Does Mother Age Influence the Development of Offspring Walking and Talking?

by

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ABSTRACT

Older motherhood (after 30 years) is increasingly common, yet relatively little is known about the relation between mother age and child development. Mother age has been linked to offspring cognitive and motor development, but those studies measured mother age with crude categorizations (e.g., older vs. younger) and varied their focus from one developmental period to another (e.g., infancy vs. early childhood). The present study used a more sensitive measure of mother age and examined both motor and language development in the same children at the same age. Mother age was considered within an ecological systems framework as a predictor of variability in offspring walking and talking. Survival analysis was used to examine a large archival dataset in Study One to create an initial snapshot of mother age effects. Study Two used online methodologies to clarify mother age effects by examining early motor (walking) and language (gestures) development in a heterogeneous sample. Older motherhood was associated with delayed walking and talking during infancy (0 to 18 months), but advanced receptive vocabulary in childhood (4 and 5 years). Such results confirm the general idea that variation in mother age has implications for offspring development, but the pattern and direction of influence appears to vary by content domain and by age. The use of a one-size-fits-all norm for typical development and for assessing developmental delay is ill-advised because children of younger and older mothers may differ in systematic ways.

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CHAPTER 1 - INTRODUCTION

Does Mother Age Influence the Development of Offspring Walking and Talking?

Delayed motherhood is a well-known trend in developed countries, yet little is known about the effects that older motherhood has on children, families, and society. Societal and economic changes such as high divorce rates, the number of women engaged in post-secondary education/careers, and advances in birth control methods have contributed to the number of women having children well into their thirties and forties (Balen, 2004; Bornstein, Putnick, Suwalsky, & Gini, 2006; Bushnik & Gerner, 2008; Statistics Canada, 2006). In 2010, 51 percent of children in Canada were born to mothers 30 years or older, and the average childbearing age increased from 26 years in 1983 to 29.5 years (Statistics Canada, 2010).

Human Resources and Skills Development Canada (HRSDC) has identified mother age as an important indicator of well-being for Canadian citizens and "*age of a mother at childbirth*" as an important variable that brings change to the family system. "*Family life events*" are defined by HRSDC as indicators that involve a change or transition (e.g., childbirth) and influence the well-being of individuals, families, and the community. Mothers are typically responsible for the emotional and physical needs of individual children, and as such are important influences over families, communities, and Canadian society as a whole. It is likely that the trend towards older motherhood brings additional changes to these systems. Significant increases in physical health-related risks and health care costs are changes that have been associated with older childbearing (e.g. increased number of caesarean sections, longer hospital stays and increased risks of birth defects; Statistics Canada, 2007). In addition, there is a growing body of literature that has examined the risk for child genetic and chromosomal disorders associated with older mother age (Chapman, Keith, & Craig, 2002).

There is however, little research demonstrating the influence of older motherhood on the developmental trajectories of healthy children. Rates of attainment (how quickly children reach developmental markers) are key features of a developmental trajectory. Individual differences in attainment are often used to predict later outcomes across domains of development. For example, early motor attainment is predictive of later gains in cognitive domains (Eaton, 2008). In addition, rates of attainment for specific developmental markers are often used as diagnostic screening measures for developmental advances or delays. For example, language delays are often used as warning signs for clinicians when diagnosing problems in development. As the average age of motherhood continues to increase it is important to recognize that “normal” (or average) development for children of 25-year-old mothers may not be average for the children of mothers over 30. If motherhood over 30 years is considered the new “average” age of motherhood then it is important to account for variations in development that might be associated with this shifting societal trend.

The purpose of this study was to create an initial framework for investigating mother age in relation to individual differences on motor and language domains among typically developing children. Mother age was used as a continuous variable across two studies to predict motor and language outcomes. In Study One, a large database of Canadian children was analyzed examine individual differences among 0- to 5- year-olds in relation to mother age. In Study Two motor and language domains were examined concurrently in 0- to 36- month-olds.

Hypotheses

Several research questions were addressed across two studies to assess mother age effects in relation to language and motor development. The main hypotheses for each study are as follows:

Study One: Examining mother age effects in a representative sample of Canadian children

1) Mother age was expected to positively predict age of first walking and negatively predict first talking in 0- to 24- month-olds (older mothers would have children who walked later and said their first words earlier).
2) Mother age was anticipated to negatively predict motor ability and positively predict social/cognitive ability in children from 0 to 47 months old.
3) Mother age projected to demonstrate a positive association to receptive vocabulary in 4- and 5- year-olds (words children understand and respond to).

Study Two: Examining mother age effects as a predictor for walking and gesture use

1) Mother age would positively predict age of first walking in an internationally diverse sample of 0- to 24- month-olds (older motherhood was associated with later walking).
2) Mother age would positively predict gesture ability in 0- to 36- month-olds (children of older mothers would use more gestures).
3) Mother age would positively predict vocabulary comprehension and production in 0- to 36- month-olds (children of older mothers would have larger vocabularies).

Definition of terms

Mother age effects were defined as mother age correlates of child developmental outcomes, and mother age was considered a continuous variable.

CHAPTER 2: LITERATURE REVIEW

Theoretical Framework

Several theories have been used to explain why infants vary in their rates of development, and studying such variation has allowed for a better understanding of the processes that influence developmental progress. One goal of early developmental researchers was to create age-related norms or trajectories of development by which individual children could be compared (Eaton, 2008; Fenson, et al., 1993; Santos, Gabbard, & Goncalves, 2001). Developmental norms have allowed researchers and clinicians to identify children who fall above or below age-related averages on several developmental milestones (tasks or skills that children achieve at certain ages, e.g. independent walking) and to predict the average timing when children reach important markers.

The development and use of age-related norms has been driven by a maturational perspective which posits that motor and language development during infancy and early childhood are related to maturational factors. According to a maturational perspective, developmental changes are related to an infant's neurological maturation, develop uniformly in sequence (where each stage of development is preceded by a subsequently passed stage within a specific domain; e.g. sitting, crawling, and walking), occur abruptly, and are reflexive in nature (Eaton, 2008; Zelazo, 1998; Zelazo & Zelazo, 1972). In contrast to the claims of a maturational perspective, recent trends in developmental theory have acknowledged that children do not develop uniformly across milestones. Developmental milestones have been found to vary in the sequence of onset, and advances or delays in one domain are not *always* predictive of advances or delays in subsequent domains (Eaton, 2008; Taanila, Murray, Jokelainen, Isohanni, & Rantakallio, 2005; Murray, et al., 2006). That being said, a number of findings suggest that rate of development in one domain does predict the rate of development in another. Age of first walking consistently predicts outcomes in several cognitive domains as well as educational outcomes in adolescence and adulthood. More specifically, earlier ages of standing and walking have been found to predict later advances on categorization and increased educational outcomes (Eaton, 2008; Taanila, et al., 2005; Murray, et al., 2006).

Age-related norms are useful for providing an overview of typical development, and in some situations norms allow for the detection of developmental delay. However, maturational age-norms provide little information on the predictive value of developmental milestones (Eaton, 2008). The maturational perspectives driving the creation of these norms cannot account for gradual variations in attainment or individual trajectories in which infants by-pass one or more milestones. For example, many children go from sitting to walking, skipping the crawling milestone altogether (Eaton, 2008). In other words, development is not as uniform or as universal as assumed by a maturational perspective. Ecological systems theory (Bronfenbrenner, 1994) is an alternative theory for explaining individual differences in developmental outcomes such as walking and talking.

Bronfenbrenner's ecological model posits that development takes place among several multidirectional and overlapping systems: individual, microsystems (immediate environment of the individual), *mesosystems* (relationships between two or more settings containing the individual), *exosystems* (relationships between two or more contexts, one of which does not include the individual), *macrosystems* (overarching systems, e.g., cultural, social systems), and *chronosystems* (time, or historical contexts) (Bronfenbrenner, 1994; Bronfenbrenner 1999). Adopting an ecological systems approach allows for a detailed assessment of development by accounting for multiple influences and gradual changes in developmental progress while considering contextual aspects of the environment (Bronfenbrenner, 1999; Eaton, 2008; Clearfield, 2010; Kamm, Thelen, & Jensen, 1990).

Instead of applying a crude categorization of development as either “delayed” or “on time”, incremental, multifactorial differences in age of attainment across milestones can be assessed with a systems model. A systems approach is one that acknowledges humans as complex beings (systems) that exist within and are influenced by multifaceted environments. Development therefore, can be conceptualized as resulting from many interlocking sub-systems (biological, emotional, environmental, etc) that act “in a cooperative, interdependent relationship with other sub-systems” (Kamm, et al., 1990; p.770) to produce differences in developmental outcomes (e.g., the onset of new milestones or abilities). Each system is free to vary; a significant change in one system will inevitably lead to a change in all others. It is these changes, or differences, that account for contextual variables that operate on the individual variation observed in developmental outcomes (Bronfenbrenner, 1999; Kamm, et al., 1990). Under an ecological systems perspective many aspects of the individual and environment are interlocking and are argued to account for individual variation in development. The research program presented addressed factors present in the individual system and the microsystem as being proximal and necessary for development. Mother age is one such factor that may lead to changes in milestone attainment and developmental ability.

In addition to accounting for various contextual factors, this study aimed to predict gradual variations in individual development. Because the goal of this study was to develop an initial picture of mother age effects in relation to development it was crucial to determine which aspects of development are predicted by mother age. A person-context model within an ecological framework was used in this study to predict development in motor and language domains. The model allowed for the prediction of developmental outcomes by examining several prospective factors that contribute to the outcomes in question (Bronfenbrenner, 1994; Johnson, 2008).

Factors relevant to developmental trajectories in healthy children such as mother age, can be identified through individual variation in a child's rate of attainment for various milestones. A clearer picture of healthy ages of attainment for certain milestones can then be used to identify underlying problems or advances in other areas of development. Infant walking and early language are two important milestones to consider because of the relevant links between early motor and later cognitive outcomes.

Measuring developmental progress: Walking and Talking

Infant walking is an important motor skill to study for several reasons. First, bi-pedal locomotion is a uniquely human and near-universal phenomenon. Moreover, the age of first independent walking provides an indication of overall health status and has been used to predict later developmental outcomes (Adolph, Vereijken, & Shrout, 2003; Adolph, & Berger, 2005; Eaton, 2008; Santos et al., 2001). Furthermore, age of first independent walking is an easily observable and usually memorable event for parents, and early motor development has been linked to later developmental outcomes (Adolph et al., 2003; Adolph, & Berger, 2005; Eaton, Bodnarchuk, McKeen, & Lewycky, 2007; Murray et al., 2006; Taanila, et al., 2005). Longitudinal research has linked parent reports of motor attainment to later cognitive outcomes; age of walking was found to predict cognitive abilities in 2-year-olds (Eaton, Bodnarchuk, McKeen, & Lewycky, 2007). Such results do not demonstrate that variation in walking attainment caused later cognitive variation, but they highlight connections between motor domains and other aspects of development.

Similarly, early language is an important indicator of underlying cognitive and social development (Fenson et al., 1993; Tamis-Lemonda, Bornstein, & Braumwell, 2001). Human speech is another near-unique and universal phenomenon that has been tied to later developmental outcomes, and advances in language use have been associated with high levels of joint attention and IQ abilities in later childhood (Baumwell, Tamis-LeMonda, & Bornstein, 1997). Delays in early language, particularly gesture use, can be indicative of poor joint attention abilities and in some cases early indicators of autism or other cognitive dysfunction (Dick, Overton, & Kovacs, 2009). Certainly walking and early talking are important yardsticks with which to measure the rate of developmental change among infants.

Predicating development: Variables of Interest

When adopting an ecological systems perspective of motor and language development, several environmental factors also become important. Mothers are consistently one of the primary influences of children's daily environments. It is possible that older and younger mothers provide distinctly different environments for their children. For example, if older mothers and younger mothers differ in their treatment of infants, such differences may well influence infants' rates of development such that the environmental changes (as a function of mother age) initiate a change in one sub-system (age of walking or early language abilities), and these changes could bring about advances or delays in other subsystems of development (social interaction, later cognitive functioning; Baumwell et al., 1997; Clearfield, 2010; Tamis-LeMonda et al., 2001). In the longer term, differences in rate of development initiated by this changing demographic may lead to a re-conceptualization of what constitutes "normal" timing.

Various individual and microsystem factors known to influence walking and talking development were used as covariates across both studies. In line with the person-context model adopted in this study, several covariates were used to gain a better understanding of whether mother age is related to development beyond these additional factors.

Previous research has linked rates of progress for motor milestones to individual level, physical factors such as gestational age, birth size, and body composition. Each physical factor has also been implicated in the timing of gross motor milestones such as crawling and walking. For example, infants who are smaller and leaner have been shown to walk earlier than larger heavier infants (Eaton, 2008), and premature or gestationally younger infants tend to develop motor skills later than infants who are born on or near their expected due date (Eaton, 2008). Other variables associated with advances in development include but are not limited to gender (girls have an advantage over boys on language domains) and birth order (later born children walk earlier; Eaton, 2008).

Several microsystem factors have also been linked to walking and talking development and were included in the present studies. These factors include: nutrition (well-nourished infants reach motor milestones sooner), season of birth (infants born in the winter and spring walk earlier), socioeconomic status (SES; higher SES leads to increased vocabulary; Blank, 1964; Pan, Rowe, Spier, & Tamis-LeMonda, 2004), and postural experience (experience in a prone position facilitates crawling; Adolph, 1997; Adolph, et al., 2003; Eaton, 2008). Similarly, early exposure to written material has been linked to increases in language and literacy skills (children with early exposure to written material have increased language and literacy; Whitehurst & Lonigan, 1998). In addition, maternal education is important to consider because older mothers tend to have higher levels of education and it is possible that a maternal-age-effect is really education in disguise (Rosenkrantz-Aronson, & Huston, 2004; Bornstein et al., 2006).

The preceding examples are only a few of the many possible environmental and biological interactions that influence individual development. Covariates for each hypothesis were selected based on their proximity to the outcome measure identified in the corresponding model. In Study Two mother personality was included to explore potential relationships between personality factors such as conscientiousness on language ability.

Older Motherhood and Developmental Outcomes

There are suggestions that maternal age at the time of childbearing is linked to the developmental rate of offspring (Bornstein et al., 2006; Bushnik & Gerner, 2008; De Jaeger & Eaton, 2010; Eaton, Bodnarchuk, McKeen, & De Jaeger, 2007; McMahon, Boivin, Gibson, Hammarberg, Wynter, et al., 2011; Pan, et al., 2004; Pollock, 1993; Rosenthal-Rollins, 2003). Mother age has traditionally been used as a categorical covariate (young vs. old) in developmental research, though the thresholds for what constitutes *older* motherhood are not well defined (McClennan-Reece, & Harkless, 1996; McMahon, et al., 2011).

In one of the only Canadian studies to focus on older motherhood Bushnik and Gerner (2008) use the National Longitudinal Study of Children and Youth (NLSCY) to directly assess older motherhood in relation to several child outcomes (cognitive, behavioural and physical health). Bushinik and Gerner's analysis included a longitudinal sample of first-born children from birth to 5 years and categories of mother age that included '*teenaged mother*' (under 20 years), '*young mother*' (20 to 24 years), '*reference mother*' (25 to 29 years), '*middle mother*' (30-34 years), and '*older mother*' (35 years or over). Comparisons between older mothers and those in the reference group, suggested that older mothers were more likely to suffer from gestational hypertension, have caesarean sections, and have children with lower birth weights and breast feed longer than mothers of other age groups. Health-related findings reported by

Bushnik and Gerner are consistent with earlier studies that link prenatal health and childbirth difficulties to older motherhood (Statistics Canada, 2007).

Only a handful of studies have specifically examined adult maternal age as a predictor for post-natal child development. In studies where mother age is used as a categorical variable, children tend to display increased cognitive and linguistic skills in early and middle childhood (3 to 10 years) when their mothers are “older than average” (older than 27 years of age; Pollock, 1993; Rosenthal-Rollins, 2003; Pan et al., 2004; Bornstein et al., 2006). Longitudinal findings from a British study provide additional support for the cognitive benefits associated with increasing maternal age, mother age is associated with higher scores on tests of vocabulary for children at 5 and 10 years of age (Pollock, 1993). Similarly, Pan and colleagues (2004) reported that children of older mothers score higher on tests of vocabulary at 3 years of age when compared children of younger mothers. Pan and colleagues also found that higher levels of spontaneous speech at the age of two, and advanced language skills at the age of three were associated with increases in mother age.

Nevertheless, there are findings that don’t support a link between mother age and language outcomes. Bushnik and Garner (2008) did not find a relation between “older first time motherhood” (over 35 years) and child vocabulary at 4 and 5 years of age. The Bushnik and Gerner (2008) results are of particular interest to the present study because the findings are incongruent with previous findings that have demonstrated positive associations for mother and language, and negative associations for mother age and motor domains (De Jaeger & Eaton, 2010; Eaton, 2008; Taanila, et al., 2005; Murray, et al., 2006). Bushnik and Gerner reported children of older mothers received lower scores on the MSD (a measure of several motor, cognitive, and social ability markers), and therefore a general delay in motor and social cognitive development. Perhaps inconsistencies between Bushink and Gerner's findings using the MSD and earlier finding that examined motor, cognitive, and language domains separately result from the combination of motor and cognitive items that make up the MSD questionnaire. Bushnik and Gerner used the MSD as it appears in the NLSCY (a total sum for all *"yes"* responses regardless of developmental domain). If mother age effects exist in opposite directions for cognitive and motor domains it is possible that these domain-specific differences are being masked by the total score used in Bushnik and Gerner's study. If motor items and social/cognitive items within the MSD were examined separately it would provide a more precise exploration of mother age effects for each domain.

