data?

Under Articles 6 and 9 of the EU General Data Protection Regulation (GDPR) your personal data and your child's personal data will be processed for scientific research in the public interest. We also ask for your explicit consent to process your data and your child's personal data as a requirement of the Irish Health Research Regulations 2018.

What are my rights in relation to my data?

You are entitled to:

- Access to your data and receive a copy of it.
- Restrict or object to processing of your data.
- Object to any further processing of the information we hold about you (except where it is fully anonymised).
- To have inaccurate information about you corrected or deleted.
- Receive your data in a portable format and to have it transferred to another data controller.
- Request deletion of your data.

You can exercise these rights by contacting the study team or the Trinity College Data Protection Officer, Secretary's Office, Trinity College Dublin, Dublin 2, Ireland. Email: dataprotection@tcd.ie . Website: www.tcd.ie/privacy.

Part 3 – Costs, Funding and Approval

Has this study been approved by a research ethics committee?

This study has been approved by the School of Psychology Research Ethics Committee (SPREC) at Trinity College Dublin on 16 July 2021 and by the ethics committee of the Coombe Women and Infants University Hospital on 22nd June 2021.

Who is organising and funding this study? Will the results be used for commercial purposes?

The study is funded by Trinity College Dublin and is conducted by the team of researchers at Trinity College Dublin. The results will not be used for commercial purposes.

Will I be paid for taking part? Will it cost anything to take part?

There is no payment for participation in this study, nor are there any costs, aside from any costs incurred in travelling to Trinity College.

Part 4 – Future Research

Will my personal data be used in future studies?

No, not without your explicit consent. As stated above, the research we do involves tracking children and their families over time, so that we can understand how children's early circumstances influence how they get on at a later age. Thus, we may want to contact you in the future to see how your child is getting on. We will never use any of your data for future studies without contacting you and seeking your permission first.

Part 5 – Further Information

Who should I contact for information or complaints?

If you have any concerns or questions, you can contact:

- *Principal Investigators:* **Dr. Elizabeth Nixon,** School of Psychology, Trinity College, Dublin 2. Email: enixon@tcd.ie. Phone: 01 896 2867; **Dr. Jean Quigley,** School of Psychology, Trinity College, Dublin 2. Email: quigleyj@tcd.ie. Phone: 01 896 2697.
- *Data Protection Officer, Trinity College Dublin:* Data Protection Officer, Secretary's office, Trinity College Dublin, Dublin 2, Ireland. Email: dataprotection@tcd.ie. Website: www.tcd.ie/privacy

Under GDPR, if you are not satisfied with your how data is being processed, you have the right to lodge a complaint with the Office of the Data Protection Commission, 21 Fitzwilliam Square South, Dublin 2, Ireland. Website: www.dataprotection.ie

What should I do now?

Within a few days of receiving this information sheet, we will be in touch with you to discuss your potential participation. If you wish to contact us before then, you can email us at infres@tcd.ie or call the study Principal Investigators (Dr Elizabeth Nixon or Dr Jean Quigley) on 01 896 2867

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Infant and Child Research Lab
Trinity College Dublin

Consent Form

PETIT Project: Preterm Infant Interaction and Development

Site	Trinity College Dublin
Principal Investigator and Co-Investigators	Dr. Elizabeth Nixon & Dr. Jean Quigley, *Associate & Assistant Professor in Psychology,* Trinity College Dublin Prof. Eleanor Molloy, *Professor of Pediatrics,* Trinity College Dublin Merve Ataman & Sarah Coughlan, *Postgraduate Students,* Trinity College Dublin
Data Controller	Trinity College Dublin
Data Protection Officer	Data Protection Officer Secretary's Office Trinity College Dublin Dublin 2

There are 4 sections in this form. Each section contains a number of statements. You are asked to write your initials in the box beside the statement if you agree. If you do not agree with a statement, please leave the box blank. The end of this form is for the researchers to complete.

If you have <u>any</u> questions, please don't hesitate to call or email the lead researchers – Elizabeth Nixon (01 896 2867; enixon@tcd.ie) or Jean Quigley (01 896 2697; quigleyj@tcd.ie). Thank you for participating.

GENERAL	**Initials**
I confirm I have read and understood the **Information Leaflet** for the above-named study. I have been given the contact details of the lead researcher to ask questions. Where I had questions, they have all been answered to my satisfaction.	
I understand that participating in this study **is entirely voluntary, and if I decide that we do not want to take part, we can stop taking part in this study at any time without giving a reason**.	