In contrast, Bornstein and colleagues (2006) found that older mothers displayed more nurturing, sensitive, and structured behaviours towards their infants than younger mothers. Older mothers were also observed engaging in responsive, rich lengthy periods of communication towards their infants (Bornstein et al., 2006). Similarly, mother age has been positively associated with optimal parenting practices including verbal and emotional responsivity, and attachment (Barratt, Roach, Colbert, 1991; Siddiqui, Hagglof, & Eisemann, 1999; Rosenkrantz-Aronson & Hudson, 2004). Further investigation of mother age in relation to social cognitive domains is required to determine the patterns that exist for children with mothers in older age groups.

There are other domains where mother age developmental benefits are associated with younger motherhood. Schum and colleagues (2001) found that younger (not older) maternal age displayed a positive association with advances on toilet training (the younger the mother, the earlier the training). Similar trends were found when examining the timing at which children first begin to sleep through the night (Adams, Jones, Esmail, and Mitchell, 2004); infants with younger mothers slept through the night sooner than infants with mothers who were older. Similarly, according to Bushnik and Gerner's (2008) definitions, children with older mothers were more likely to be "*late to take first steps"* compared to children with mothers in the reference category. Milestone attainment was defined as *'late'* for any children who fell above the 90th percentile for a given milestone. In other words, a child was considered late if 90 percent of children of the same age had reached the milestone and the child in question fell within the 10 percent of children who did not (Bushnik & Gerner, 2008).

The mother age effects reported thus far have been found using crude categorizations such as younger vs. older, but the sensitivity with which relationships can be detected is limited when using such categorizations. Mother age should be used as a continuous variable to better understand the relationship between increasing mother age and child development. While analyses employing mother age categories are valuable, there is some information lost during analysis. Small differences attributed to mother age may go undetected because of variation within age categories. Considering mother age as a continuous variables increases the sensitivity of statistical analyses and allows for an examination of mother age effects incrementally by year of age rather than in a broad grouping based on age. In this vein, my Master's research (De Jaeger & Eaton, 2010) revealed a relationship between maternal age (at time of birth), and the age at which a child begins to walk when several other factors were accounted for (De Jaeger & Eaton, 2010). Older motherhood was associated with later walking, and earlier motherhood was associated with earlier walking. According to our model the onset of parent-reported age at first walking was delayed by approximately 2.5 days for every year of mother age. For example, a 33-year-old-mother expect her child to walk approximately 12.5 days later than a baby born to a 28-year-old mother (currently average age). Thus, although mother age effects tend to favour older mothers on social and linguistic domains in older children, younger motherhood seems to be more favorable when considering motor domains during infancy.

As the preceding review of a skimpy literature suggests, mother age effects do exist and exert some influence on development in several domains above and beyond other known predictors of early development. Despite these important links there are some limitations in the existing literature regarding mother age effects: 1) mother age is commonly studied as a categorical variable, 2) many studies examine mother age effects in populations of teenage mothers and do not assess the effects in populations of older mothers, 3) few studies exist that have assessed mother age effects in relation to motor development, and 4) there are no studies that have examined mother age effects across multiple domains of development concurrently. For example, the relation between mother age and language is typically studied in children older than 3-years, while mother age in relation to motor outcomes is studied in children under 2-years of age. It is important to address the aforementioned limitations if we are to gain insight into mother age effects and begin unpacking them in a meaningful way. The overarching goal of this study was to examine the relationship between mother and that the developmental timing of events as well as the sophistication, or age-related achievements in development across two important domains (motor and language). This research program used a two-study approach to address inconsistencies in the existing mother age literature, and to clarify the role of mother age effects in relation to walking attainment and language ability.

A nationally representative, longitudinal database of Canadian children was analyzed in Study One to examine individual differences on several motor and language outcomes in relation to mother age. Mother age was used as a continuous variable and as such was unrestrained by traditional age categories (teenage, average, and older). Study One included a population of children from 0 to 5 years of age and provided a basic framework of mother age effects in relation to motor and language domains. Study Two was a simultaneous comparison of motor and language domains during the first two years of life. Measures of attainment for the key gross motor milestone walking and gesture ability were used to assess each domain concurrently using a heterogeneous international sample of 0 to 47-month-olds.

CHAPTER 3 – STUDY ONE

Examining Mother Age Effects in a Representative Sample of Canadian Children

Examining motor and language domains in a large, representative sample was a logical first step to ameliorate some of the previously observed inconsistences of mother age effects. A population-based dataset was used in Study One to identify the contribution of mother age to motor and language outcomes after controlling for other important aspects of development.

As discussed in Chapter 2, Bushnik and Gerner's (2008) analysis provides a preliminary description of mother age effects in relation to child outcomes, but also demonstrate inconsistencies with the existing literature on mother age. It is possible that these inconsistencies can be clarified through the use of more sensitive statistical methodologies. The overarching goal of Study One was to address inconsistencies in the existing developmental literature by assessing maternal age as one factor in the developmental process. It was anticipated that mother age effects would demonstrate positive relationships to motor milestones (children of older mothers would walk later) and negative relationships to language milestones (children of older mothers would talk earlier and have better vocabulary).

The present study aimed to improve on the Bushnik and Gerner (2008) methodology in several ways. First, mother age effects were examined using mother age as a continuous rather than categorical variable to generate a statistically sensitive measure of mother age and assess the study hypotheses. Second, the outcome variables for motor milestones in this study consisted of reported dates of attainment rather than the binary outcomes used in previous studies (milestone reached vs. not reached). Using the date of attainment for milestones allowed for a prediction of the age at which developmental markers are reached. Third, Bushnik and Gerner examined older motherhood in a sample of first-time mothers. In the present study later-born children were included in addition to first-born children to account for potential birth-order effects. On one hand it is logical to look at first-born children because of the increasing number of older first time mothers. That being said, if mother age is a factor that influences development, then mother age effects should be present not only in first born children, but in all children regardless of birth order.

Fourth, the research questions in this study were designed to investigate mother age effects on the developmental timing of specific events (e.g. motor attainment or first words at a specific age). Although regression analyses are practical and useful for studying developmental phenomena, these models can be flawed when dealing with time-related events in longitudinal and cross-sectional datasets. For example, regression models cannot account for the issue of missing outcome data, and those with missing outcome measures are removed from a regression analysis. In longitudinal studies attrition is typically quite high, which reduces both sample size and the statistical power of the model (Allison, 2004). More crucially, the omitted cases are more likely to be those where milestone attainment was delayed, thus biasing the results against a significant finding. Survival models provides an ideal alternative for developmental researchers in that survival models allow for the inclusion of missing outcome data (Eaton, Bodnarchuk, & McKeen, 2014; Tamis LeMonda, et al., 2001). Survival analysis, also known as event history analysis, is a statistical method originally used to estimate the likelihood of death given a variety of circumstances. Similar to regression, survival analysis can be useful for developmental research in that it can predict the timing of various developmental events using a series of predictors; researchers can predict *when* an event occurs and not simply whether or not the event has happened (Allison, 2004; Singer, & Willett 1994). In other words, we can predict how long it will take a specific child to reach a milestone based on the predictors he/she experiences. When a survival model is applied, missing cases can be retained as estimates, and the sample size can be protected. Thus, a survival approach offers an ideal means to examine time-situated events such as the onset of motor and linguistic markers.

Research Questions

A combination of survival and regression models were applied to address the research questions in this study and mother age was expected to operate differentially on language, cognitive, and motor domains. Overall, children of older mothers were projected to reach gross motor milestones (e.g. walking) later, but to reach language milestones (first words) earlier and to demonstrate greater receptive vocabulary at 4- to 5-years of age.

Several hypotheses were addressed in Study One: first, the association between mother age and the time-situated outcome age of attainment was assessed for motor and language milestones. Mother age was expected to positively predict age of first steps (older motherhood predicts later walking) and negatively predict age of first words (older motherhood predicts earlier talking).

Second, mother age entered as one covariate in a regression model to predict ability scores on the MSD (composite, motor, and social cognitive questions). It was projected that older motherhood would predict lower scores for motor items, higher scores for social cognitive items, and lower scores for composite items (all items combined).

Finally, regression analysis was used to assess mother age in relation to the score-based measure of receptive vocabulary provided by the PPVT-R. Mother age was expected to demonstrate a positive relationship with total PPVT-R score; older motherhood would predict better receptive vocabulary.

Methods

A large, longitudinal, and heterogeneous sample of children was required to test the proposed study hypotheses. Comprehensive datasets were needed to ensure that information was available for all relevant variables in each model. The National Longitudinal survey of Children and Youth (NLSCY), a longitudinal dataset collected from thousands of Canadian children, fit the aforementioned criteria and was used to address the research questions presented in Study One. Data collection for the NLSCY was carried out by Statistics Canada every two years and funded by Human Resources and Skills Development Canada (HRSDC). The NLSCY contains several longitudinal samples (representative of the original populations from which they were drawn) designed to capture the development and well-being of Canadian children from birth to adulthood.

Data collection for the NLSCY began in 1994/1995 (Cycle 1) and continues biennially. New samples of children are added to the NLSCY on a two-year cycle; each sample of children is followed until adulthood. The most recent data release (Cycle 8) includes data collected in December 2008. Copies of the master data files for the NLSCY were accessed through the Statistics Canada Research Data Centre (RDC) in Winnipeg, Canada.

Participants

The NLSCY target population consists of children from each of the 10 Canadian provinces living in private households. A complex, national sampling methodology is used within the NLSCY. Longitudinal and cross sectional samples have been drawn from Statistics Canada's Labour Force Survey's (LFS) list of respondent households with the exception of the sample of 0- to 1-year-olds recruited in 2000 (Cycle 4). Children in the exception category were selected from the provincial birth registry data for those years in addition to the LFS. Children who were living in institutions, on reserves, and/or on Armed Forces bases at the time of data collection were excluded from the NLSCY sampling frame at every cycle.

Two samples are included in the NLSCY at each cycle: the original cohort, a longitudinal sample selected at Cycle 1, and the Early Childhood Development (ECD) sample. The ECD group consists of children 0- to 7-years old at the time of data collection plus those children from previous cycles within the same age-range. Cycles 1 through 3 were omitted from the present study sample because some key variables were not collected by the NLSCY until Cycle 4 (2000-2001). The population for the present study was drawn from the ECD data collected in Cycles 5 (2002-2003), 6 (2004-2005), 7 (2006-2007), and 8 (2008-2009). The ECD dataset was constructed by Statistics Canada at Cycle 5; however, children who were 0 to 1 year old at the time of Cycle 4 data collection (December 31, 2001) were partitioned out for a comparable ECD dataset from Cycle 4 and included in this study. Children retained in the initial sample for this study were those whose biological mother was the survey respondent (person most knowledgeable; PMK) and whose cross-sectional weights were provided at each cycle.

The NLSCY is made up of several questionnaires and cognitive tests collected at each cycle. Questionnaires include: a child questionnaire (for 0-17 year-olds, completed by the person most knowledgeable; PMK), an adult questionnaire (for 0-17 years-olds, completed by the PMK), a self-completed questionnaire (for 12-17 year-olds, completed by the youth), a youth questionnaire (for 16 years and older, completed by the youth), and several cognitive tests (administered by Statistics Canada). The child questionnaire, the adult questionnaire, and the child cognitive test components were utilized in this study. Factors that could be tied to both mother age and the outcomes of interest (language and motor development) were included in each model. Variables in each questionnaire are labelled according to a detailed structure developed by Statistics Canada. All variables were renamed from their original NLSCY coding to facilitate analysis, and several variables were combined to address the study questions.

Measures

All measures used in the study models were drawn from the child and parent questionnaire and are outlined in the following discussion. Various sub-samples and combinations of covariates were used in each model to test the corresponding study hypotheses. Univariate statistics and centering procedures for variables included for each model can be found in the corresponding results section.

Milestone attainment. Key milestones (walking and talking) were assessed using the developmental milestones (MIL) section of the child questionnaire booklet. These questions asked PMKs to recall the age in months their child reached each milestone addressed. Questions in the MIL section were only presented when children were between the ages of 0 and 47 months at the time of the interview. Whether these estimates are recalled accurately is not really known by Statistics Canada; however, several researchers have found parent-reports to be valid and reliable measurements of easily observable events such as walking (Donoghue & Shakespeare, 1967) and first words (Zambrana, Ystrom, & Pons, 2012).

First words. Age of first words was measured using the following question: *"at what age (in months) did your child start saying his/her first word? By word, I mean a sound or sounds a baby says consistently to mean someone or something such as 'baba' for 'bottle'".*

First steps. Age of first steps was measured using the following question: *"at what age (in months) did your child take his/her first steps?"*

Motor and social ability. The motor and social development scale was used in the NLSCY to assess children's motor, cognitive, and social development. The MSD is appropriate for children 0 to 47 months of age and consists of 48," *Yes/No*" questions. Questions vary by the age of the child at the time of the interview and are asked in sets of 15 questions corresponding to the child's age in months. Appendix A includes a complete description of questions asked at each age. MSD scores reflect the sum of *yes* responses for each age regardless of developmental domain (Statistics Canada, 2007). The NLSCY includes both standardized and raw scores for the MSD. Cycles 1 through 3 included all 48 questions of the MSD, but the first 8 items lacked variation and were dropped from later cycles. Cycles 4 through 8 include items 8 to 48 of the MSD, and these 40 questions were used in the present study. Social/cognitive and motor scores were separately analyzed as outcome variables in addition to overall summed scores. Appendix A includes a description of the motor and social cognitive items used in this study.

Receptive vocabulary. Early vocabulary skills were assessed using the Peabody Picture Vocabulary Test-Revised (PPVT-R). The Peabody Picture Vocabulary Test- Revised (PPVT-R) is a measure of receptive vocabulary (words the child can understand and respond to) and has been extensively tested through large-scale norming studies. In the NLSCY the PPVT-R was administered to children between the ages of 4 and 5 years by a research associate employed by Statistics Canada. Tests were administered using computer assisted technology within the child's home. The PPVT-R is composed of a number of pictures that are identified and matched to a word read out loud by the research associate. Raw scores for the PPVT-R were utilized in the present study (Statistics Canada, 2007).

Maternal age. Maternal age was assessed using the "*age of biological mother at the birth of this child*" variable from the NLSCY adult questionnaire. Maternal age was recorded as age in years and was used as a continuous variable in this study. No modifications to the existing NLSCY variable were made.

Marital status. Many children live in common-law households. To account for those children who live in dual-parent households, but whose parents are not married a *number of adults* living in the house variable was created and used as a proxy for marital status. The NLSCY relationship status variable *"what is your marital status"* with responses *"married, common-law, single, divorced, and widowed"* was recoded as *1 = single parent household* (included: single, divorced, and widowed), and *2 = dual parent household* (included: married or common-law).

Mother education. Mother education was measured using the question "*What is the highest grade or level of education you have completed?"* Potential responses ranged from "0 = *no education*" to "13 = *earned Doctorate*".

Parenting Style. Three parenting scales were included in the NLSCY to measure parent/child interactions on three dimensions: positive, ineffective, and consistent across various age groups. Scores on the positive and ineffective parenting scales for 0- to 1- year-olds and 2- to 5- year-olds were used in the present study. Parents were asked to report on several possible parent/child interactions and rate how often they engaged in each behaviour. For example, *"How often do you praise this child, by saying something like 'Good for you!' or 'What a nice thing you did" or that's good going?"* The scales ranged from "*1 = never* to *5 = many times a day*". A complete description of questions that comprise each subscale of the parenting questionnaires, the ages at which each question was asked, and the Cronbachs' Alpha for each index can be found in Appendix B.

Gestational age and ponderal index. A "gestational age in weeks" variable was included to control for gestational age. Gestational age in weeks was calculated by subtracting the child's birthdate from their due date. Ponderal index (a measure of chubbiness) is comparable to BMI and allows for a fairer comparison between individuals of different statures. Ponderal index has been linked related to motor outcomes such that larger infants reach motor milestones later than leaner infants (Eaton, 2008). A "*Ponderal Index (PI)*" variable was calculated using a standard ponderal index formula *100*(child birth weight (grams)/ child birth length (cm)).*

Child Health. Poor overall health can be linked to delays on both motor and cognitive domains. General health was assessed using a question about overall health, "*in general, would you say this child's health is... excellent, very good, good, fair, or poor?*"

Birth order. Birth position has been linked to motor attainment and inconclusively found to impact language development (Oshima-Takane, Goodz, & Devernsky, 1996; Pine, 1995; Zambrana, et al., 2012). A *birth position* variable was created using the following formula: number of older siblings + 1.

Breastfeeding. PMKs were asked a series of questions about breastfeeding practices. There was a significant amount of missing data on the duration of breastfeeding questions asked by the NLSCY, so the dichotomous "*ever breastfed"* (*yes/no*) variable was used in this study.

Child education. When examining child receptive vocabulary, level of education was controlled for using the variable "*School grade (national level) child is currently enrolled*'. Child education was only recorded for children who were 4 and 5 years at the time of data collection.

Primary child care. Childcare was included to examine whether differences in motor or language domains could be partially accounted for by type of care. The primary childcare variable was created using the following question *"what is your primary type of childcare?"* responses included: *"no child care, child cared in the home by a relative, child cared for outside of the home by a relative, child cared for outside of the home by a non-relative, and care in a childcare centre".*

Statistical Design

Survival analysis. The ability to include missing data for dependent variables is one of the largest benefits of using survival analysis to predict the timing of an event (or hazard). In survival analysis the hazard creates a plot of the probability of 'survival' versus time. Applying survival analysis to developmental studies creates a probability plot (or hazard ratio) for the event (age of attainment) while identifying the predictors that facilitate the onset of developmental milestones (Singer & Willett, 1994). Outcome variables for survival models may be censored in three ways: 1) the event was recorded (data point); 2) the event occurred before data collection took place and the timing is unknown (left censored); or 3) the event occurred after data collection took place and the timing is unknown (right censored). In this study items either contained data points or were right censored (took place after data collection).

Questions relating to milestone attainment were administered to participants from 0 to 47 months of age (one bi-annual cycle NLSCY) and typically occurred during the initial study time point for participants. The developmental milestone questions were not asked retroactively within the NLSCY; when a child was older than 47 months during their initial round of data collection milestone questions were skipped. Similarly, if a child was between 0 and 47 months but had not reached the milestone of interest at the time of the interview, the age of attainment was recorded as missing. The result of each scenario is a sample comprised of data points and only right censored data (children who have not reached the milestone). PHREG, a semi-parametric survival model based on Cox's Regression was used to account for this right truncated dataset (Allison, 2008).

Regression analysis. Hierarchical multiple regression models were used to analyze the hypotheses which included non-time situated outcomes (e.g., MSD and PPVT-R scores). A hierarchical regression was selected because it allowed for an assessment of the relationship between mother age and the outcome variables after other influential variables were accounted for (Cohen, Cohen, West, & Aiken, 2002; Miles & Shevlin, 2007). Each covariate group was entered as one step in the regression model with mother age entered in the last step. Only those participants with complete data on each of the covariates and the outcome variable were included in the analysis. Non-time situated outcomes (e.g., gesture and vocabulary ability) were assessed using several regression models. Each model included two groups of covariates: child characteristics (child gender and gestational age) and household characteristics (e.g., number of children in the house, marital status, childcare), and mother age. In this study all variable sets were forced into the model. Retaining predictors through each step of the model allowed for an analysis of mother age effects regardless of significance.

Results

The goal of Study One was to examine mother age effects using a series of statistically sensitive models. Mother age effects were suspected to operate differentially on child motor and language domains from birth to 5 years. Three sets of analyses were conducted to assess the overarching research question. First, when the outcome was a time-situated event (e.g., age of attainment) survival analysis was used to examine mother age as a predictor for motor (age of walking) and language outcomes (age of talking) in children from 0 to 47 months. Second, when the outcome was a non-time situated event a series of regression models were used to assess mother age effects on motor, social/cognitive, and combined motor/social cognitive outcomes using the MSD questionnaire at 0 to 47 months. Finally, regression analysis was used to explore mother age effects in relation to receptive vocabulary scores at 4 and 5 years of age. SAS version 9.3 and SUDAAN Standalone programs were used to conduct all statistical analyses.

The total sample for Study One was drawn from the ECD files contained in Cycles 4 through 8 of the NLSCY. Although each hypothesis required a specific sample several general exclusionary criteria were applied to the total initial sample. Only children whose PMK was their biological mother and who lived with that biological mother were included in the total study sample. Adopted mothers were dropped from the analysis because they made up less that 5% of the total eligible sample. Because there was no “age of adoption” variable contained in the NLSCY it was difficult to account for early experiences.

Covariates

There were 17 possible covariates considered for the various models that make up Study One. Each covariate and the corresponding study hypotheses are outlined in Table 1.

Multicollinearity checks were conducted on all covariates within each sub-sample. Variables were flagged if correlations between covariates were higher than $r^2 = .35$, further tests of tolerance and VIF scores were conducted on flagged variables. Covariates with VIF scores greater than 2 and/or tolerance values below 0.8 were eliminated from the corresponding model (Miles & Shevlin, 2007).

Table 1

Child, mother, and household characteristics included in one or more hypothesis test

	Hypothesis		
Variable	Walking and talking	Motor and social ability	Vocabulary
Child characteristics			
Age		√	√
Gender	√	√	√
Gestational age	√	√	
Ponderal index	√	√	
Birth order	√	√	√
Ever breastfed	√	√	√
Education			√
Child care	√	√	√
Mother characteristics			
Age	√	√	√
Number of adults	√	√	√
Education	√	√	√
Positive Parenting	√	√	√

Ineffective parenting demonstrated unstable effects in samples of younger children (0 to 3 years; Statistics Canada, 2007) and were highly skewed to the negative (most parents reported *never* engaging in these behaviors). Given the instability of the ineffective parenting scales these measures were removed from the analyses. The remaining covariates were used in one or more models.

Hypothesis 1: Motor and language attainment

The goal of objective one was to examine mother age effects using survival analysis and mother age as a continuous variable. It was suspected that mother age effects would positively predict age of first steps (older motherhood would lead to later first steps) and negatively predict age of first words when all covariates were accounted for (older motherhood would lead to earlier first words).

The SURVIVAL function in SUDAAN was not powerful enough to run the analysis required for this study and could not account for the right censored dataset. As a result, bootstrapping techniques were not applied to the milestone analyses, but standardized (normalized) weights were used in conjunction with the PHREG to assess the research questions. Applying normalized weights in SAS allowed for the consideration of survey weights without inflating the sample or effect sizes. Cross-sectional weight variables contained within the NLSCY were used to calculate an average weight for each cycle; weights were then combined using the formula: *new weight (all cycles) = cross sectional weight for cycle / mean weights for that cycle*.

Exclusions. Participants for the milestones analyses were drawn from the initial study sample as described previously. Only children who fell within the 0 to 47 month range were included in the milestones sub-sample. The goal of this study was to gauge age of first steps and first words in typically developing infants. Because the goal of this study was to examine mother-age effects in relation to healthy children, those who were born prematurely (i.e., those whose gestational age at birth was younger than 34 weeks) and/or whose parents reported that the child was in *'fair'* or *'poor'* health most of the time were excluded from the milestones sub-sample. A small number of children with more than 6 siblings were excluded, as were children who reportedly walked or talked at an impossibly young age (younger than 5 months in the first steps sample and younger than 3 months in the first words sample). Impossibly early attainment was selected to be consistent with guidelines presented by the World Health Organization (Wijnhoven, et al., 2004). The final milestones sub-samples included only those individuals with complete data on all covariates.

Attainment: First steps. It was hypothesized that children of older mothers would take their first steps later than children of younger mothers. Age of first walking was the event (or hazard) variable for the first steps survival model. Parents were asked by the NLSCY to report the age at which their child first walked. The mean age for first walking in this sample was 12.4 months (SD = 2.3).

Covariates. Mother education was highly correlated ($r > .35$) with mother age and number of adults prompting an investigation of the tolerance and variable inflation scores for mother education. Tolerance and VIF values indicated that the variable should be removed from the model. Two parenting scales are included in the NLSCY one for children from 0 to 12 months, and one for children over 12 months. Two parenting scales (one for each age) would have been needed to cover children in the survival models and the inclusion of two scales would violate the model assumptions. As a result parenting was removed from the analysis. The remaining child, mother, and household characteristics were centred and entered in the survival model (Table 2). Mother age was centred on the mean ($M = 29$), gestational age was centred on 40 weeks, and ponderal index was centred on the median (2.5).

Table 2

First steps sample characteristics and centred covariates for survival analysis

	Descriptive Statistics							
Continuous Predictors	*M*	Median	*SD*					
Mother age (years)	29.9	29	4.9					
Gestational age (weeks)	39.1	39.5	1.4					
Ponderal index	2.6	2.5	0.6					
	Percentage by survival analysis coding category							
Categorical predictors	-3	-2	-1	0	1	2	3	4
Number of adults[a]			12	88				
Ever breastfed[b]			16	84				
Child gender[c]				51	49			
Primary child care[d]				41	44	15		
Birth position[e]	--	--	--	--	--	--	--	--

Note. n = 10547, participants with complete data on all covariates.
[a]Number of adults categories: Single adult home, *dual adult home*.
[b]Ever breastfed categories: never breastfed, *breastfed*.
[c]Child gender categories: *Male*, female.
[d]Childcare categories: *in home by parent*, in home by non-parent, outside home.
[e]Birth position categories: *first born*, second, born third born, later than third born. This distribution could not be released by the RDC due to small sample sizes in the upper and lower quartiles.

Mother age effects were examined in relation to age of walking as measured by age of first steps (Table 3). Using survival analysis, it was hypothesized that mother age would decrease the risk of the hazard/event (first steps). In other words, as mother age increased there would be a decreased probability of the risk, or longer time to first steps (i.e., children of older mothers would walk later). Maternal age was confirmed as a significant predictor of age at first steps $x^2(1, 7) = 12.95$, $p < .01$ above and beyond each of the study covariates contribution to the prediction.

Table 3

Age of first steps as predicted by mother age and demographic covariates

Variable	Parameter Estimate	*SE*	x^2	Hazard Ratio
Infant Characteristics				
Gestational age	0.073	0.008	88.91*	1.08
Ponderal Index	0.001	0.017	0.00	1.00
Child Gender	-0.001	0.022	0.00	0.99
Ever breastfed	0.195	0.031	40.27*	1.22
Birth Position	0.014	0.013	1.27	1.02
Childcare	0.181	0.015	149.54*	1.20
Mother Characteristics				
Mother Age	-0.009	0.002	12.95*	0.99
Number of adults	-0.103	0.038	7.57*	0.90

Note. n = 10547. *Wald* = 311.45. *p < .01.

Number of adults living in the household, type of childcare, breastfeeding, and gestational age were found to be significant predictors of first steps in addition to mother age. According to this model: children of younger mothers, who were born on or after their due date, who live in dual-adult households, and have some type of childcare walk earlier. The statistic for each covariate reflects its ability to predict age of first steps independent of all other covariates.

Attainment: First words. In contrast to the first steps hypothesis, it was predicted that children of older mothers would speak their first words earlier than children of younger mothers. Age of first words was measured in the same manner as first steps; parents reported the age at which their child said his/her first words. The mean age for first words in this sample was 14.5 months (SD = 18.37).

Covariates. Mother education was removed from the model as the variable displayed the same level of collinearity in this sample it did in the first steps samples. Child, mother and household covariates used in the first words analysis were centered consistently with the first steps model (Table 4).

Table 4

First words sample characteristics and centred covariates for survival analysis

	Descriptive Statistics							
Continuous Predictors		*M*		Median		*SD*		
Mother age (years)		29.7		29.7		4.9		
Gestational age (weeks)		34.9		34.5		1.4		
Ponderal index		2.6		2.5		.6		
	Percentage by survival analysis coding category							
Categorical predictors	-3	-2	-1	0	1	2	3	4
Number of adults[a]			12	88				
Ever breastfed[b]			16	84				
Child gender[c]				51	49			
Primary child care[d]				40	44	16		
Birth position[e]	--	--	--	--	--	--	--	--

Note. *n* = 10544, participants with complete data on all covariates.
[a]Number of adults categories: Single adult home, *dual adult home*.
[b]Ever breastfed categories: never breastfed, *breastfed*.
[c]Child gender categories: *Male*, female.
[d]Childcare categories: *in home by parent*, in home by non-parent, outside home.
[e]Birth position categories: *first born*, second, born third born, later than third born.

Mother age as a predictor for age of first words was explored using a second survival analysis model. It was expected that mother age would accelerate the occurrence for the hazard/event (first words). That is, children of older mothers would say their first words earlier than children with younger mothers. Mother age was confirmed as a significant predictor for the timing of first words ($x^2(1, 7) = 51.38$, $p < .001$); however, the effect was not in the expected direction. Older motherhood predicted later age of first words in this model (Table 5).

Table 5

Age of first words as predicted by mother age and demographic covariates

Variable	Parameter Estimate	*SE*	x^2	Hazard Ratio
Infant Characteristics				
Gestational age	0.012	0.008	2.67	1.01
Ponderal Index	-0.013	0.016	0.67	0.99
Child Gender	0.122	0.022	32.15**	1.13
Ever breastfed	-0.003	0.029	0.008	0.99
Birth Position	0.004	0.029	0.08	1.00
Childcare	0.055	0.015	13.23**	1.06
Mother Characteristics				
Mother Age	-0.055	0.002	51.38**	0.98
Number of adults	-0.060	0.037	2.58	0.94

Note. *n* = *10544*. *Wald* = 110.34. ***p* < *.001*.

Hypothesis 2: Motor and social ability

Investigating mother age effects in relation to the MSD required a two-step approach: first, the total MSD score was examined using mother age as a continuous variable; second, the MSD was partitioned into motor and social/cognitive sub-sections to parse out differences related to each developmental domain, and each sub-section was analyzed as an outcome variable. A series of regressions analyses were conducted to address the study questions.

Exclusions. MSD questions were asked to children between 0 and 47 months old (see

Appendix A for a breakdown of questions asked at each age). Two samples were required to address the MSD hypotheses; a sample of younger children 0 to 23 months (younger sample) and a sample of other children 24 to 47 months (older sample). Splitting the sample at 24 months prevented any participants from being included in both the younger and older samples. Exclusions were the same for both groups. Children who were born prematurely (gestational age < 34 weeks), who had more than 6 siblings, and those whose parents reported that the child was in '*fair'* or *'poor'* health most of the time were excluded from each of the MSD sub-samples to ensure the samples included typically developing, health children.

Multiple regression models were used with appropriate survey and bootstrap weights for each cycle in Standalone SUDAAN. Bootstrapping was used to produce variance estimates and account for the complexity of the NLSCY survey design. Cross-sectional bootsrap weights supplied by the NLSCY were applied using the balanced repeated replicates (brr) option.

Covariates. There were slight variations in the covariates included for each age group. Child covariates in the younger sample included: age, gestational age, ponderal index, gender, birth position, childcare, and breastfeeding. Gestational age, ponderal index, and breastfeeding were not included in the older models. These variables are temporally distant from, and not as relevant to, developmental processes at 24 to 47 months of age. In addition, there were large amounts of missing data on the breastfeeding variables in the older age group which significantly reduced the sample size. Mother characteristics were the same for both age groups and included: age, education, number of adults in the home, and positive parenting. Descriptive statistics for the centred continuous covariates Gestational age (40 weeks), mother age (29 years), and ponderal index (2.5) can be found in Table 6 and Table 7.

Table 6

Younger sample (0 to 23 months) sample characteristics and centering for regression covariates

Continuous Predictors	Descriptive Statistics		
	M	Median	*SD*
Mother age (years)	29.9	30	5.2
Child age (months)	13.3	13	5.1
Gestational age (weeks)	39.1	39.4	1.4
Ponderal index	2.6	2.5	0.6
Positive parenting	17.6	18	2.1

Categorical predictors	Percentage by survival analysis coding category							
	-3	-2	-1	0	1	2	3	4
Mother education[a]	10	16	15	59				
Number of adults[b]			10	90				
Ever breastfed[c]			15	85				
Child gender[d]				51	49			
Primary child care[e]				52	37	11		
Birth position[f]				44	38	13	4	1

Note. n = 9850 participants with complete data on all covariates.
[a]Number of adults categories: Single adult home, *dual adult home*.
[b]Ever breastfed categories: never breastfed, *breastfed*.
[c]Child gender categories: *Male*, female.
[d]Childcare categories: *in home by parent*, in home by non-parent outside home.
[e]Birth position categories: *first born*, second, born third born, later than third born.

Table 7

Older sample (24 to 47 months) sample characteristics and centering for regression covariates

Continuous Predictors	Descriptive Statistics		
	M	Median	*SD*
Mother age (years)	29.7	29.8	4.5
Child age (months)	33	32	5.4
Positive parenting	16.9	17	2.0

Categorical predictors	Percentage by survival analysis coding category							
	-3	-2	-1	0	1	2	3	4
Mother education[a]	11	19	15	54				
Number of adults[b]			13	87				
Child gender[c]				51	49			
Primary child care[d]				31	48	21		
Birth position[e]				45	37	13	4	1

Note. n = 11753 participants with complete data on all covariates.
[a]Number of adults categories: Single adult home, *dual adult home*.
[b]Ever breastfed categories: never breastfed, *breastfed*.
[c]Child gender categories: *Male*, female.
[d]Childcare categories: *in home by parent*, in home by non-parent, outside home.
[e]Birth position categories: *first born*, second, born third born, later than third born.

Ability: Motor and social development. The continuous variable mother age was used to predict overall motor and social development as measured by the raw total MSD score (composite MSD) to clarify the results of Bushnik and Garner (2008). It was anticipated that children with older mothers would have lower scores for the composite MSD score when all other predictors were controlled in both age groups.

The hypothesis was confirmed, mother age was negatively related to composite MSD score across both age groups: younger (0 to 23 months), R^2 = .05, t = -3.70, p < .001, and older

(24 to 47 months), $R^2 = .09$, $t = -2.14$, $p < .001$. Children of older mothers had lower composite MSD scores. Several additional characteristics were found to predict composite MSD score in addition to mother age (Table 8).

Table 8

Composite MSD score younger and older groups predicted by mother and child characteristics

	Younger (0 to 23 months)[a]			Older (24 to 47 months)[b]		
Variable	Parameter Estimate	*SE*	*t*	Parameter Estimate	*SE*	*t*
Intercept			22.39**			17.91**
Child age	-0.06	0.01	-7.38**	0.32	0.01	47.31**
Child gender	0.34	0.08	4.46**	0.97	0.07	13.80**
Gestational age	0.20	0.03	7.56**			
Ponderal index	-0.08	0.07	-1.05			
Birth position	0.01	0.05	0.13	-0.01	0.04	-0.30
Ever breastfed	0.20	0.10	1.97*			
Childcare	0.31	0.06	5.01**	0.21	0.06	3.72**
Mother education	-0.11	0.04	-2.88*	0.15	0.03	4.33**
Number of adults	0.01	0.14	0.07	0.18	0.12	1.57
Positive parenting	0.20	0.02	9.70**	0.14	0.02	7.71**
Mother age	-0.03	0.01	-3.70**	-0.02	0.01	-2.14*

Note. $^{*}p < .05$. $^{**}p < .001$.
[a]$R^2 = 0.05$. $n = 9848$.
[b]$R^2 = 0.39$. $n = 11751$.