I understand that we **will not be paid for taking part in this study** and that there will be no direct benefits to us from taking part in the study.	
I know how to **contact the research team** if I need to.	
I agree to take part in this study with my child having been fully informed of the **risks, benefits and alternatives** which are set out in full in the information leaflet with which I have been provided. This includes risk associated with the COVID-19 pandemic, including the transmission of the virus. However, every effort will be made to mitigate these risks, including temperature checking, physical distancing, FFP2 mask-wearing and hand-sanitising.	
I agree that I and my child can be **contacted by researchers by email and phone** as part of this research study.	
I agree to be video-recorded playing with my child.	

DATA PROCESSING	**Initials**
I give my permission for my own and my child's data, including video recordings, to be processed in line with the aims of the research study, as outlined in the information leaflet. I agree that the researchers may be granted access to the medical files held about my child and the data collected as part of the GENIE study.	
I understand that I am entitled to access any data that is held about me or my child.	
I understand that **personal data will be collected and stored as part of this research project.** The consent forms, my contact data, the video-recordings, and the completed questionnaires/medical data (if applicable), including data collected as part of the GENIE study, will be stored separately from each other, and a unique study ID to which only the lead researchers have access will be used to link the different pieces of data.	
I understand that the personal information collected in the study will be kept **strictly confidentia**l and will only be made available to researchers who are part of the study team and **used only for the purpose of research approved by a Research Ethics Committee**.	
I understand that **confidentiality may be breached in circumstances in which**: 3. The research team has a strong belief or evidence exists that there is a serious risk of harm or danger to either the participant or another individual. This may relate to issues surrounding physical, emotional and/or sexual abuse, concerns for child protection, rape, self-harm, suicidal intent or criminal activity. 4. Disclosure is required as part of a legal process or Garda investigation. In such instances, information may be disclosed to significant others or appropriate third parties without permission being sought. Where possible, a full explanation will be given to the participant regarding the necessary procedures and also the intended actions that may need to be taken.	

I understand that **I can withdraw my permission for me/my child to take part in this study** at any time without giving a reason. I understand that in this case, the researchers will delete all information related to us and we will be removed from the study.	

RETENTION OF INFORMATION	
I understand that my data may be retained by the study team for seven years.	
I understand we may be contacted within the seven years about follow-up stages of the research.	

SHARING OF INFORMATION	
Data will not be shared with researchers outside of the study team. The data will only be used for research projects related to the goals of this study.	

Child Name (Block Capitals)

--- --- ----------------------------
Parent/Guardian Name (Block Capitals) Parent/Guardian Signature Date

--- -- ----------------------------
Lead Researcher Name (Block Capitals) Lead Researcher Signature Date

To be completed by the Principal Investigator or nominee and retained by parent/guardian

I, the undersigned, have taken the time to fully explain to the above participant the nature and purpose of this study in a way that they could understand. I have explained the risks and possible benefits involved. I have invited them to ask questions on any aspect of the study that concerned them.
I have given a copy of the information leaflet and consent form to the participant with contacts of the study team.

Researcher name:

Title and qualifications:

Signature:

Date:

Tel: 01 8962867

Email: infres@tcd.ie

This sheet to be retained by guardian/parent of participant

Infant and Child Research Lab
Trinity College Dublin

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

PETIT PROJECT: **Pret**erm **I**nfant In**t**eraction and Development

Debriefing Form

Thank you for your help!

Many thanks for giving us your time to participate in our study. Remember that the information which you have shared with us is **confidential** will be used **only for the purpose of the research.**

Any identifying details will be changed to protect your anonymity.

If the lab visit has raised any issues which have been upsetting or distressing for you, we recommend that you get in touch with your GP or your local health centre.

Also, please find below the contact details of some relevant organisations which you may find useful.

Barnardos
CallSave 1850 222300 email info@barnardos.ie www.barnardos.ie

Parentline: Helpline for parents under stress
LoCall 1890 927277 email info@parentline.ie www.parentline.ie

If you require further information about the research or want to contact the research team, our details are:

Dr Jean Quigley quigleyj@tcd.ie 01 896 2697
Dr Elizabeth Nixon enixon@tcd.ie 01 896 2867
School of Psychology, Áras an Phiarsaigh, Trinity College, Dublin 2

Appendix K

Typically Developing Cohort: Ethical Approval Letter (School of Psychology Research Ethics Committee)

COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH | TRINITY COLLEGE DUBLIN
Ollscoil Átha Cliath | The University of Dublin

F.A.O. Dr Jean Quigley and Dr Elizabeth Nixon

School of Psychology Research Ethics Committee

17th September 2014

The School of Psychology Research Ethics Committee has reviewed your application entitled "Parent-child interaction and child development outcomes", and I am pleased to inform you that it was approved.