In addition to overall motor and social development, the MSD questions were partitioned into separate social/cognitive and motor categories. These domain-specific categories were then used as outcome variables. Examining the MSD by developmental domain helped to explore the possibility that differences associated with motor and cognitive scores were offset by one another when the composite score was considered. Children of older mothers were expected to have lower scores on the motor items and higher scores on the social/cognitive items of the MSD questionnaire. Social/cognitive and motor scores were analyzed as outcome variables in separate models to determine whether social/cognitive and motor domains were differentially influenced by mother age.

The 40 eligible MSD questions were examined by two independent coders (99% agreement) and categorized to create the motor and social/cognitive indices. Appendix A includes a description of questions included in each index. Reliability estimates for each of the indices exceeded acceptable thresholds (α > .70) and both motor and social/cognitive scores were used as outcome measures for each age group (younger and older). Covariates included in the supplementary analyses mirrored those used in the MSD composite analyses.

Ability: Motor Development. When examining mother age effects and motor development scores alone it was anticipated that mother age would demonstrate a negative relationship with overall motor score (older motherhood would lead to lower scores). The hypothesis was confirmed in the 0 to 23 month age group; a negative relationship was found between mother age MSD motor score, R^2 = .03, t= -2.56, p = .01. However, no significant relationship between mother age and motor score in the 24 to 47 month group, R^2 = .08, t = 0.88 p >.05. Primary childcare, gestational age, child age, breastfeeding, and positive parenting were also found to significantly predict MSD motor score in the younger group (Table 9). In this model children who were cared for by non-parents, who were breastfed, had later gestational ages and whose parents engaged in more positive parenting practices had higher motor ability ratings. Surprisingly, younger children also had more reported motor skills. Similar patterns were found in the 24 to 47 month group. Positive associations were found for primary childcare, child age, positive parenting, and birth position were significant predictors of MSD motor score (Table 9). Children in the older group whose birth position was later than first born, who were older, who were cared for by non-parents, and whose parents engaged in more positive parenting practices had higher motor ability scores measured by the MSD.

Table 9

Motor MSD score younger and older groups predicted by mother and child characteristics

	Younger (0 to 23 months)[a]			Older (24 to 47 months)[b]		
Variable	Parameter Estimate	*SE*	*t*	Parameter Estimate	*SE*	*t*
Intercept			17.66**			13.71**
Child age	-0.03	0.01	-5.07**	0.09	0.00	31.96**
Child gender	-0.04	0.06	-0.73	0.02	0.03	0.70
Gestational age	0.14	0.02	7.10**			
Ponderal index	-0.01	0.05	-0.10			
Birth position	0.00	0.04	0.03	0.04	0.02	2.36*
Ever breastfed	0.15	0.08	2.02*			
Childcare	0.21	0.04	4.89**	0.07	0.02	2.70*
Mother education	-0.01	0.03	-1.31	0.01	0.02	0.44
Number of adults	-0.07	0.11	-0.60	0.08	0.05	1.51
Positive parenting	0.11	0.02	6.83**	0.04	0.01	4.76**
Mother age	-0.02	0.01	-2.56*	0.00	0.00	0.88

Note. *$p < .05$. ** $p < .001$.
[a]$R^2 = 0.03$. $n = 9850$.
[b]$R^2 = 0.18$. $n = 11753$.

Ability: social/cognitive development. Mother age effects on cognitive domains have not been previously examined in younger children. Based on previous studies that found positive relationships between mother age and cognitive abilities in 5-your-olds, it was suspected that a positive relationship would extend to mother age and social/cognitive scores on the MSD among 0- to 47- month-olds (Taanila, et al., 2005). However, the mother age hypothesis in relation to social/cognitive scores was not confirmed. Surprisingly, mother age was negatively related to social/cognitive scores, $R^2 = .05$, $t = -2.83$, $p = .01$, among younger children (0 to 23months), but was not significantly related to social/cognitive scores in older children (24 to 47months). In other words, between the ages of 0 and 23 months children of older mothers have lower social/cognitive scores as measured by the MSD, and these effects were no longer significant over 24 months of age.

Furthermore, the models for younger and older children are distinctly different. In addition to mother age, mother education (less education), gestational age (older), child gender (girls), child age (older), and increased positive parenting practices were found to predict higher social/cognitive scores in the younger group. While primary childcare (children cared for by non-parents), dual adult homes, gender (female), child age (older), birth position (first born), and more positive parenting predicted higher social/cognitive scores in the older group. Table 10 provides a detailed description of the model associated with each age group.

Overall the hypotheses relating mother age to MSD outcomes were partially confirmed. Mother age has a significant influence on motor and social/cognitive scores in younger children, but these effects do not extend to children in the older group (over 24 months).

Table 10

Social/Cognitive MSD score younger and older groups predicted by mother and child characteristics

<table>
<tr><th></th><th colspan="3">Younger (0 to 23 months)[a]</th><th colspan="3">Older (24 to 47 months)[b]</th></tr>
<tr><th>Variable</th><th>Parameter Estimate</th><th>SE</th><th>t</th><th>Parameter Estimate</th><th>SE</th><th>t</th></tr>
<tr><td>Intercept</td><td></td><td></td><td>17.59**</td><td></td><td></td><td>16.27**</td></tr>
<tr><td>Child age</td><td>-0.01</td><td>0.00</td><td>-2.07*</td><td>0.20</td><td>0.01</td><td>39.87**</td></tr>
<tr><td>Child gender</td><td>0.34</td><td>0.04</td><td>8.42**</td><td>0.80</td><td>0.05</td><td>15.49**</td></tr>
<tr><td>Gestational age</td><td>0.06</td><td>0.01</td><td>4.24**</td><td></td><td></td><td></td></tr>
<tr><td>Ponderal index</td><td>-0.06</td><td>0.04</td><td>-1.49</td><td rowspan="2">-0.12</td><td rowspan="2">0.03</td><td rowspan="2">-4.00**</td></tr>
<tr><td>Birth position</td><td>0.00</td><td>0.03</td><td>0.09</td></tr>
<tr><td>Ever breastfed</td><td>0.01</td><td>0.05</td><td>0.24</td><td></td><td></td><td></td></tr>
<tr><td>Childcare</td><td>0.05</td><td>0.03</td><td>1.35</td><td>0.19</td><td>0.04</td><td>4.37**</td></tr>
<tr><td>Mother education</td><td>-0.06</td><td>0.02</td><td>-2.57*</td><td>0.16</td><td>0.03</td><td>6.01**</td></tr>
<tr><td>Number of adults</td><td>0.05</td><td>0.07</td><td>0.65</td><td>0.20</td><td>0.08</td><td>2.40*</td></tr>
<tr><td>Positive parenting</td><td>0.13</td><td>0.01</td><td>10.09**</td><td>0.10</td><td>0.01</td><td>7.91**</td></tr>
<tr><td>Mother age</td><td>-0.01</td><td>0.00</td><td>-2.83**</td><td>0.00</td><td>0.01</td><td>0.20</td></tr>
</table>

Note. $^*p < .05$. $^{**}p < .001$.
[a]$R^2 = 0.05$. $n = 9850$.
[b]$R^2 = 0.35$. $n = 9021$.

Hypothesis 3: Vocabulary

This study aimed to strengthen previous findings that linked older motherhood to better language ability in early childhood by examining mother age in relation to receptive vocabulary among 4- and 5- year-olds. Mother age was expected to positively predict vocabulary scores even after several additional covariates were accounted for. The PPVT-R was used to measure receptive vocabulary and was entered as the outcome variable in a regression analysis designed to test the aforementioned hypothesis. Standalone SUDAAN was used to apply cross-sectional bootsrap weights using the brr option.

Exclusions. The PPVT-R was administered to children who were 4 and 5 years old at the time of the survey cycle and those children made up the sub-sample used in this analysis. As with the previous hypotheses, children under 34 weeks gestational age, who were in *"poor"* or *"fair"* heath, or had more than 5 siblings were removed from the PPVT-R.

Covariates. Covariates included in the PPVT-R analysis were consistent with those used in the MSD older sample analysis with the addition of child education (Table 11).

Ability: Receptive vocabulary. Mother age effects in relation to receptive vocabulary were assessed by regressing the continuous variable mother age on PPVT-R score. It was hypothesized that children of older mothers would have higher scores on the PPVT-R than children of younger mothers. The expectation was confirmed. Mother age was found to be a significant predictor for PPVT-R score, $R^2 = .20$, $t = 5.80$, $p < .001$. Several additional characteristics were found to predict receptive vocabulary in addition to mother age, namely, child gender, birth position, and positive parenting. A complete description of the PPVT-R model can be found in Table 12.

Table 11

PPVT-R sample characteristics and centered covariates for regression analysis

	Descriptive Statistics							
Continuous Predictors	*M*			Median		*SD*		
Mother age (years)	29.7			29.7		4.7		
Child age (months)	59.2			59		5.4		
Positive parenting	15			15		2.1		
	Percentage by survival analysis coding category							
Categorical predictors	-3	-2	-1	0	1	2	3	4
Mother education[a]	10	18	15	57				
Child education[b]		7	34	58	1			
Number of adults[c]			14	86				
Ever breastfed[d]			19	82				
Child gender[e]				51	49			
Primary child care[f]				36	42	22		
Birth position[g]				44	38	13	3	2

Note. n = 7250, participants with complete data on all covariates.
[a]Mother education categories: less than secondary, secondary school graduation, beyond high school, college, *university or trade*.
[b]Child education categories: not in school, junior kindergarten, *kindergarten*, grade one
[c]Number of adults categories: Single adult home, *dual adult home*.
[d]Ever breastfed categories: never breastfed, *breastfed*.
[e]Child gender categories: *Male*, female.
[f]Childcare categories: *in home by parent*, in home by non-parent, outside home.
[g]Birth position categories: *first born*, second, born third born, later than third born.

Table 12

PPVT-R score predicted by mother age, child and household covariates

Variable	Parameter Estimate	*SE*	*t*
Intercept			-7.62**
Child age	1.30	0.08	16.87**
Child gender	1.37	0.62	2.24*
Child Education	0.82	0.61	1.33
Birth position	-2.51	0.37	-6.87**
Ever breastfed	2.03	0.91	2.24*
Childcare	0.93	0.47	1.99*
Mother education	2.29	0.36	6.31**
Number of adults	2.29	0.95	2.42*
Positive parenting	0.49	0.14	3.40**
Mother age	0.44	0.08	5.80**

Note. $n = 7250$. $R^2 = 0.20$. $^*p < .05$. $^{**}p < .001$.

Discussion

Mother age is a factor of growing importance but is relatively understudied in the current developmental literature. The overarching goal of Study One was to explore the story of mother age using sensitive statistical methods in a large sample of Canadian children. Previous research has suggested that mother age influences motor domains during infancy up to about 18 months (e.g., age of walking), but language and cognitive domains later in childhood (Bushnik & Gerner, 2008; De Jaeger & Eaton, 2010; Eaton, Bodnarchuk, McKeen, & De Jaeger 2007).

This study aimed to clarify some of the effects reported by Bushnik and Gerner (2008) regarding mother age and child outcomes. Several outcomes were used to explore mother age effects and child outcomes. The first series of models examined mother age effects on the timing of motor (first steps) and language (first words) attainment. Survival analysis was used to investigate whether mother age effects predicted the onset of walking and talking. The expected pattern of mother age effects (older motherhood predicts later attainment) was revealed for both motor, and, surprisingly, first words attainment in 0- to 24-month-old children. The second set of models used regression analysis to explore the relationship between mother age and each of the social/cognitive, motor, and composite MSD indices. The MSD contains several parent-report questions asking whether or not the child is able to engage in a specific motor or social/cognitive skill. Consistent with previous findings increases in mother age led to decreases in motor ability and social/cognitive ability scores for children up to 23 months. Mother age effects disappeared for children over 24 months when motor and social/cognitive domains were investigated separately. Finally, the relationship between mother age and receptive vocabulary was examined in 4- and 5- year-olds. As expected, mother age effects were linked to PPVT-R scores such that older motherhood was related to better receptive vocabulary.

Taken together the results of this study imply that neither older nor younger motherhood is either inherently better or worse, but simply that mother age does not operate uniformly across age or developmental domain. In this study children of older motherhood were at a disadvantage for the timing of development (age of walking and talking), but once children reached the age of around 24 months older motherhood became an advantage (higher vocabulary scores).

Motor domains

Previous patterns of mother age effects for motor domains suggest that children of younger mothers are at an advantage when it comes to motor attainment. Consistent patterns were expected to emerge in the present study when using age of attainment for first steps, and motor scores on the MSD. It was also anticipated that mother age effects would hold true for children from 0 to 47 months.

The hypothesis was partially confirmed; mother age was found to predict age of first-steps, and the children of older mothers took their first steps later. Applying a survival model to age of first steps demonstrated that children with older mothers were at lesser risk of reaching the ‘hazard’ of first steps. That is, as mother age increased so did the age of first steps. This direct relationship between mother age and age of walking held true even after all other covariates were accounted for.

Mother age effects also held true when predicting motor scores for younger children (under 24 months) on the MSD questionnaire. Children of older mothers had lower scores (fewer motor abilities) than children of younger mothers. This hypothesis was only partially confirmed, as mother age effects disappeared in children over 24 months. It is possible that there are different mechanisms related to mother age when children are younger ages and these mechanisms change as children get older.

The MSD contains 21 gross and fine motor items. It is possible that mother age effects are stronger for gross motor abilities over fine motor abilities and vice versa. This could be a possible explanation for the differences observed in mother age effects in the younger and older groups. For example, mothers could be more restrictive of their child’s gross motor activity at younger ages and less restrictive at older ages. The gross motor abilities measured in the 24 to 47 months group included activities such as jumping, climbing, etc. that inherently allowing children for opportunities of exploration. Children at younger ages are more likely to be held for longer periods of time and/or spend time in equipment that restricts movement such as swings and car seats. It is also likely that the proxy provided by mother age is only influential during the first 12 months when variation in gross motor development is relevant. For example infants vary greatly in their ability to walk (gait, posture, ability) however these effects disappear with maturation, and older children may be less influenced by mother-related behaviours with respect to environment.

Language domains

Older mothers display more sensitive and nurturing behaviours to their children (Bornstein, et al., 2006), and they also engage in more conversation-style play (Bornstein et al., 2008) both of which have been linked to attachment, self-efficacy, and language development (Bigelow, et al, 2010). It was suspected that these behaviours might lead older mothers to provide more opportunities for conversation than younger mothers, and these opportunities would extend to faster attainment for first words and higher vocabulary abilities. In addition, the predicted relationship between mother age and first words was generated under the assumption that early onset would parallel better vocabulary. Contrary to the expectations mother age effects did not operate in the suspected pattern when predicting age of first words (older motherhood predicted later, not earlier first words). Rather, and surprisingly, survival model results suggest the probability of saying first words is delayed for every year of mother age over 29 years. This finding was surprising given the previous relationship observed between language abilities and mother age.

The PPVT-R, a widely used measure of receptive vocabulary, was used in this study to replicate the positive relationship between mother age and receptive vocabulary. The results from this study were consistent with earlier findings confirmed that children of older mothers had the advantage when it came to language ability (receptive vocabulary). For example, children of mothers who are 35 years old at the time they are born will score 5 points higher than their peers on the PPVT-R. The PPVT-R is a valid and reliable measure of verbal intelligence and predictive of later academic achievement, so a gain of 5 points would suggest that children will likely perform better academically than their same-age peers.

Taken together the first words and PPVT-R analyses demonstrate variations in mother age effects when considering the underlying mechanisms of development. In addition these findings suggest that age of first words does not necessarily parallel later language ability. Reaching the milestone of talking happened later for children of older mothers in this study, but it seems once children begin talking they accelerate faster than their peers and their abilities become more sophisticated. Perhaps, the difference in mother age effects can be contributed to differences in the mechanisms required for language onset versus vocabulary development that are also associated with mother age. Previous findings indicate that later communication is predicted by early communicative ability, and that verbal ability is facilitated by opportunities for language practice (Prior, et al., 2008; Zambrana, et al., 2012). That is, one on hand, children who are provided with more opportunities to talk will become more frequent and sophisticated talkers. On the other hand, perhaps the onset of first words is more related to brain development. Considering these alternatives, one possible explanation for the difference in mother age effects might be a relationship between mother age and variation in either the biological development or language experiences presented to children.

Social cognitive domains

The MSD in its original format mixes motor skills and social/cognitive abilities. When considering the MSD composite score the results of this study are in line with the previous research conducted by Bushnick and Garner (2008); children of older mothers have lower composite scores than children of younger mothers. The interpretation of these results suggests that children of older mothers are at a disadvantage in that they have fewer motor and social/cognitive abilities than children of younger mothers. While composite effects hold true for children from 0 to 47 months of age (increasing mother age indicates lower MSD ability) but it tells us little about how mother age operates on each domain within the questionnaire. When the social/cognitive scores were isolated, mother age effects were present for children at younger ages (older motherhood resulted in lower ability) but disappeared for children over 24 months old.

When considering social/cognitive items of the MSD in isolation, insight was gained into how mother age operates in several social/cognitive areas. There are several aspects of social and cognitive development represented in the 19 social/cognitive MSD questions (numeric, social-cognition, language, gesturing) and only a few of these items were asked at each age. The degree of variation in the types of social/cognitive abilities represented and the relatively small number of questions for each ability highlight the ineffectiveness of the MSD to gauge overall social/cognitive development. Further investigation of with clearly defined variables is needed to decipher the meaning behind the relationships found in this study.

Limitations

The purpose of Study One aimed to examine mother age effects in a representative sample of Canadian children. While the NLSCY provided a large, rich dataset to address the study question, there are always pitfalls associated with secondary data analysis. Measurement of key variables was one issue related to secondary data analysis that was present in this study. Often studies such as the NLSCY are designed with a specific set of research questions in mind. While these large datasets can be useful for examining additional questions such as those presented in this study, future analyses are restricted to the variables available within the original datasets. For example, a main goal of Study One was to examine mother age effects in relation to language ability among children of various ages. No language ability measures for children under 4 years were found in Cycles through 8 of the NLSCY, so first words was used as a proxy for early language ability. As the results of this study demonstrate, a measure of early vocabulary in addition to first words would have helped to clarify the pattern of mother age effects on language domains.

The goal of this study was to explore mother age in Canadian children. It is unclear based on the results of Study One whether the pattern of mother age effects found in this study would hold true across cultures. It is possible that mother age effects would operate differently given wide variety of global child rearing practices.

Finally, this study has only examined mother age effects in pre-school children, yet the findings have revealed that mother age operates differently at various ages. Future studies utilizing the NLSCY could examine the effects of mother age on social and cognitive functioning into emerging adulthood.

Implications

The combined results of Study One confirm that mother age is definitely of importance when examining child outcomes. It is also becoming clear that variation in mother age (particularly older motherhood) may have considerable consequences across developmental domains and age groups. It seems as though mother age effects vary consistently with additional age-specific influences that begin at different times. Alternately, there may be core influences related to mother age that facilitate some outcomes and discourage others, and it is possible these influences would operate at the same time. To fully understand mother age effects it would be helpful examine whether the differential influence of mother age holds true when language and motor domains are studied simultaneously. To address this issue early language and first steps were examined in Study Two.

CHAPTER 4 – STUDY TWO

Examining Mother Age Effects as a Predictor for Walking and Gesture Use

The results of Study One make a strong case for the importance of mother age effects when studying child outcomes. Similar findings have implicated mother age as a variable of importance for both language and motor domains when examining children at different ages and stages of development (Bushnik & Gerner, 2008; De Jaeger & Eaton, 2010; Taanila, et al., 2005; Murray, et al., 2006). These patterns provide additional support for the hypothesis that mother age might be influencing different mechanisms at different ages (one for language and one for motor ability), but age-specific achievements in each domains have not been measured concurrently. In language domains mother age appears to influence attainment measures (first words at 12 to 24 months) differently from measures of later age-related ability (PPVT-R at 4 and 5 years). Such a pattern implies that mother age effects are not operating uniformly across developmental domains, outcomes, or developmental period.

The overarching goal of Study Two was examine whether the differential effects of mother age for motor and language outcomes hold true when these domains were measured concurrently in the same group of children. The difficulty with this hypotheses became apparent when considering age of attainment versus ability. Motor milestones are typically reached between 2 and 18 months while spoken language only begins to emerge around 12 to 14 months. Because most children are preverbal, there are no traditional spoken vocabulary measures that can be used concurrently with gross motor development during infancy. Consequently, infant gestures, the most common form of pre-verbal communication, were used in Study Two were considered as a measure of early language ability.

Infant Gesturing

Communication between infants and caregivers begins prior to the use of spoken language. Gestures are common pre-verbal communication tools that occur during infancy and several studies have demonstrated the importance of early symbolic gestures (the production of intentionally communicative actions) as the basis of language and shared actions or intentions (Crais, Watson, & Baranek, 2009; Bavin, et al., 2008; Capirci, Contaldo, Caselli, & Volterra, 2005; Capirici & Volterra, 2008; McGregor, 2008; Piaget, 1962, as cited by O'Reilly, Painter, & Bornstein, 1997). The emergence of language, particularly vocabulary has been theorized by many to stem from early gesture use (Bates & Dick, 2002; Iverson & Golden-Meadow, 2005; Crais, et al., 2009; O'Reilly, et al., 1997; Tsao, Liu & Kuhl, 2004). Furthermore, gesture abilities have been used with groups of late-talking children to identify who will 'catch up' and reach typical linguistic skills and who will not (Crais, et al., 2009).

There are two primary categories of gestures used by pre-linguistic children: *Deictic gestures* (e.g., showing or pointing) and *representational gestures* (e.g., games). Deictic gestures typically emerge around 7 to 10 months of age and mark the onset of child-initiated joint attention. These gestures coincide with a time when children begin to engage in triadic communications (those that involve the sharing of interest between child, parent, and external object; Bavin, et al., 2008). Children produce two types of deictic gestures: *contact gestures*, involving contact with a caregiver or object (e.g., pushing an adult's hand away to indicate '*no*') are the earliest to emerge at around 7 months of age (Crais et al, 2009). Distal gestures, those that do not require contact, are typically implicated in early joint attention activities such as pointing. Over 80 percent of the gestures produced by infants and young toddlers are deictic gestures (Thal & Tobias, 1992; as cited in Crais et al, 2009). Consistent, positive relationships have been found between the use of deictic gestures and later vocabulary comprehension; more gesturing predicts better vocabulary comprehension (Bates, Thal, Whitesell, Fenson & Oakes, 1989; as cited by Bavin, et al., 2008; Fenson, et al, 1993).

Representational gestures have also been sub-divided into two main categories: *Conventional gestures* (e.g., playing peek-a-boo, shaking head '*yes*' or '*no*') and *Recognitory or object related gestures*. Conventional gestures are used when children need to socially represent a concept. They emerge around 12 months of age and are typically acquired through conventional routines, games, or imaginary play with parents and other adults (Bavin, et al., 2008; Crais, Douglas, & Campbell, 2004; Fenson et al., 1993). Positive associations have also been found between conventional gestures and later vocabulary production (more gestures predicts better vocabulary production; Bates, et al., 1989; as cited in Bavin, et al., 2008). Recognitory gestures are used by children to symbolically represent some feature of a referent or object. For example, blowing to indicate something is hot. These gestures typically emerge around 12 months, a time when toddlers start to name objects. The use of recognitory gestures is believed to signal a child's awareness of object function and symbolic representation (Bates & Dick, 2002; Bavin, et al., 2008; Capone & McGregor, 2004). Taken as a whole the category of representational gestures has been positively associated with later language skills and are strongly related to child play behaviour (Bavin, et al., 2008; Crais, et al., 2004).

The MacAurther Bates Communicative Development Inventory (MCDI) is an extensively used and rigorously documented measure of early gesturing (Fenson et al, 1993; Fenson, et al., 2007). Both deictic and representational gestures can be measured using the MCDI and the tool has been generalized for use in other countries. Bavin and colleagues (2008) confirmed the positive relation between early gesture use (deictic and representational) and later vocabulary outcomes (measured by the MCDI) in a sample of Australian children. Additional studies established the MCDI as an acceptable measure to predict both vocabulary production and understanding at 12 and 24 months (Fenson, et al., 1993).

Early gesture use as measured by the MCDI has been well researched as a precursor to later language ability and was used in Study Two as a measure of pre-verbal language ability. Gesture learning is an interactive behaviour strengthened through reciprocal rehearsals between mothers and children. These rehearsals provide a scaffold for early word learning and are easily influenced by differences in maternal characteristics (McGregor, 2008). Older mothers have been found to engage in lengthier ‘conversation- style’ play and more sensitive, nurturing behaviours than younger mothers (Bornstein, et al., 2006). Because of the interactive nature of gesturing and the links between mother age and language found in earlier studies, it is plausible to hypothesize that mother age plays a role in gesture abilities. Early vocabulary was assessed in addition to gesture use for children in this study who had already started to talk. It was hypothesized that mother age would be positively associated with both gesture ability and vocabulary; children of older mothers would use more gestures (or say more words) than the children of younger mothers. A secondary goal of this study was to see if the previously found associations between mother age and early vocabulary at 4 and 5 years would spread to 1-year-old children.

Mothers play a key role in these developmental processes, but the benefits of older mothering in linguistic domains are not necessarily present in motor domains (De Jaeger & Eaton, 2010; Eaton, et al., 2014). The relationship between mother age effects and age of walking was examined in Study One using a Canadian sample of children. Because older motherhood is an increasing trend among well-off countries it was important to examine whether the established relationship between mother age and walking could extend to countries outside of Canada. The third goal of Study Two was to replicate the existence of mother age effects on age of first steps in a more heterogeneous international sample.

When considering language and motor domains it is important to take into account other characteristics that might contribute to variation in development. Several factors known to influence both motor and language development as outlined in Chapter 2 were used this study in addition to mother age.

Research Questions

The overarching goal of Study Two was examine whether the differential effects of mother age for motor and language outcomes hold true when these domains were measured concurrently in the same group of children. First, the association between mother age and onset of walking was tested using an international sample. Mother age was expected to demonstrate a positive association to age of first steps; older motherhood would be linked to later walking. Second, mother age was assessed in relation to gesture ability in the same group of children. Older motherhood was expected to predict better gesture ability. Third, the relationship between mother age and vocabulary was tested in a group of 8- to 36- month-olds. Mother age was expected to positively predict better vocabulary ability (children of older mothers would have increased vocabulary scores). Online parent report methodologies were used in Study Two to examine the outlined study questions in a timely and cost effective manner.

Methods

Participants

Mothers with infants between the 8 and 24 months were recruited as participants. This age range was selected because children typically begin using gestures around 8 months of age and walking usually occurs between 10 and 14 months. The lower limit (8 months) ensured that extremely early walkers and gesturers would be included in the study. The upper limit (24-months) was selected to minimize memory biases in the accuracy of parent recall for walking attainment. Gesture use declines with age and is replaced with 1- to 2-word sentences at around 24 months, so the 24-month limit also captures the age of most frequent gesture use.

Procedure

A cross-sectional, self-report, internet questionnaire was used to address the research questions addressed in Study Two. This study was approved by the University of Manitoba Research Ethics Board. A copy of the ethics certificate can be found in Appendix C. Online methodology was the ideal mechanism for this study because it provided an opportunity to reach the large and heterogeneous sample needed to assess the study questions and examine mother age effects in other countries.

Participants were primarily recruited with online text advertisements implemented with the Google Adwords system. A small number of participants were recruited from personal invitations. Interested parents were then asked to complete an online survey that was developed using the software program *Survey Gizmo 3.0*. The questionnaire was designed to capture measures of various child and parent related characteristics, milestone attainment, gesture use, and vocabulary, (a copy of the questionnaire can be found in Appendix D). All participant information was written to the host server at the end of each study portion in order to ensure that no data was lost from participants who exited prematurely.

Participants were accumulated using the following methods of online recruitment: AdWords through Google that ran 24 hours a day, 7 days a week (see Appendix E for a detailed explanation the Google Ad process used in this study). Ads were monitored for effectiveness using Google Analytics, and only those ads that produced most traffic to the study website were retained for the duration of recruitment. The Google algorithm compared the content of each ad to the content of the website; each ad was written so that it referred to some element of the study content. A click on the ad transferred the prospective participant to the study description. Second, personal invitations were sent to social networking sites such as Facebook and Twitter (a description of the personal invitation is outlined in Appendix E).

Measures

Previous studies suggest that parents seem to be highly motivated observers of their children’s behavior, and response rates have been found to be adequate when conducting online research using parent-report methods (De Jaeger & Eaton, 2010). Adequately utilized parent reports in conjunction with survey methodologies allowed for the collection of a large, rich dataset with a fraction of the resources (time and money) required by large-scale observational or laboratory studies (Bodnarchuk & Eaton, 2004; Clarke-Stewart, Fitzpatrick, Allhusen, & Goldberg, 2000; Donoghue & Shakespeare, 1967; Fenson et al., 1993; O'Neill, 2007). Parents can accurately recall events such as walking because they are easily observable, concrete and memorable (Donoghue & Shakespeare, 1967; Davis, Moon, Saches, & Ottolini, 1998). Infant gesture use and vocabulary has also been reliably reported by parents (Fenson et al., 1993), and parent report measures were utilized for each outcome measure.

When designing any type of correlational model it is important to remember that any relationships between characteristics and outcomes may also be attributed to other co-varying characteristics. Covariates for this study were selected based on the proximity of influence they have during infancy and early childhood.

Milestone attainment. Walking attainment was measured using an age of first steps variable developed by the World Health Organization (WHO) Multicentre Growth Reference Study (MGRS; Wijnhoven et al., 2004). Findings from the MGRS and other studies indicate that parents/caregivers are able to correctly determine the onset of major gross motor milestones (such as walking) with great accuracy when using similar definitions (Donoghue & Shakespeare, 1967; Bodnarchuk & Eaton, 2004). Parents were initially asked to report whether or not their child had "*Taken 5 or more short, distinct steps without any support. Arms are held apart and up for balance. May fall frequently* (*yes/no*)". If parents selected *yes* they were then asked to record the date when the event was first observed.

Gesture ability. The MCDI is one of the most widely used measures of early vocabulary and gesture use in early childhood. It comprises several scales designed to assess communicative development in children between 8 and 30 months of age (Fenson et al., 1993). The MCDI inventories have been extensively tested through large-scale norming studies, reflect high reliability and validity, and can be used in multicultural samples. Three of the five MCDI gesture scales were used in the present study: Section A, *"First Communicative Gestures"*, Section B, *"Games and Routines"*, and Section C, *"Actions with Objects"*. The gesture use indices only appear in the MCDI infant scales (0 to 17 months) because gesture use declines significantly once children become verbal. Gesture use sections were presented to all children in this study regardless of age.

The 12 items in Section A are designed to capture the onset of intentional communication. Items in this section include deictic gestures (initiators of joint attention), as well as conventionalized gestures (those with communicative intent such as shaking head "*yes*" or "*no*"). Mothers were asked to identify how frequently "*infants used the listed gestures to make their wishes known"* response options ranged from *often, sometimes, not yet*. A score of 1 was recorded for *often* and *sometimes* responses, and 0 was recorded for *not yet*.

Section B consists of 6 items designed to measure child-initiated social interaction through gesture use, items include thing such as "*plays peek-a-boo*". Finally, Section C contains 17 items that capture children's understanding of object use through the use of recognitionary gestures (Fenson et al., 1993). Sections B and C were scored using the same coding structure. Mothers were asked to answer a series of *'yes' or 'no'* indicating whether or not the child initiated the gestures in each section at the time of the survey. Responses were coded *yes* = 1 and *no* = 0 and summing the number of *yes* responses for each individual. A total gesture score was created by adding the total number of 1 scores form Sections A, B, and C.

Vocabulary. Two MCDI forms were used to measure vocabulary: the MCDI Level 1 Infant Very Short Form (0 to 17 months) consisting of 89 words was used to measure vocabulary comprehension and production, and the MCDI Level 2 Toddler Very Short Form (18 to 24 months) consisting of 100 items was used to capture productive vocabulary (Fenson et al., 2000). High intercorrelations between the early vocabulary indices and gesture scales of the MCDI (r = .51 to .74) have been reported, with the scores for gestures and vocabulary comprehension and production correlating most strongly with r's of .73 and .74 (Fenson et al., 1993).

The MCDI Level 1 Infant form required mothers to record the words her child *understands* and the words the child *understands and says*. Children in the 0 to 17 month age group end up with two scores for vocabulary: a *vocabulary comprehension* score (sum of words child *understands* and *understands and says*) and a *vocabulary production* score (sum of words child *understands and says*).

Mothers who received the MCDI Level 2 Toddler form were required to indicate all listed the words the child currently *says*. A *vocabulary production* score was created by summing the number of words recorded. A combined words component *"has your child begun to combine words yet, such as 'nother cookie' or 'doggie bite'?"* was used to measure sentence construction. Response options ranged from *often, sometimes, not yet.*

Mother age. A mother age variable was created as part of an 'About You' demographic questionnaire. Participants were asked to record the year of their birth. Infant year of birth was subtracted from mothers' year of birth to determine maternal childbearing-age and create the crucial *mother age* variable.

Marital status. A *number of adults* living in the house variable was created and used as a proxy for marital status. The *number of adults* variable was coded as *1 = single parent household*, and *2 = married or common-law*.

Mother Education. Participants were asked to report their most recently completed level of education on a seven-item scale ranging from *1 = some high school* to *7 = Doctorate.*

Mother Personality. Mother personality was assessed using the Ten Item Personality Inventory (TIPI), developed by Gosling, Rentfrow, and Swann (2003). Questions were developed using a combined list of unipolar and bipolar markers, and an adjective checklist of markers from the Big Five personality inventory (Goldberg, 1992, John, & Srivastava, 1999; as cited in Gosling et al., 2003). Questions contained in the TIPI of questions provide an accurate measurement for each of the five personality domains included in the Five Factor Model (openness, agreeableness, conscientiousness, extraversion, and neuroticism), which is probably the dominant current model for personality. Participants were asked to rate themselves on each of ten descriptor-pairs (two for each of the five personality traits) using a 7-point scale ranging from *"disagree strongly"* to *"agree strongly"*.

Socioeconomic Status. SES is not a universal construct and varies greatly depending on the society in which individuals live. Traditional measures of SES typically include income and education as two key factors indicating status; however, the levels of income and education can vary depending on the social/cultural context in which the person lives. For example a middle SES woman living in the United States might have higher income and more education than a middle SES woman living in India. Previous studies have found that SES can be related to mother age, age of walking, and gesture use (Bavin, et al., 2008; Williams & Scott, 1953), so SES was believed to be an important construct for this study. A measure of subjective social status, the MacArthur Scale of Subjective Social Status, was used in lieu of traditional measures of SES, which don't generalize well across countries and currencies (Goodman, et al., 2001; Operario, Adler, & Williams, 2004). Participants were asked to rank where they perceived themselves to fall on a 10-rung ladder representing status in their society. The MacAurthur Scale of Subjective Social Status has been demonstrated as a reliable and valid measure of income, education, and health outcomes (Goodman et al., 2001; Operario et al., 2004).