Yours sincerely,

Richard Carson
Chair,
School of Psychology Research Ethics Committee

SCHOOL OF PSYCHOLOGY
Arás an Phiarsaigh
Trinity College
Dublin 2

Scoil na Siceolaíochta
Dámh na nEolaíochtaí Sóisialta agus Daonna,
Áras an Phiarsaigh, Coláiste na Tríonóide,
Baile Átha Cliath 2, Éire

School of Psychology
Faculty of Arts, Humanities and Social Sciences,
Áras an Phiarsaigh, Trinity College,
Dublin 2, Ireland

T +353 (0)1 896 1886
F +353 (0)1 671 2006
psychology@tcd.ie
www.psychology.tcd.ie

Appendix L

Typically Developing Cohort: Information Leaflet, Consent Form, and Debriefing Sheet

Parent – Child Interaction Study

Information Leaflet

Infant & Child Development Lab
School of Psychology, TCD

This leaflet provides information on the research study and aims to answer any questions you may have.

Who are we?

We are lecturers and researchers in the School of Psychology, Trinity College Dublin. In our Infant and Child Development lab, we study parent-child interaction and its contribution to infant and child development.

What is the research about?

We want to find out what features of parent-child interaction are most important for infant and child development. In our research studies, we observe, record and analyse in detail how infants, children and their parents react and respond to each other when interacting, and how these patterns of interaction relate to aspects of child development. For example, we know that the way adults typically respond to babies' babbling aids language development. Even very young babies actively participate in, and initiate interaction with, their parents and other family members and using video observation tools we study this behaviour in detail. This type of approach assumes that parents and children influence each other such that parents' behaviours shape childrens' behaviours which, in turn, has an effect on parents' behaviours. We are particularly interested in investigating differences between mothers and fathers (if any), in the role parents play in interactions with their children and in finding out more about how fathers interact with and respond to their children.

What will the research involve?

To explore these questions, mother, father and infant or child (0-5 years) will be asked to visit our lab and to interact and to play together in our playroom just as you would at home. We are interested in studying the kinds of games, activities and ordinary conversational interactions that families engage in at home every day.

Specifically, your participation in a study will involve one visit to the lab in TCD lasting no longer than 2 hours, during which you will be with your baby or child at all times. Mother and father will be asked to provide some information about yourselves and your family and to complete some questionnaires, for instance, on your stress levels, your parenting styles and beliefs, your child's temperament. In addition a researcher will administer short age appropriate cognitive and language ability tests to your infant or child. Then we wish to simply observe you and your child interacting and playing as normal for a short period. This will be recorded and stored for analysis later. You will also be invited to return for a short follow-up visit in six months.

How can you get involved?

If you are interested in participating, you can contact us, via telephone, facebook, email, or text message. We will then contact you by telephone to tell you more about the study, to answer any questions you might have and to informally get your consent to participate. If you are willing to participate in the research, we will send you an information leaflet and an appointment will be made for your family to visit the lab in Trinity College. When you visit, you will be required to sign a consent form, indicating that you have read the information leaflet, had any questions answered and are happy to participate in the study.

What will happen to the findings of the study?

All information collected from your family will be treated in the strictest of confidence and individuals will not be identified in any written reports. All questionnaire/assessment data will be anonymously coded (names and addresses will not be linked to that data), and links can only be made between questionnaire data, and the observation data by the researchers. Only the researchers working on the study will have access to the video material, which will be kept in a secure location. Video data will only be used for the purpose of research. In these cases, it is not possible to anonymise the data, as you can of course be seen and heard on the video recordings. If you would be happy to allow us to use your stored video data for other research questions in future research projects under the same strict conditions of storage, anonymity and confidentiality, we will ask you to sign a separate consent form also. In the event that you or any member of your family reveal information that causes concern or worry for the researchers, or in the event that the researcher observes an interaction that makes him/her concerned for the welfare/safety of the child/parent, the researcher is obliged to adhere to a set of follow-up procedures.

Parent – Child Interaction: Consent Form

I have read the information sheet and I agree to take part in the study. I understand that this involves being observed and recorded as I interact with my child. I understand that the study will also involve some testing and assessment of my child. ☐

I understand that the information that the researcher collects will be confidential to the research team and used only for the purpose of the research. Any identifying information will be changed. ☐

I understand that I am free to withdraw from participation at any time. ☐

I understand that if anything emerges during the lab visit that causes the researcher to be concerned about me or my baby/child, the researcher will have an obligation to follow this up afterwards. ☐

Participant's Name [Printed] ……………………………………………

Participant's Signature ……………………………………………

Parent – Child Interaction: Information and Consent Form for future use of video material

We would like to take this opportunity to thank you once more for your generosity in participating in this study.