Gestational age. Gestational age was calculated by subtracting the child's birthdate from the mother's report of expected due date. Scores were then converted to gestational age in weeks and centred on 40 weeks (typical gestation). Participants with a gestational age less than 34 weeks were considered premature and not included in the final study sample.

Child Health. General health was assessed using the overall child health question from the NLSCY: "*in general, would you say this child's [your] health is... excellent, very good, good, fair, or poor?*"

Number of siblings. The number of other children living in the household was asked in the "About Child" section of the questionnaire as a proxy for birth order. Children with less than 6 siblings were included in the final study sample. Number of other children was included in lieu of birth order to account for the effects of mixed families.

Breastfeeding. Mothers were asked whether or not they breastfed their child even for a brief period of time (*yes/no*). The resulting "*ever breastfed"* variable was used in this study.

Statistical Design

This cross-sectional study included both time-situated (age of attainment) and ability measures. Survival analysis was used to examine the relationship between mother age and motor attainment, while regression models were applied to the gestures and vocabulary models.

Survival analysis. In this study the age of first steps measure resulted in three possible outcome points: 1) an age of attainment (mother reported *yes* the child had walked and an age in moths was entered, 2) left censored data (mother reported *yes* the child had walked but the age of attainment was unknown), and 3) right censored data (mother reported *no* the child had not walked at the time of the study). The resulting right and left censored dataset was analyzed with the parametric survival model LIFEREG, and a gamma distribution (Allison, 2008).

Multiple regression analysis. Non-time situated outcomes (gesture and vocabulary ability) were assessed using several regression models. Each model included two groups of covariates: child characteristics (child gender and gestational age) and household characteristics (number of children in the house and SES), and mother age. Each group was then entered as an individual step in the regression model. A forward linear regression with two steps was used to examine each of the variable sets. Using a forward selection model typically adds variables into the model until no remaining variables produce a significant *F*-value. In this study both variable sets were forced into the model. Retaining predictors through each step of the model allowed for an analysis of mother age effects regardless of significance.

Results

There were two main objectives in Study Two: first, the study aimed to determine whether mother age effects would be found in relation to infant gesture use and early vocabulary. Second, the relationship between mother age and age of first steps assessed. SAS 9.3 was used to conduct all statistical analyses.

Data collection for Study Two occurred over eight months. The initial study sample consisted of $N = 1046$ *'responses*', individuals who came to the study, gave consent, and answered at least one question before leaving the survey. High attrition rates are one drawback of internet research. Many individuals will complete the first couple pages of an online questionnaire and abandon the survey partway through. To account for these attrition rates and ensure that key variables were included in the study analysis, individuals who completed enough of the study to enter their child's birthdate (page 6 of the online survey) were included in the raw study sample ($n = 441$).

Exclusions. As with any online study parents with children who were older and younger than the targeted age-range completed the questionnaire. Children younger than 3 months ($n = 9$) and older than 47 months ($n = 4$) on the basis that they did not fit within the parameters of the desired sample. The focus of this study was mother age effects in relation to child outcomes among typically developing children. Participants who were not mothers (e.g., fathers) were not included in the analysis ($n = 50$), nor were non-biological mothers (adopted or step-mothers; $n =$

7). Children who were born prematurely (i.e., those whose gestational age at birth was younger than 34 weeks; *n* = 7), reported more than 6 general health issues (*n* = 1), and whose parents reported that the child was in *'fair'* or *'poor'* health most of the time (*n* = 25) were also removed from the sample. The option *'gout'* (an impossible disease to have during childhood) was included in the child health issues section to flag suspect responses. If gout was selected, the case was eliminated from the study sample (*n* = 3). Participants with an impossible first-steps date (e.g., the date of first steps was entered as a date that occurred before the child was born) and those who reportedly walked at an extremely young age (less than 7 months; *n* = 10) or at an extremely old age (over 18 months; *n* = 2) were eliminated as extreme outlier values. For a description of the remaining participants for each outcome measure please see Table 13.

Table 13

Participant Flow: participants retained and eliminated

Progress	Retained (*n*)	Eliminated (*n*)	Total (*n*)
Answered ‘*yes*’ to initial consent			1046
Provided child birthdate	441	605	441
Met inclusion criteria	323	118	323
Complete data on all covariates[a]	296	27	296
Reported first-steps information[b]	138	150	138
Reported gesture information[c]	171	125	171
Reported Level 1 vocabulary information[d]	37	259	37
Reported Level 2 vocabulary information[e]	30	266	30

[a]Initial study sample for all models.
[b]Initial sample size for mother age effects and walking model.
[c]Iniital sample size for mother age effects and gesture models. Total sample (3 to 36 months).
[d]Initial sample size for mother age effects and vocabulary model 3 to 17 months.
[e]Initial sample size for mother age effects and vocabulary model 17+ months.

Final sub-samples for each model were derived from the total study sample and included only those individuals with complete data on all covariates (n = 296) and the outcome in question. Table 14 provides a summary of the covariates used in Study Two. Mothers ranged in age from 13 to 42 years, with a mean of 29 years (*SD* = 5.2) and 93% reported living in dual-adult households (married or common law). The sample was internationally diverse with the highest number of participants coming from Western Europe and India (Figure 1).

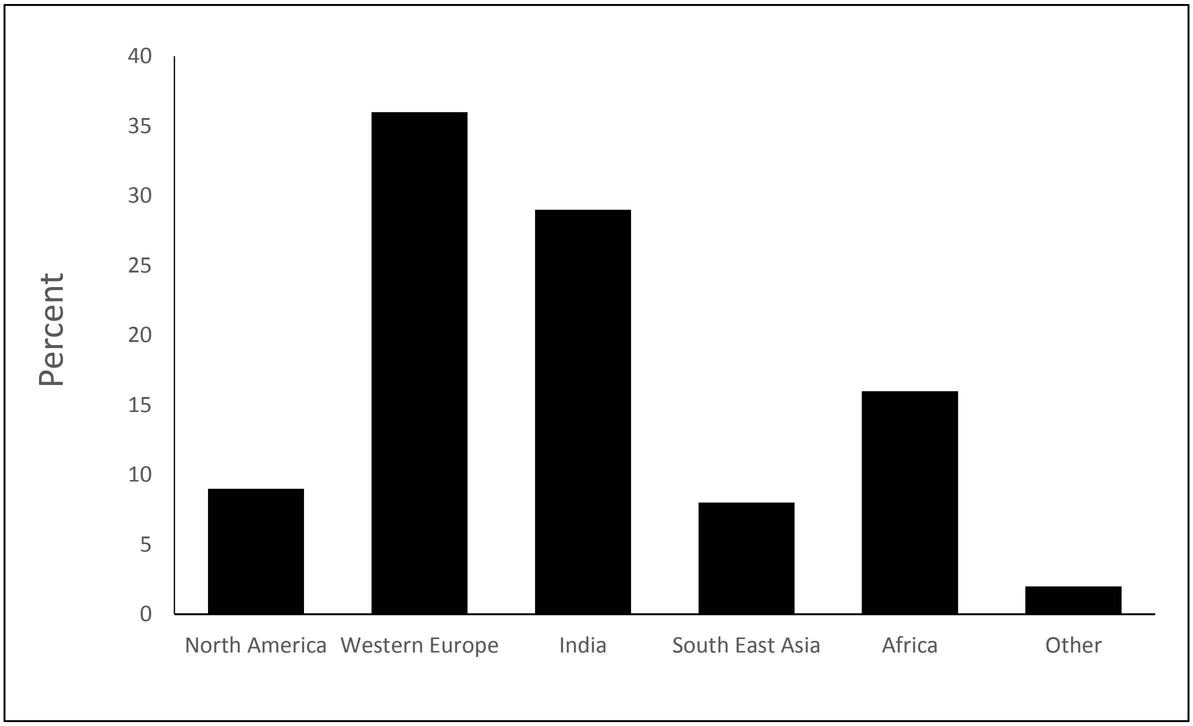

Figure 1. Percentage of sample by geographical region. $N = 296$.

Covariates. Subjective SES was included in each model instead of mother education because of international differences in educational opportunities. Mother, child, and household characteristics were centred and entered into the models. Table 14 below outlines the final centering procedure and descriptive statistics for each covariate. In this model mother age was centred on the mean ($M = 29$ years) and gestational age on 40 weeks (Table 14).

Multicollinearity checks were performed on each of the study covariates. Covariates with correlations above $r = .35$ were flagged and eliminated from the corresponding analysis. Correlations that approached the $r = .35$ limits were investigated using tests for tolerance (tolerance > .80) and variable inflation (VIF > 2) to ensure each covariate met the required independence assumptions. Covariates that violated the cut-off tolerance or VIF values were removed from the analysis.

Table 14

Sample mother, child, and household characteristics and centred covariates

	Descriptive Statistics							
Continuous Predictors	*M*	Median	*SD*	Minimum		Maximum		
Mother age (years)	29.2	29	5.2	13		54		
Gestational age (weeks)	39.3	39.4	1.4	35.6		43.1		
	Percentage by analysis coding category							
Categorical predictors	-4	-3	-2	-1	0	1	2	3
Child gender[a]					46	54		
Number of siblings[b]				66	25	7	1	1
Subjective SES[c]	2	5	13	24	27	14	7	8

Note. N = 296, participants with complete data on all covariates.
[a]Child gender categories: *female*, male.
[b]Number of siblings categories: *only child*, one sibling, two other siblings, three siblings, more than three siblings.
[c]Subjective SES categories: 3, 4, 5, 6, 7, 8, 9, 10. Centred on 7, M = 6.8, SD = 1.6.

Hypothesis 1: Motor Attainment

Replicating mother age effects on age of attainment for walking was an important first step in Study Two. Survival analysis was used to examine the hypothesis that later motherhood would lead to later age of walking. Data collected in this study included an indicator of whether the child had reached first steps (*yes/no*) and the date when the event occurred. The outcome variable age of attainment (first steps) was calculated by subtracting the recorded steps date from the child's date of birth in cases where the date of first steps was recorded. Age of first steps ranged from 7 to 19 months (M = 12, SD = 2.4).

Survival analysis was used to test the hypothesis that mother age would positively predict age of first steps. Greater mother age was expected to predict later onset of first steps. Mother age was, indeed, a significant predictor of age at first steps $x^2(1, 7) = 9.32$, $p < .01$. As expected older mothers had children with later first steps. In addition to mother age, gestational age was negatively associated with age of walking ($x^2(1, 7) = -13.20$, $p < .001$); children born before 40 weeks walked later. Table 15 outlines the complete survival model for walking attainment.

Table 15

Survival Model: Age of first steps predicted by mother, child and household characteristics

Variable	Parameter Estimate	*SE*	x^2	95% Confidence	
Gestational age	-0.04	0.01	13.20**	-0.06	-0.02
Child Gender	0.02	0.03	0.48	-0.04	0.08
Number of siblings	0.01	0.02	0.38	-0.02	0.04
SES	-0.02	0.01	2.78	-0.04	0.00
Mother Age	0.01	0.00	9.32*	0.00	0.02

Note. $N = 289$. $^{**}p < .001$.

Hypothesis 2: Gesture ability

Pre-verbal ability was measured using child gesture ability. A positive relationship between mother age and gesture use was expected (older mother have children who use and understand more gestures). Younger group (3 to 16 months) older group (17 months and older) sub-samples were created and used to assess the gesture hypothesis.

Four scores were used to measure gestures in both age groups. The summed score for first communicative gestures section included both gestures that the child uses *sometimes* and *often*. Scores for each remaining sections contained the sum of *yes* responses for gestures the child used. A total gesture use score was created by summing the scores for each category. Descriptive statistics for each gesture score are outlined in Table 16.

Table 16

Sample size and mean scores for MCDI Gesture use by age

	Younger (3 to 16 mos)[a]			Older (> 17 mos)[b]		
MCDI Gesture Measure	*M (SD)*	Min	Max	*M (SD)*	Min	Max
First communicative gestures	13.3 (8.9)	1	12	11.0 (1.5)	6	12
Games and routines	2.5 (1.8)	0	6	4.9 (1.1)	1	6
Actions with objects	5.1 (4.5)	0	17	14.2 (2.6)	7	17
Total gesture use	13.3 (8.9)	0	35	30.0 (4.3)	18	35

[a]Sample size ranged from n = 109 to n = 115. [b]n = 56.

Four regression models (one for each gesture score) were used to assess the relationship between mother age and gesture use. Total gestures, first communicative gestures, actions with objects, and games and routines were regressed on mother age to test the study hypothesis that older motherhood leads more gestures used. Bilingual children have been shown to use more gestures than monolingual when they are first learning languages (Nicoladis, Pika, & Marentette, 2009). Only monolingual children were included in the gesture analysis to avoid possible interactions associated with learning multiple languages.

As noted earlier two age-based sub-samples were created, a *younger* group consisting of 0- to 16- month-olds (n = 108) and an *older* group of children 17 months and older (n = 54) in order to maintain the psychometric properties of the MCDI scales. The sample size for the older group was quite small (the results from the corresponding regression models should be interpreted with caution.

Overall, the models employed in this study accounted for 6 to 11 percent of the variance in gesture use across both age groups. The hypothesis that increasing mother age would predict a larger gesture repertoire was not supported for either age group. Mother age demonstrated a trend in the positive direction for first communicative gestures, actions with objects, and overall gesture use, but none were significant over the *p* > .05 level. In the younger group, gestational age demonstrated a positive association with the actions with objects, games and routines, and total gestures sections. Higher subjective SES predicted increased scores for the actions with objects sub-section. No significant relationships were found in the older group. A description of the total gestures model can be found in Table 17. Descriptive tables for each regression model corresponding to first communicative gestures, games and routines, actions with objects are located in Appendix F.

Table 17

Total gesture use predicted by child characteristics, SES, and mother age

	Younger (3 to 16 mos)[a]			Older (> 17 mos)[b]		
Covariate	Parameter Estimate	*SE*	*F*	Parameter Estimate	*SE*	*F*
Intercept			112.38***			824.65***
Gestational age	1.54	0.63	6.04**	-0.09	0.45	0.04
Child Gender	-1.92	1.70	1.27	0.06	1.29	0.00
Number of siblings	-0.72	1.14	0.40	0.07	0.90	0.01
SES	0.95	0.49	3.70*	0.18	0.40	0.21
Mother age	-0.17	0.17	0.92	-0.16	0.10	2.19

Note. Restricted to monolingual households, *bilingual* = 1; **p*<.05, ***p < .01*, ****p < .001*.
[a]Younger group: N = 108, R^2 = 0.11, $F(5, 102)$, 2.44, $p < 0.05$.
[b]Older group: N = 54, R^2 = 0.05, $F(5, 48)$, 0.47, $p < 0.04$.

Hypothesis 3: Vocabulary Ability

The purpose of objective three was to determine whether the relationship between mother age and vocabulary in 4- and 5- year-olds would be applied to the younger ages of 1- to 3- years-old. The hypothesis that older motherhood would result in higher vocabulary was tested using hierarchical linear regressions with two groups of covariates (as described previously).

Summed scores for each of the MCDI vocabulary questionnaires were used to measure vocabulary production and comprehension. Scores for vocabulary production (words child says and understands) as well as a vocabulary comprehension (words child *says and understands* and words child *understands*) were generated for Level 1 (3 to 16 months). Level 2 (17 to 36 months) measured vocabulary production only. Table 18 contains a description of each vocabulary outcome used in this study. The MCDI vocabulary measures have been validated in some countries, but only the English versions were used in this study. The sample was restricted to English speaking monolingual households.

Table 18

Sample size and mean scores for MCDI Level 1 and Level 2 Very Short Form vocabulary

Vocabulary Measure	n	Mean	SD	Minimum	Maximum
MCDI VS Level 1 comprehension[a]	34	35.0	31.0	2	89
MCDI VS Level 1 production[a]	21	10.3	16.0	1	61
MCDI VS Level 2 production[b]	15	62.7	34.4	6	100

Note. Sample contains only English speaking monolingual households, *bilingual* = 1 with information on all covariates.
[a]Children 3 to 16 months.
[b]Children 17 to 36 months.

Larger samples of English only speaking children were required for the analysis described in this study. A minimum of 10 participants per predictor variable are required to maintain the integrity of a regression model. The sample sizes for Level 1 and 2 vocabulary were very small once all filters were applied (Table 18). The proposed models required a minimum of

70 participants to be statistically valid. Since this minimum criteria was not met the vocabulary models could not be included in the study analysis.

Discussion

The results of Study Two suggest that mother age operates differentially across developmental domains. The aim of the study was to determine if the differential effects of mother age for motor and language outcomes hold true when measured in the same group of children at developmental period (4 to 24months). Gestures were used as a measure of preverbal ability and motor attainment was measured using age of first steps. Overall the hypotheses tested in Study Two were partially confirmed. The association between mother age and age of first walking was replicated (older mothers had children who walked later). However, no significant relationship was found between mother age and gesture ability.

Motor Domains

The first research question in Study Two aimed to extend the relationship between mother age and age of first steps to an international sample. The hypothesis was confirmed, and mother age was found to predict gross motor development even when several other factors were controlled for. Mother age holds up as a variable of significance for predicting the onset of walking even in an international sample. It is possible that additional factors are associated with the mother age and walking relationship. For example, differences in the way infants are handled (postural experiences) have been linked to the onset of walking. Mothers who actively engaged in formal handling practices, and/or value motor stimulation through handling tend to have children who reach gross milestones at younger ages (Keller, Yovsi, & Voelker, 2002; Hopkins & Westra, 1988). While cultural handling practices were beyond the scope of this study, it is possible that mother age might play a role in the types of handling practices mother use. Perhaps younger mothers are more likely to engage in handling practices that facilitate motor development. An exploration of age-related variation in mother and child motor interactions are an important area for future research.

Language Domains

The second goal of this study was to explore the relationship between gesture ability and mother age. Useful links have been found between mother age and vocabulary ability (children of older mothers have better vocabularies) at 4 and 5 years of age (Bushnik & Gerner, 2008). Based on the assumption that gesture ability is a known precursor to early language development, it was suspected that the relationship between mother age and child vocabulary might extend to gesture abilities during infancy. The MCDI, a well-known tool for assessing early language development was used to measure gesture ability across two age groups: 0- to 16-month-olds (tool was developed for children in this age-range), and 17 months and older. Mother age did not contribute to gesture ability in this study. However, mother age did demonstrate a positive trend for actions with objects, games and routines, and overall gesture ability among children in the younger group.

Alternatively, mother age effects could be a crude measure for other more important factors related to infant gesturing. Gesture ability is strengthened through reciprocal rehearsals between two individuals. Early vocabulary is encouraged through communicative gesture interactions that take place between children and caregivers both in language and in play (McGregor, 2008). It seems likely that gesture and language interactions are influenced by differences in maternal as well as socio-cultural characteristics. For example, SES predicted gesture use among younger children in the actions with objects section of the MCDI. Questions in this section includes items such as "*puts on a necklace, bracelet or* watch" and "*put telephone* *to* ear". In this study the average subjective SES was 7 (towards the higher end of the scale). It is possible that higher SES households might have a larger number of objects with which children can interact and the frequency of those opportunities might contribute to the variation observed in gesture ability.

Overall the results of Study Two are a good "first step" in examining mother age and preverbal language ability. These results should be interpreted with caution as the models in this study only accounted for 6 to 10 percent of the variance in gesture ability which suggests other influential variables are missing from the analysis.

As a result of small sample sizes the third research question in Study Two could not be addressed. The MCDI has been validated in multiple languages (Spanish, Hebrew). Future studies that allow participants to complete the MCDI in languages other than English might alleviate some of the sample size issues encountered in this study. In addition, similar methods could account for various cultural factors related to individuals completing the questionnaire in their native language.

Limitations

A main limitation of this study was the sample sizes associated with the gesture and vocabulary measures. It could be that gesture differences do exist in relation to mother age but those differences went unnoticed because of the small sample sizes. Particularly, the models for mother age effects in relation to vocabulary could not be conducted because of the extremely small sample sizes associated with the vocabulary measures. The ability to measure early vocabulary would have helped to fill the gap of mother age effects in the group of older children (those over 17 months). It is possible that the reliability and validity of the paper pencil version of the MCDI vocabulary measures do not extend to an online version of the tools. Alternately, the nature of the MCDI itself might have contributed to the small samples sizes found in this study.

The Level 1 vocabulary forms required parents to discriminate between words a child *understands* or *understands and says*. If the child does not yet say the word in question a parent has the decision to either leave the question blank, or to interpret the child's silence as *understands* and select the appropriate box. The first alternative would lead to a number of missing data points (and in some cases complete missing data if the child does not say or understand any of the words on the list). The latter choice, would introduce an upward bias into the outcome variable as parents might select *understands* simply because they do not want to leave the question blank, and no alternative exists for *child does not say this word*.

A similar scenario presents itself with the MCDI Level 2 vocabulary form. Parents were asked to only select the words their child *says* and leave the remaining words unchecked. When the Level 2 form is scored, the total number of checked words makes up the vocabulary score. If a child does not say any of the words on the list the MCDI score would be blank. Blank responses mean that children who are within the age range for the MCDI Level 2 form, but who do not yet say any of the words on the list would be counted as missing data points. Again, this scenario would increase the number of participants with missing data and decrease the sample size. It is also possible that an upward bias was entered into the MCDI outcome as the sample only included children who said one or more words found on the form and eliminated those who were not able to say any words. For these reasons future studies should examine the MCDI for use on the internet. In addition, a validity study between the MCDI and a modified version of the forms that allows for the capture of children who do not say any words on the list are of importance if we are to understand child vocabulary and mother age relationships.

Social and cultural interactions might also have masked potential effects in this study. Social/cultural or language differences associated with the international sample used in this study might account for some of the variation in gesture ability. Applying multiple versions of the MCDI in various languages would help to clarify any potential language effects. It is possible that during development some languages require the use of different gestures or less gesture use overall. Because of the small sample size a country-level analysis of the gesture scales was not possible in this study.

Lastly, the questionnaire used in Study Two included several pages and took participants an average of 15 minutes to complete which is long for an internet study (Dillman, Smyth, & Christian, 2009). High attrition rates were a likely contributing factor to the small sample sizes in this study. Areas for future research might include smaller more focussed versions of each outcome with a select group of additional characteristics and repackaged into a series of smaller more focussed studies.

Implications

The results from this study buttress the idea that mother age is an important variable to consider when studying motor development during infancy. In addition, Study Two was the first to examine motor and language ability concurrently in the same group of children. The non-significant relationship between mother age and gesture ability was reinforces the hypothesis that mother age operates differently for language and motor domains at the same time during infancy. The results of Study Two add to the empirical literature outlining mother age as a variable for consideration and continue to build the story of mother age in relation to child development.

CHAPTER 5 – DISCUSSION

This research examined age of motherhood as a variable for predicting child motor and language outcomes within an ecological systems framework. In this section, the results of both studies will be discussed in relation to each developmental domain. Second, the findings from both studies will be situated within the context of the ecological system. This will be followed by a discussion of general study limitations and implications.

The increased age of motherhood has become an important and well-known demographic shift in developed countries around the world. In the last decade the average age of child bearing in Canada, the UK, and Australia has increased from approximately 26 years to 30 years of age in each country (McMahon, et al., 2011). Yet, there is a paucity of literature that specifically examines this in relation to the developmental trajectories of healthy children. A small number of studies has found that older mothers have children who reach gross motor milestones later, while others have found older motherhood predicts more proficient language abilities in early childhood (Bushnik & Gerner, 2008; De Jaeger & Eaton, 2010; Eaton, 2008; Taanila, et al., 2005; Murray, et al., 2006). The relationship between mother age and child outcomes is still relatively unclear. No studies have examined motor and language domains concurrently, hence, the focus of this research.

The results of this study confirm the idea that increasing age of motherhood has implications for child development, but the pattern and direction of influence varies by content domain and by age. While older motherhood might not benefit the timing of walking and talking during infancy, it does benefit receptive vocabulary in childhood. This distinction is an important step in exploring mother age as a variable of significance for predicting child outcomes. Such results suggest that use of a one-size-fits-all norm for typical development and for assessing developmental delays is ill-advised because children of younger and older mothers may differ in systematic ways.

Mother Age and Motor Domains

The direct relationship between mother age and age of walking has been found previously (De Jaeger & Eaton, 2010; Eaton, et al., 2014; Eaton, Bodnarchuk, McKeen, & De Jaeger, 2007), and was replicated within the current study. Mother age was found to significantly predict walking in both studies; older mothers had children who walked later. Older motherhood was also indicative of fewer motor skills during infancy (0 to 24 months). Indeed, the association between mother age and gross motor attainment was the strongest and most consistent pattern across the models examined in this research program.

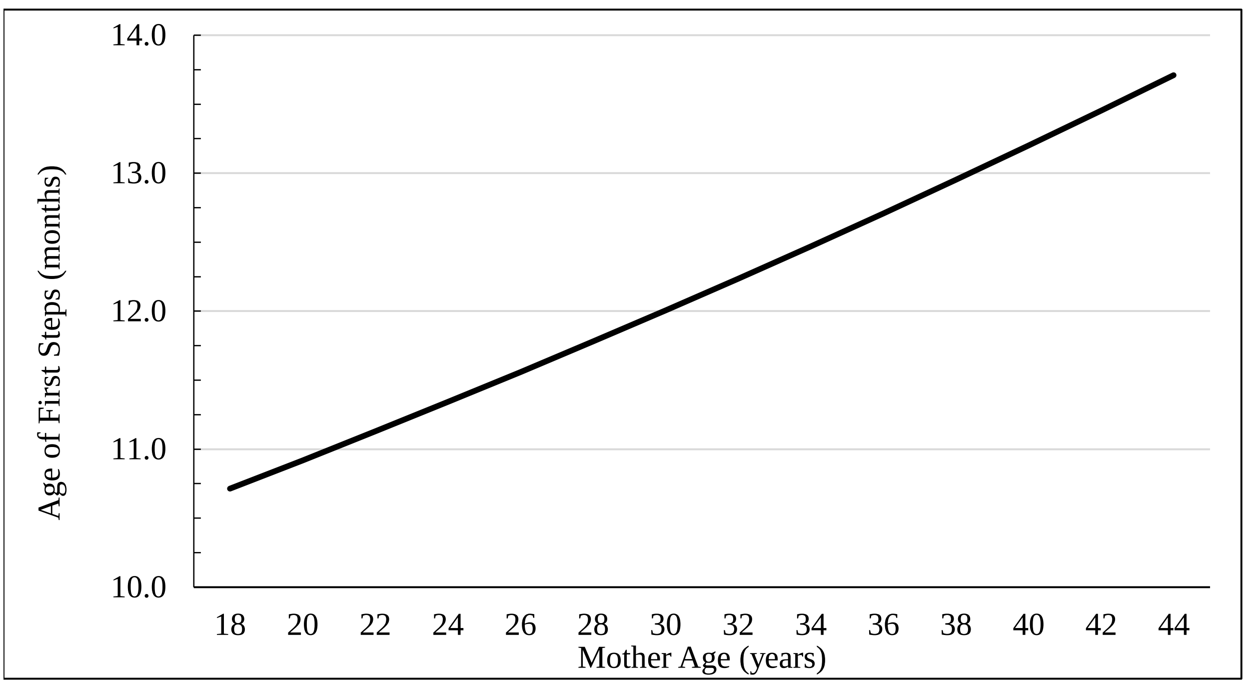

Figure 2. Survival analysis predicted age of first steps by mother age

For example, in Study Two (Figure 2) onset of walking was delayed approximately 3 days (0.10 of a month) for every year of mother age. In other words, a 10-year mother age difference would predict a month's difference in the timing of walking. Not only is this difference statistically significant, it is likely substantively quite important when gauging typical development. Walking is marker of overall health status and delays in walking are often used as an early indicator for issues such as general global delays, or cerebral palsy. It is becoming clear that age of motherhood should be considered age-related norms are used to measure typical development in motor domains.

Conceivably an underlying factor associated with mother age may be operating to delay motor development during infancy. Determining *what* that factor might be was beyond the scope of this study, but there are some plausible alternatives. For example, older mothers are at an increased risk for prenatal complications such as gestational diabetes and hypertension (Jolly, Sebire, Harris, Robinson, & Regan, 2000). It remains to be determined how these prenatal experiences influence later development, but biological differences in children of older and younger mothers should not be discounted.

Physical freedom and independence are additional factors also plausibly related to motor development and mother age. At younger ages, children are largely dependent, and mothers exert a considerable amount of control over a child's daily environment and the experiential opportunities presented within those environments. The amount of time an infant spends free to explore his/her physical environment has been positively related to competence during the first few years of life (Adolph et al., 2003; Adolph, & Berger, 2005; Adolph, 2008; Blank, 1964), and infants have been found to reach motor milestones later when mother were protective, restrictive and less encouraging of independence (Blank, 1964). Extremely young mothers and older-than-average mothers were found to provide fewer objects and opportunities for exploration compared to mothers of typical childbearing age (Bornstein, et al., 2006). This finding supports the hypothesis that younger and older mothers may offer systematically different environments for development. The results of the current study cannot provide an explanation about why infants of older mothers have fewer motor skills. However, it is possible that older mothers provide fewer opportunities for exploration and independence than younger mothers, which may contribute to delays in motor development.

Mother Age and Language Domains

Consistent with the existing literature (Bushnik & Gerner, 2008) children of older mothers had higher scores for receptive vocabulary in early childhood (4 and 5 years). With the relationship between mother age and vocabulary in mind, children of older mothers were expected to talk earlier and use more gestures when studied during infancy. Surprisingly, in this study the benefits between older motherhood and vocabulary scores in childhood did not extend to language domains in infancy. Children of older mothers talked later and there were no significant effects for gesture use.

When these findings are taken together it appears that although older motherhood does not benefit the onset of speech. Once speech begins for those children, they not only catch up, but they surpass their peers in vocabulary ability at later ages. This result suggests that older motherhood is not beneficial for the timing of the language attainment, but becomes beneficial for the sophistication of language ability at later ages. One possible explanation for these findings might be differences in the quality and opportunities presented for language interaction by older mothers. A number of studies have shown that as maternal age increases mothers display more nurturing, sensitive and structured behaviours, and engage in responsive lengthy periods of communication towards their infants (Bigelow, 2010; Bornstein et al., 2006; Bornstein, Tamis-LeMonda, Hahn, & Haynes, 2008). Benefits of these behaviours include increased language ability (Bigelow, et al., 2010; Hirsh-Pasek, 2006). Perhaps it is these interactions that aid in the development of verbal intelligence among the children of older mothers.

Mother Age and Social Cognitive Domains

In Study One, examining the relationship between social/cognitive ability and mother age was included as a supplementary analysis. Older motherhood in this study was found to predict increased social/cognitive abilities from birth to 47 months. Other studies have linked mother age to social/emotional difficulties at 3 and 5 years old. For example children with older mothers have fewer emotional difficulties and higher social skills (Sutcliff, et al., 2012). In addition, mother age has also been linked to higher levels of verbal and emotional responsivity, and attachment (Barratt, et al., 1991; Siddiqui, et al., 1999; Rosenkrantz-Aronson & Hudson, 2004). Links between mother age and children's social skills are relatively recent findings, though if older mothers provide interactions that lead to higher levels of verbal and emotional responsiveness, it seems reasonable that these the associations might lead to advances in social skills. Further observational research is require to gather a more specific picture of the variations that might exist in the interactions between children and older mothers.

Theoretical framework

Ecological systems theory posits human development as the product of an interaction between several systems (Bronfebrenner, 1994). Ecological systems theory was a useful framework for the present study as it allowed for mother age effects to be isolated while accounting for other influential variables as well as the context in which development occurs.

Several factors, one of which was mother age, were used in a person-context model within the ecological framework to predict walking and talking development. By applying a systems perspective of development, gradual variations in attainment and individual trajectories could be accounted for.

The multifaceted nature of predicting developmental phenomena becomes apparent when examining the multiple significant findings that have emerged from this research. Human development is complex with many multidirectional links between and within systems. Several factors come to mind when considering walking and talking development including gender, gestational age, and SES, but mother age has typically not been one of them. However, in light of changing societal norms the main goal of this study was to parse out the effects older motherhood (over 30 years) on child development.

Older motherhood is an important contextual phenomena for this study and fits well within the ecological framework; the variable *mother age* was considered to be a component of two overlapping systems: the mother and the child. In the "mother system", the variable mother age was considered an individual level variable. However, the trend towards older motherhood has been substantially influenced by changes in macro and chronosystem variables such as increasing international economies and societal trends leading to delayed childbearing (Bronfenbrenner, 1994). More importantly for this study the variable mother age also operated as a microsystem variable within the "child system" when examining developmental outcomes. The focus of this research program was to investigate mother age as it operates within the child system.

Situating the present research within an ecological systems framework required the consideration of several overlapping and interlocking systems, therefore several co-varying factors were included in the person-context. The co-varying factors, in addition to mother age were selected because of their proximity to the outcomes of interest. All covariates in these studies fit within the individual and microsystem levels of the child system.

Child individual Factors. Individual characteristics of the children were a key component in predicting the outcomes for this research. Factors such as gender, gestational age, and birth order were included in several models and linked to variation in motor and language development. For example, a first born female in Study One would have a higher vocabulary score than a male or a later born female. In addition the results from both Study One and Study Two implicate gestational age as a potent variable with effects that carry forward into outcomes associated with older age groups (older gestational age leads to better outcomes). Table 19 outlines the individual system factors in relation to each developmental outcome measured across both studies.

While the mother age variable does not fall within the individual level it is crucial to acknowledge that other features associated with maternal age could be important at this level. Research in human genetics has suggested that hormone levels and nutrition during pregnancy might vary for older mothers and have an impact on post-natal child outcomes (Bottini, Cosmi, Nicotra, Cosmi, & Bottini, 2005). In addition, genetic influences on rate of attainment might be important. For example, the age at which mother's first walked independently might be predictive of their infant's motor and language attainment. One way of partially controlling for genetic influences in future studies would be to include questions about the mother's and father's age of first walking and talking. A genetic hypothesis might predict that age of parents' first steps would be a significant predictor infant first steps. Genetic links for verbal intelligence have found between adults, but have not been examined in children (Prior, et al., 2008). Should such a findings emerge, they would argue strongly for including more individual level, biological predictors in models that examine developmental rate and ability.

Table 19

Individual system factors that predict child developmental outcomes

Outcome	Gender[a]	Gestational age (weeks)[b]	Ponderal index	Birth order[c]
Motor attainment (3 to 47months)	ns	√	ns	ns
Motor ability (3 to 24 months)	ns	√	ns	ns
Motor ability (24 to 47months)	ns	√	ns	√
Language attainment (3 to 47 months)	√	√	ns	ns
Gesture ability (3 to 47 months)	ns	√	ns	--
Vocabulary ability (4 to 5 years)	√	--	--	√

Note. ns = not statistically significant, √ = statistically significant, -- not assessed.
[a]Gender relationship to outcome: female = earlier attainment and higher ability scores.
[b]Gestational age relationship to outcome: gestational age over 40 weeks = earlier attainment and higher ability scores.
[c]Birth order relationship: first born = lower motor ability, higher vocabulary ability scores.