The video data we have collected from you is a very valuable resource and it could be used to answer a lot of different research questions. I would be very grateful if you would consider whether or not you would like to consent to the video tapes of your family being analysed for other research projects.

Please note that as data like facial expression and tone of voice are so important in the sort of questions we are asking, it would not be possible to anonymise the material and therefore you and your baby would be identifiable in the videos, although of course the material would be stored and used in a strictly professional manner.

Please take the time to consider this request and if you feel you would like to consent to this use of your videotapes, please sign below.

I agree that the researchers may use the video material recorded with my family in future research projects. ☐

I understand that this stored video material will be confidential to the research team and used only for the purpose of research. ☐

Participant's Name [Printed] ………………………………………………

Participant's Signature ………………………………………………

Parent – Child Interaction: Consent Form for Follow-up visit

We would like to take this opportunity to thank you once more for your generosity in participating in this study.
This type of research assumes that the way we routinely interact with our infants and young children influences not only their behaviour and responses in the short term but critically influences all aspects of their later development.
The data we have collected from you today is very valuable and can help us to answer many questions about the dynamics of interaction. We are also very interested in how our behaviour now impacts children's development over time.
If you would be willing to participate in a follow-up visit in 6 months time, please sign below.

I agree that the researchers may contact me to participate in a follow-up study within a 6 month period. ☐

I understand that I am free to decline to participate in a follow-up study when contacted. ☐

Participant's Name [Printed] ……………………………………………

Participant's Signature ……………………………………………

Parent – Child interaction: Debriefing Form

Thank you for your help!

Many thanks for giving us your time to participate in our study. Remember that the information which you have shared with us is **confidential** will be used **only for the purpose of the research.**

Any identifying details will be changed to protect your anonymity.

If the lab visit has raised any issues which have been upsetting or distressing for you, we recommend that you get in touch with your GP or your local health centre.
Also, please find below the contact details of some relevant organisations which you may find useful.

Barnardos
CallSave 1850 222300 Email: info@barnardos.ie www.barnardos.ie
Parentline: Helpline for parents under stress
LoCall: 1890 927277 Email: info@parentline.ie www.parentline.ie

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If you require further information about the research or want to contact the research team, our details are:

Dr Jean Quigley quigleyj@tcd.ie 01 896 2697
Dr Elizabeth Nixon enixon@tcd.ie 01 896 2867

School of Psychology, Aras an Phiarsaigh, Trinity College, Dublin 2.

Appendix M

Preterm-Born Cohort: COVID-19 Screening Form

COVID checklist

Due to the ongoing COVID Pandemic, please complete the following symptom checklist and check your temperature 24 hours prior to your laboratory visit.
If you answer 'yes' to any of these questions or have a temperature outside the normal range, depending upon how the measurement is taken

- Do not leave your house
- Isolate yourself from other household contacts
- Contact your GP if you are unwell and require medical advice
- Inform us that your visit will need to be rescheduled.

Indicate yes or no for each symptom for you, your partner, and your child:

SYMPTOM	Mother name:	Father name:	Child's name:
Cough			
Fever			
Shortness of Breath			
Loss of Taste/Smell			
Sore Throat			
Flu-like Illness			
Diarrhoea			

	Mother	Father	Child
Have you visited countries outside of Ireland in the last 14 days?*			
Are you a close contact of a person who is a confirmed or suspected case of COVID-19 in the past 14 days? (i.e. less than 2 more for more than 15 mins in a day)			
Have you been advised by a health professional to self-isolate in the last 14 days?			
Temperature Check (to be completed upon arrival)			

*If you respond 'yes' to this question, please state whether you have complied with the requirements for travelling to Ireland as outlined by the Department of Justice prior to travelling:

Appendix N

Comparison of Families with and without Father Free-Play Recordings

Independent-samples t-tests were used to compare the demographic, linguistic, and turn-taking characteristics of mother-infant dyads belonging to families where two parents (both mother and father; $n = 17$) or only one parent (mother only; $n = 5$) attended the in-lab testing session. Parametric t-tests were used unless the statistical assumptions of homogeneity of variance and/or normality were violated. When the homogeneity of variance assumption was violated (Levene's test, $p < .05$), Welch's t-test was used. Meanwhile, when the normality assumption was violated (Shapiro-Wilk test, $p < .05$), the Mann-Whitney U test was used.

With relation to the demographic characteristics of the mother-infant dyads, it can be seen in Table N1 that the two groups of mother-infant dyads did not significantly differ with respect to the child's age, degree of prematurity (gestational age), or the mother's level of education. However, families with two parents participating in the free-play interactions had significantly younger mothers than those with mother-only participation.

With respect to the linguistic features of mother-infant free-play interactions displayed in Table N1, there were no significant between-group differences in the volubility (words per minute), lexical diversity (type-token ratio), or morphosyntactic complexity (mean length of utterance in morphemes, mean length of utterance in words, verbs per utterance) of speech produced by either mothers or infants. The distribution of conversational load between mother and infant (mean length of turn ratio) also did not significantly differ between groups.

Table N1

Independent-Samples Comparison of the Demographic and Linguistic Characteristics of Mother-Infant Dyads belonging to Families where Two Parents (Mother and Father) or One Parent (Mother-only) Participated in the Dyadic Free-Play Recordings

	Two-parent participation (17 families)			Mother-only participation (5 families)					
	M	*SD*	*Mdn*	*M*	*SD*	*Mdn*	Test statistic	*p*	95% CI
Demographics									
Child age	26.63	4.14	25.97	28.18	2.38	28.67	*t*(20) = -0.79	.439	-5.64, 2.54
Gestational age (weeks) [a]	31.18	4.16	33.00	31.23	2.27	31.00	*W* = 47	.753	-4.29, 4.00
Mother education [a, b]	6.38	0.77	7.00	6.20	0.84	6.00	*W* = 37	.666	-1.00, 1.00
Mother age [c]	35.85	2.61	35.00	39.00	0.71	39.00	*t*(15.34) = -3.99	.001	-4.83, -1.47
Mother speech									
Words per minute	70.60	23.51	71.72	67.25	30.32	80.3	*t*(20) = 0.26	.795	-23.21, 29.90
Type-token ratio	0.29	0.06	0.28	0.31	0.10	0.26	*t*(20) = -0.57	.576	-0.09, 0.05
MLU (morphemes)	4.25	0.87	4.56	4.06	0.96	4.04	*t*(20) = 0.42	.680	-0.75, 1.13
MLU (words)	3.98	0.81	4.20	3.81	0.87	3.88	*t*(20) = 0.41	.688	-0.70, 1.04
Verbs per utterance	0.72	0.16	0.76	0.71	0.20	0.75	*t*(20) = 0.20	.841	-0.16, 0.19
Infant speech									
Words per minute	13.56	10.66	10.25	18.75	12.24	14.74	*t*(20) = -0.93	.364	-16.86, 6.48
Type-token ratio [a]	0.52	0.17	0.47	0.47	0.08	0.44	*W* = 45	.875	-0.08, 0.15
MLU (morphemes)	2.08	0.74	1.83	2.04	0.55	1.84	*t*(20) = 0.09	.926	-0.72, 0.79
MLU (words)	1.98	0.67	1.83	1.89	0.50	1.80	*t*(20) = 0.28	.784	-0.58, 0.76
Verbs per utterance	0.27	0.19	0.29	0.21	0.15	0.16	*t*(20) = 0.67	.510	-0.13, 0.25
Mother-infant dyad									
MLT ratio	0.22	0.16	0.19	0.31	0.15	0.32	*t*(20) = -1.11	.281	-0.26, 0.08

Note. CI = confidence interval; MLU = mean length of utterance; MLT = mean length of turn.

[a] Mann-Whitney U test (when the normal distribution assumption was violated). [b] Mother education was measured on an 8-point scale ranging from “1 = no formal education” to “8 = doctoral-level education”. [c] Welch’s t-test (when homogeneity of variance was not found).

With regards to the mother-infant turn-taking characteristics, it can be observed in Table N2 that there were no significant between-group differences in the responsiveness of the mother or infant, the rate of turn-pairs or multiturn conversational episodes, or in the average duration of multiturn conversational episodes (measured in either seconds or turns).

Table N2

Independent-Samples Comparison of the Turn-Taking Characteristics of Mother-Infant Dyads belonging to Families where Two Parents (Mother and Father) or One Parent (Mother-only) Participated in the Dyadic Free-Play Recordings

	Two-parent participation (17 families)			Mother-only participation (5 families)					
	M	*SD*	*Mdn*	*M*	*SD*	*Mdn*	Test statistic	*p*	95% CI
Responsiveness									
Mother [a]	0.86	0.14	0.89	0.85	0.19	0.89	$W = 42$	1.000	-0.14, 0.12
Infant	0.49	0.22	0.55	0.62	0.25	0.64	$t(20) = -1.16$	.259	-0.37, 0.11
Turn-pairs									
Rate per minute	9.34	5.18	9.14	13.27	7.48	12.59	$t(20) = -1.35$	.192	-9.98, 2.14
MTCE									
Rate per minute	1.54	0.72	1.64	1.54	0.60	1.85	$t(20) = 0.01$	.996	-0.74, 0.74
Average duration – seconds [a]	14.28	4.17	13.72	22.28	13.16	16.57	$W = 23$	.140	-15.48, 0.85
Average duration – turns [a]	5.69	1.93	5.17	9.57	6.90	7.00	$W = 24$	.158	-10.76, 0.42

Note. CI = confidence interval; MTCE = multiturn conversational episode.
[a] Mann-Whitney U test (when the normal distribution assumption was violated).

Appendix O

Spearman Correlations between Mother-Infant Turn-Taking and Infant BRIEF-P and Bayley-III Scores

Table O1

Spearman Correlation Coefficients

	1	2	3	4	5	6	7	8	9	10	11
1. Infant responsiveness											
2. Mother responsiveness	-0.02										
3. Turn pairs (rate per minute)	0.96	0.08									
4. MTCE (rate per minute)	0.55	0.08	0.64								
5. MTCE average duration (seconds)	0.55	0.09	0.47	0.03							
6. MTCE average duration (turns)	0.67	0.01	0.69	0.26	0.59						
7. Global executive composite (BRIEF-P)	0.04	0.13	0.01	0.20	0.33	0.15					
8. Cognitive (Bayley-III)	0.36	-0.18	0.35	0.10	0.04	0.09	-0.25				
9. Receptive communication (Bayley-III)	0.46	0.07	0.48	0.31	0.12	0.30	-0.05	0.80			
10. Expressive communication (Bayley-III)	0.38	-0.05	0.41	0.18	0.19	0.40	-0.10	0.69	0.78		
11. Social-emotional (Bayley-III)	0.19	0.10	0.13	0.02	-0.01	0.24	-0.01	0.48	0.73	0.69	

Note. Missing data handled with pairwise deletion. MTCE = multiturn conversational episode.

Table O2

Spearman Correlation p-values

	1	2	3	4	5	6	7	8	9	10	11
1. Infant responsiveness											
2. Mother responsiveness	.945										
3. Turn pairs (rate per minute)	< .001	.728									
4. MTCE (rate per minute)	.008	.707	.001								
5. MTCE average duration (seconds)	.008	.690	.028	.879							
6. MTCE average duration (turns)	.001	.962	< .001	.240	.004						
7. Global executive composite (BRIEF-P)	.888	.619	.961	.447	.212	.575					
8. Cognitive (Bayley-III)	.103	.428	.110	.644	.860	.694	.346				
9. Receptive communication (Bayley-III)	.045	.785	.039	.196	.633	.212	.857	< .001			
10. Expressive communication (Bayley-III)	.107	.835	.081	.452	.431	.090	.746	.001	< .001		
11. Social-emotional (Bayley-III)	.482	.710	.641	.939	.961	.379	.964	.057	.003	.006	

Note. Missing data handled with pairwise deletion. MTCE = multiturn conversational episode.

Table O3

Spearman Correlation Pairwise Sample Size

	1	2	3	4	5	6	7	8	9	10	11
1. Infant responsiveness											
2. Mother responsiveness	22										
3. Turn pairs (rate per minute)	22	22									
4. MTCE (rate per minute)	22	22	22								
5. MTCE average duration (seconds)	22	22	22	22							
6. MTCE average duration (turns)	22	22	22	22	22						
7. Global executive composite (BRIEF-P)	16	16	16	16	16	16					
8. Cognitive (Bayley-III)	22	22	22	22	22	22	16				
9. Receptive communication (Bayley-III)	19	19	19	19	19	19	14	19			
10. Expressive communication (Bayley-III)	19	19	19	19	19	19	14	19	19		
11. Social-emotional (Bayley-III)	16	16	16	16	16	16	13	16	14	14	

Note. Missing data handled with pairwise deletion. MTCE = multiturn conversational episode.

Appendix P

Spearman Correlations between Father-Infant Turn-Taking and Infant BRIEF-P and Bayley-III Scores

Table P1

Spearman Correlation Coefficients

	1	2	3	4	5	6	7	8	9	10	11
1. Infant responsiveness											
2. Father responsiveness	0.16										
3. Turn pairs (rate per minute)	0.73	-0.30									
4. MTCE (rate per minute)	0.21	-0.81	0.66								
5. MTCE average duration (seconds)	0.82	0.35	0.38	-0.06							
6. MTCE average duration (turns)	0.76	0.34	0.55	-0.06	0.64						
7. Global executive composite (BRIEF-P)	0.47	0.21	0.43	0.08	0.29	0.51					
8. Cognitive (Bayley-III)	0.42	-0.04	0.37	0.19	0.40	0.23	-0.25				
9. Receptive communication (Bayley-III)	0.51	-0.17	0.43	0.29	0.46	0.29	-0.05	0.80			
10. Expressive communication (Bayley-III)	0.53	0.16	0.46	0.05	0.62	0.49	-0.10	0.69	0.78		
11. Social-emotional (Bayley-III)	-0.06	0.39	-0.22	-0.25	-0.08	-0.05	-0.01	0.48	0.73	0.69	

Note. Missing data handled with pairwise deletion. MTCE = multiturn conversational episode.

Table P2

Spearman Correlation p-values

	1	2	3	4	5	6	7	8	9	10	11
1. Infant responsiveness											
2. Father responsiveness	.541										
3. Turn pairs (rate per minute)	.001	.245									
4. MTCE (rate per minute)	.428	< .001	.004								
5. MTCE average duration (seconds)	< .001	.168	.135	.808							
6. MTCE average duration (turns)	< .001	.178	.021	.822	.005						
7. Global executive composite (BRIEF-P)	.127	.505	.162	.812	.353	.091					
8. Cognitive (Bayley-III)	.095	.869	.144	.470	.110	.371	.346				
9. Receptive communication (Bayley-III)	.063	.571	.122	.312	.098	.322	.857	< .001			
10. Expressive communication (Bayley-III)	.054	.587	.099	.875	.018	.075	.746	.001	< .001		
11. Social-emotional (Bayley-III)	.853	.214	.488	.427	.802	.875	.964	.057	.003	.006	

Note. Missing data handled with pairwise deletion. MTCE = multiturn conversational episode.

Table P3

Spearman Correlation Pairwise Sample Size

	1	2	3	4	5	6	7	8	9	10	11
1. Infant responsiveness											
2. Father responsiveness	17										
3. Turn pairs (rate per minute)	17	17									
4. MTCE (rate per minute)	17	17	17								
5. MTCE average duration (seconds)	17	17	17	17							
6. MTCE average duration (turns)	17	17	17	17	17						
7. Global executive composite (BRIEF-P)	12	12	12	12	12	12					
8. Cognitive (Bayley-III)	17	17	17	17	17	17	16				
9. Receptive communication (Bayley-III)	14	14	14	14	14	14	14	19			
10. Expressive communication (Bayley-III)	14	14	14	14	14	14	14	19	19		
11. Social-emotional (Bayley-III)	12	12	12	12	12	12	13	16	14	14	

Note. Missing data handled with pairwise deletion. MTCE = multiturn conversational episode.

Appendix Q

AN(C)OVAs Investigating the Effect of Birth Status and the Speech Sampling Context on the Linguistic and Paralinguistic Features of Infant Speech

Table Q1

AN(C)OVAs Corresponding to the Linguistic Features of Infant Speech

	Main/Interaction effects	Test statistic	p	η_p^2
Types [a]	Infant Age	$F(1, 41.82) = 16.07$	**< .001**	.28
	Birth Status	$F(1, 41.98) = 0.07$	.794	< .01
	Speech Context	$F(1, 38.93) = 1.95$	.170	.05
	Birth Status*Speech Context	$F(1, 38.96) = 0.69$	.410	.02
Tokens [a]	Infant Age	$F(1, 42.04) = 10.15$	**.003**	.19
	Birth Status	$F(1, 39.55) = 0.20$	.657	< .01
	Speech Context	$F(1, 36.50) = 0.51$	.481	.01
	Birth Status*Speech Context	$F(1, 36.54) = 1.71$	.200	.04
Type-token ratio	Birth Status	$F(1, 42.94) = 1.55$	.220	.03
	Speech Context	$F(1, 42.01) = 0.16$	.692	< .01
	Birth Status*Speech Context	$F(1, 42.01) = 5.73$	**.021**	.12
% nouns	Birth Status	$F(1, 43.48) = 1.57$	.218	.03
	Speech Context	$F(1, 38.82) = 1.08$	.304	.03
	Birth Status*Speech Context	$F(1, 38.82) = 0.15$	.703	< .01
% verbs [a]	Infant Age	$F(1, 42.41) = 5.60$	**.023**	.12
	Birth Status	$F(1, 42.60) = 0.04$	.850	< .01
	Speech Context	$F(1, 42.23) = 0.28$	.602	< .01
	Birth Status*Speech Context	$F(1, 42.26) = 0.19$	.663	< .01
% adjectives	Birth Status	$F(1, 40.68) = 1.90$	.176	.04
	Speech Context	$F(1, 30.49) = 6.34$	**.017**	.17
	Birth Status*Speech Context	$F(1, 30.49) = 2.38$	.133	.07
MLUm [a]	Infant Age	$F(1, 44.02) = 8.03$	**.007**	.15
	Birth Status	$F(1, 44.14) = 0.09$	.766	< .01
	Speech Context	$F(1, 39.98) = 2.62$	.114	.06
	Birth Status*Speech Context	$F(1, 40.00) = 0.07$	.798	< .01
MLUw [a]	Infant Age	$F(1, 43.85) = 7.95$	**.007**	.15
	Birth Status	$F(1, 43.99) = 0.09$	.763	< .01
	Speech Context	$F(1, 40.23) = 1.57$	.218	.04
	Birth Status*Speech Context	$F(1, 40.26) = 0.36$	.553	< .01
Verbs per utterance [a]	Infant Age	$F(1, 43.33) = 9.13$	**.004**	.17
	Birth Status	$F(1, 43.50) < 0.01$	.950	< .01
	Speech Context	$F(1, 41.01) = 0.02$	.879	< .01
	Birth Status*Speech Context	$F(1, 41.05) = 0.12$	.730	< .01

Note. Type III sums of squares. Statistically significant effects ($p < .05$) are shown in bold. Speech context = Speech sampling context.
[a] ANCOVA controlling for infant age.

Table Q2

AN(C)OVAs Corresponding to the Paralinguistic Features of Infant Speech

	Main/Interaction effect	Test statistic	*p*	η_p^2
Volubility [a]	Infant Age	$F(1, 42.05) = 11.01$	**.002**	.21
	Birth Status	$F(1, 41.02) = 1.46$	.233	.03
	Speech Context	$F(1, 38.74) = 1.10$	.300	.03
	Birth Status*Speech Context	$F(1, 38.81) = 2.15$	.151	.05
Speech rate	Birth Status	$F(1, 45.15) = 1.81$	.185	.04
	Speech Context	$F(1, 42.01) = 0.15$	.699	< .01
	Birth Status*Speech Context	$F(1, 42.01) = 0.12$	.723	<. 01
Intelligibility [a]	Infant Age	$F(1, 39.60) = 2.43$	.127	.06
	Birth Status	$F(1, 40.02) = 11.79$	**.001**	.23
	Speech Context	$F(1, 39.46) = 0.06$	.808	< .01
	Birth Status*Speech Context	$F(1, 39.49) = 1.54$	.222	.04
Intelligible words per min [a]	Infant Age	$F(1, 41.96) = 6.20$	**.017**	.13
	Birth Status	$F(1, 42.26) = 0.07$	.798	< .01
	Speech Context	$F(1, 39.11) = 2.24$	.143	.05
	Birth Status*Speech Context	$F(1, 39.14) < 0.01$	.971	< .01

Note. Type III sums of squares. Statistically significant effects ($p < .05$) are shown in bold. Speech context = Speech sampling context.

[a] ANCOVA controlling for infant age.

Appendix R

Coefficients of Variation

The coefficient of variation is a standardized measure of variability which facilitates comparisons of variance across variables which were measured on different scales. Coefficients of variation for the Bayley language scores (Table R1) and LSA measures (Table R2) were calculated by dividing the standard deviation for each measure by its corresponding mean.

Table R1

Coefficients of Variation for the Bayley Language Scores

	Term	Preterm
Receptive communication	0.22	0.39
Expressive communication	0.23	0.49
Language composite	0.11	0.24

Table R2

Coefficients of Variation for the LSA Measures

	Mother-infant conversation		Father-infant conversation	
	Term	Preterm	Term	Preterm
Linguistic				
Types	0.52	0.61	0.48	0.62
Tokens	0.58	0.71	0.56	0.66
Type-token ratio	0.26	0.13	0.25	0.31
% nouns	0.51	0.57	0.54	0.50
% verbs	0.68	0.56	0.77	0.56
% adjectives	1.08	1.11	1.43	1.16
MLU (morphemes)	0.29	0.33	0.30	0.34
MLU (words)	0.28	0.32	0.30	0.33
Verbs per utterance	0.84	0.70	0.96	0.81
Paralinguistic				
Volubility (words per min)	0.55	0.72	0.53	0.60
Speech rate (words per min)	0.21	0.18	0.19	0.21
Intelligibility	0.23	0.08	0.15	0.13
Intelligible words per min	0.31	0.20	0.12	0.27

Note. The coefficients of variation for each LSA measure were calculated following the removal of outliers for the AN(C)OVA analyses.