Child microsystem factors. In addition to individual system factors, it is important to consider other environmental characteristics that are associated with walking and/or talking. During infancy, parents (particularly mothers) are the greatest source of influence over the environments in which development occurs. As such, the choices mothers make regarding these environments should be considered when examining developmental outcomes. Of particular importance to this study was the inclusion of mother age as a microsystem variable of interest (Table 20).

Table 20

Microsystem factors that predict child developmental outcomes

Outcome	MA[a]	BF[b]	Sibs[c]	Care[d]	Adults[e]	Edu[f]	PP[g]
Motor attainment (3 to 47months)	√	√	n/a	√	√	--	--
Motor ability (3 to 24 months)	√	√	ns	√	ns	ns	√
Motor ability (24 to 47months)	ns	ns	√	√	ns	--	√
Language attainment (3 to 47 months)	√	ns	--	√	ns	√	--
Gesture ability (3 to 47 months)	ns	ns	ns	--	ns	--	--
Vocabulary ability (4 to 5 years)	√	√	--	√	√	√	√

Note. ns = not statistically significant, √ = statistically significant, -- not assessed.
[a]Mother age relationship: older motherhood – later attainment and higher ability scores.
[b]Ever breastfed relationship: breastfeeding = earlier attainment and higher ability scores.
[c]Number of children in the home relationship: fewer = earlier attainment and higher ability scores.
[d]Childcare relationship: non-parent primary care = earlier attainment and higher ability scores.
[e]Number of adults in home relationship: two adults = later attainment and higher ability.
[f]Mother education relationship: higher education = higher ability.
[g]Positive parenting relationship: increases in positive parenting = higher ability.

One notable pattern that emerged from this research was the influence of childcare on developmental outcomes. In Study One children who were cared for by other family members and childcare centres reached milestones earlier and had higher motor and language abilities. While childcare is an important variable on its own, variations in childcare have been found in association with mother age. Older mothers have reported returning to work earlier and using more external childcare resources than younger mothers (Meggiolaro & Ongaro, 2012). Child care is just one variable in a complex microsystem. Positive parenting was linked to motor and skills and receptive vocabulary suggesting that experiential variables are conceivably related to the domains of interest and should be included in future studies.

It is possible that the relationship between motor and language development is also partially explained by environmental variations associated with mother age. For example, features of experience that appears to be an important influence on the age of onset of walking are child handling, physical freedom, and opportunities for exploration (Blank, 1964; Hopkins & Westra, 1988; Keller et al., 2002; Santos et al., 2001; White, 1975). In addition, learning language is a reciprocal process, and maternal education has been positively associated with language comprehension and production (Hirsh-Pasek & Golinkoff, 2012; Zambrana, et al., 2012), and is similar to the previous finding in this study that mother age effects are strongest for language at later ages. To extend the hypothesis further, it is possible that mothers with higher education provide more language opportunities than younger, less educated mothers and that the quality of these interactions varies accordingly (Prior, et al., 2008). Further research is required to determine whether there are additional environment characteristics related to mother age that significantly impact motor and/or language domains.

Overall the ecological framework provided a good starting point for understanding the effects of older motherhood as a microsystem factor of importance for child development. In addition the person-context model allowed for an examination of the advantages and disadvantages associated with older motherhood and how these seem to change as children age.

Limitations and future research

There are additional study limitations beyond those discussed in earlier sections. First, macrosystem contexts such as cultural differences were not controlled. It is possible that variations in cultural practices relating to child rearing (e.g., handling practices) interact with the relationships demonstrated between mother age and the domains of interest.

Second, mother age effects were assessed during infancy and early childhood. These effects cannot be generalized to older children or adolescents. It is possible that mother age effects could change with later developmental periods. For instance children's vocabulary skills get more advanced at 4 and 5 years of age (Bushnik & Gerner, 2008) and children of older mother have demonstrated advanced categorization abilities in adulthood (Pollock, 1993; Rosenthal-Rollins, 2003; Pan et al., 2004). It is also possible that the mechanisms relating to mother age might vary beyond early childhood. For example, the mechanisms become less important for motor domains (e.g. all adults walk well) but more important for cognitive/language domains. It is likely that mother age effects do not disappear, but they change with developmental period. Future studies might utilize the NLSCY database to explore mother age effects in relation to adolescent and early adulthood populations.

Third, the measures across both studies were parent reports. The data for Study One was drawn from telephone survey data collected by the NLSCY and the data for Study Two was collected via an online survey. While parent reports have been found to be reliable and valid for both motor and language outcomes, there may be inconsistencies that are introduced. For example, older mothers may answer questions in a slightly different way than younger mothers. Future studies might conduct reliability and validity tests on parent report measures from mothers of various ages to see if age related differences in reporting exist. These studies could then be used to inform future investigations into mother age effects.

Lastly, this research used a person-context model within an ecological systems framework to examine the unique contribution of mother age on child development. However, this study was subject to the limitations of a person-context approach and therefore, cannot account for the processes involved in the development of walking and talking. That is, although variation in mother age is important for predicting walking and talking, it cannot be said for certain exactly how mother age interacts with the processes that lead to changes in development. (Johnson, 2008). Future studies might consider including variables such as daily experience to capture the person, environment, and process interactions that influence developmental outcomes.

Implications

This study is an important contribution to the limited literature regarding older motherhood, an increasing trend in Westernized societies. Older motherhood is an emerging research area and as such there is limited theoretical work relating older mothering to developmental outcomes. Applying an ecological systems framework to examine older motherhood was a unique and important first step in unpacking mother age effects. As the average age of motherhood continues to increase, an understanding of how mother age influences the developmental trajectories of healthy children is essential. Within this research, mother age effects have been demonstrated in two important aspects of development. It is reasonable to assume that these effects extend beyond early childhood to other domains as well.

This study was the first to measure gross motor attainment and language ability concurrently among pre-school children. Should these effects be replicated in future studies, it would represent an important stepping stone toward increasing our understanding of the wide variation in abilities during childhood. The magnitude of the differences found in this study beg for reflection on developmental norms and how rates of “normal development” might shift in light of additional information. What is normal for the children of 25 year old mothers may not be normal for the children of older mothers. Areas of future research might want to examine the long term implications for these alterations in development.

Conclusions

These two studies demonstrate that mother age is important for predicting the timing and sophistication of developmental events such as age of walking and age of talking. These findings are particularly interesting because the timing of events shifts towards later development as mother age increases. Across both studies variation in mother age effects was observed across age groups (0 to 24 months vs. over 24 months) and developmental domains (gross motor vs. language). Mother age effects were strongest among younger children on attainment (motor and words), and demonstrated positive effects on motor ability at younger ages (0 to 23 months), and verbal ability at older ages (4 and 5 years). Results from this study suggest that mother age effects operate on different mechanisms of development, but they do not indicate *how* mother age effects operate.

The goal of this study was to gain a better understanding of older motherhood and the influence this variable has on development in early childhood. As increasing age of motherhood becomes more common, it is crucial to understand how such variation may influence developmental trajectories of healthy children. Understanding the predictive value of older motherhood as a factor of importance may result in reflection on how normal developmental trajectories are defined. Furthermore, by continuing to explore the relationship between a mother's age and the timing and/or sophistication of developmental milestones, future research can make a significant contribution to the growing body of maternal-age literature. Systematic differences in development between children of older and younger mothers have come to light in this study. Moving forward it is important to study and communicate the influence delayed motherhood has on both families and children.

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APPENDIX A

Motor and Social Development Scale

MSD items and corresponding age groups

	Motor and social development items	Code[a]	Child age (months) 0 to 3	4 to 6	7 to 9	10 to 12	13 to 15	16 to 18	19 to 22	23 to 47
1.	When lying on his/her stomach, has this child ever turned his/her head from side to side?	n/a	X							
2.	Have his/her eyes followed a moving object?	n/a	X							
3.	When lying on his/her stomach on a flat surface, has he/she ever lifted his/her head off the surface for a moment?	n/a	X							
4.	Have his/her eyes ever followed a moving object all the way from one side to the other?	n/a	X							
5.	Has he/she ever smiled at someone when that person talked to or smiled at (but did not touch) him/her?	n/a	X							
6.	When lying on his/her stomach, has he/she ever raised his/her head and chest from the surface while resting his/her weight on his/her lower arms or hands?	n/a	X							
7.	Has he/she ever turned his/her head around to look at something?	n/a	X							
8.	When lying on his back and being pulled up to a sitting position, did this child ever hold his head stiffly so that it did not hang back as he was pulled up?	M	X	X						
9.	Has he ever laughed out loud without being tickled or touched?	SC		X						
10.	Has he ever held in one hand a moderate sized object such as a block or a rattle?	M		X						

11.	Has he ever rolled over on his own on purpose?	M	X			
12.	Has this child ever seemed to enjoy looking in the mirror at himself?	SC	X	X		
13.	Has this child ever been pulled from a sitting to a standing position and supported his own weight with his legs stretched out?	M	X	X		
14.	Has he ever looked around with his eyes for a toy which was lost or not nearby?	SC	X	X		
15.	Has he ever sat alone with no help except for leaning forward on his hands or with just a little help from someone else?	M	X	X		
16.	Has he ever sat for 10 minutes without any support at all?	SC	X	X		
17.	Has he ever pulled himself to a standing position without help from another person?	M	X	X		
18.	Has this child ever crawled when left lying on his stomach?	M	X	X	X	
19.	Has he ever said any recognizable words such as 'mama' or 'dada'?	SC	X	X	X	
20.	Has this child ever picked up small objects such as raisins or cookie crumbs, using only his thumb and first finger?	M	X	X	X	
21.	Has he ever walked at least 2 steps with one hand held or holding on to something?	M	X	X	X	
22.	Has this child ever waved good bye without help from another person?	SC	X	X	X	X
23.	Has he ever shown by his behaviour that he knows the names of common objects when somebody else names them out loud?	SC		X	X	X
24.	Has he ever shown that he wanted something by pointing, pulling, or making pleasant sounds rather than crying or whining?	SC		X	X	X

25.	Has he ever stood alone on his feet for 10 seconds or more without holding on to anything or another person?	M	X	X	X				
26.	Has this child ever walked at least 2 steps without holding on to anything or another person?	M	X	X	X	X			
27.	Has he ever crawled up at least 2 stairs or steps?	M		X	X	X			
28.	Has this child said 2 recognizable words besides 'mama' or 'dada'?	SC		X	X	X			
29.	Has this child ever run?	M		X	X	X	X		
30.	Has he ever said the name of a familiar object, such as a ball?	SC		X	X	X	X		
31.	Has he ever made a line with a crayon or pencil?	M		X	X	X	X		
32.	Did he ever walk up at least 2 stairs with one hand held or holding the railing?	M		X	X	X	X		
33.	Has he ever fed himself with a spoon or fork without spilling much?	M			X	X	X		
34.	Has this child ever let someone know, without crying, that wearing wet (soiled) pants or diapers bothered him?	SC			X	X	X	X	
35.	Has he ever spoken a partial sentence of 3 words or more?	SC			X	X	X	X	
36.	Has he ever walked up stairs by himself without holding on to a rail?	M			X	X	X	X	
37.	Has he ever washed and dried his hands without any help except for turning the water on and off?	SC				X	X	X	
38.	Has he ever counted 3 objects correctly?	SC				X	X	X	
39.	Has he ever gone to the toilet alone?	SC				X	X	X	
40.	Has he ever walked upstairs by himself with no help, stepping on each step with only one foot?	M				X	X	X	
41.	Does he know his own age and sex?	SC					X	X	

42.	Has this child ever said the names of at least 4 colours?	SC	X	X
43.	Has this child ever pedalled a tricycle at least 10 feet?	M	X	X
44.	Has this child ever done a somersault without help from anybody?	M		X
45.	Has this child ever dressed himself without any help except for tying shoes (and buttoning the backs of outfits)?	SC		X
46.	Has this child ever said his first and last name together without someone's help? (Nickname may be used for first name.)	SC		X
47.	Has this child ever counted out loud up to 10?	SC		X
48.	Has this child ever drawn a picture of a man or woman with at least 2 parts of the body other than a head?	SC		X

Note. Adapted from Bushnik and Gerner (2008).
[a]SC = item coded as social/cognitive, M = item coded as motor

APPENDIX B

NLSCY Parenting Scales

NLSCY Positive parenting practices scale items by age

		Child age (months)	
	Positive parenting item[a]	0 to 35[b]	36 to 60[c]
1.	How often do you praise this child, by saying something like 'Good for you!' or 'What a nice thing you did" or that's good going?	X	X
2.	How often do you and this child talk or play with each other, focusing attention on each other for five minutes or more, just for fun?	X	X
3.	How often do you and this child laugh together?	X	X
6.	How often do you do something special with this child that he enjoys?	X	X
7.	How often do you play games, sports, hobbies or games with this child?	X	X

Note. Adapted from Bushnik and Gerner (2008).
[a]Response options: never, about once a week or less, a few times a week, one or two times a day, and many times each day.
[b] $\alpha = 0.622$.
[c] $\alpha = 0.679$ (24 to 48 months), $\alpha = 0.677$ (48 to 60 months).

NLSCY ineffective parenting practices scale items by age

	Ineffective parenting item	Child age (months)	
		0 to 35[c]	36 to 60[d]
4.	How often do you get annoyed with this child for saying or doing something he is not supposed to? [a]	X	X
5.	How often do you tell this child that he is bad or not as good as others? [a]	X	
8.	Of all the times that you talk to this child about his behaviour, what proportion is praise?[b]		X
9.	Of all the times that you talk to this child about his behaviour, what proportion is disapproval? [b]		X
13.	How often do you get angry when you punish this child? [b]		X
14.	How often do you think that the kind of punishment you give this child depends on your mood? [b]		X
15.	How often do you feel you are having problems managing this child in general? [b]		X
18.	How often do you have to discipline this child repeatedly for the same thing? [b]		X

Note. Adapted from Bushnik and Gerner (2008).
[a]Response options: never, about once a week or less, a few times a week, one or two times a day, many times each day.
[b]Response options: never, less than half the time, about half the time, more than half the time, all the time.
[c] $\alpha = 0.343$.
[d] $\alpha = 0.607$ (24 to 48 months), $\alpha = 0.630$ (48 to 60 months).

APPENDIX C

Study Two Ethics Approval Certificate

Human Ethics
208 - 194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Fax 204-269-7173

UNIVERSITY OF MANITOBA | Office of the Vice-President (Research and International)
Research Ethics and Compliance

APPROVAL CERTIFICATE

June 11, 2012

TO:	**Warren O. Eaton** Principal Investigator
FROM:	**Bruce Tefft, Chair** Psychology/Sociology Research Ethics Board (PSREB)
Re:	**Protocol #P2012:034** **"Examining Mother Age Effects as a Predictor for Walking and Gesture Use"**

Please be advised that your above-referenced protocol, as revised, has received human ethics approval by the **Psychology/Sociology Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement (2). This approval has been issued based on your agreement with the change(s) to your original protocol required by the PSREB. It is the researcher's responsibility to comply with any copyright requirements. **This approval is valid for one year only.**

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:

- If you have funds pending human ethics approval, the auditor requires that you submit a copy of this Approval Certificate to the Office of Research Services, fax 261-0325 - please include the name of the funding agency and your UM Project number. This must be faxed before your account can be accessed.

- if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.

The Research Quality Management Office may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans*.

The Research Ethics Board requests a final report for your study (available at: http://umanitoba.ca/research/orec/ethics/human_ethics_REB_forms_guidelines.html) **in order to be in compliance with Tri-Council Guidelines.**

umanitoba.ca/research/orec

APPENDIX D

Study Two Questionnaire

Early Words and Milestones Study

Child Information
Thanks for agreeing to participate. We would like to refer to your child by name in all further questions. In order for us to do so, please provide your child's first name gender and age in months.

Child's first name or nickname:*
____

Child's gender:*
( ) Female
( ) Male

How old is your child (in months)?
____

What language is spoken most often in your home?

Is there more than one language spoken often in your home?
( ) Yes
( ) No

Which additional language is spoken often in your home?

Baby Milestones

Here are some drawings and descriptions of baby positions. If you *have ever seen* [CHILD NAME] show the described position, choose "Yes." If [CHILD NAME] has not shown that position, choose "No."

On Hands and Knees. Using hands and knees, holds body up for 5 or more secs. Back is curved. May rock back and forth or move by falling forward. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

Reaches from Hands and Knees. With weight on knees and one hand, uses other hand to reach forward and up for an object. Has [CHILD NAME] ever done this?
( ) Yes

( ) No
( ) Not sure

Curved-Back Crawl. Moves forward by shifting weight from one hand and opposite knee to the other hand and knee; lower back is curved. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

1-Knee 1-Foot Kneel. With weight on one knee, the other foot, and one or both hands; may move but does not stand. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

Half-Kneel. With weight on one bent knee and the other foot, body is upright and one arm is free. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

Pulls to Tip-toe Stand. Using hands or arms for support, stands and leans toward furniture. Weight is on toes or inside of foot. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

Stands Without Support. Stands alone for 5 secs with no support and weight on feet. Movements of feet and toes and arms held apart and high are used for balancing. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

Hands-and-Feet to Stand. From having weight on hands and feet, pushes up quickly to a standing position. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

Stands and Turns. With weight on the soles of widely spaced feet and one arm in contact with a surface, body is turned to side with other arm free. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

Controlled Lowering. Standing on both feet and using one hand for support, intentionally lowers self. May not return to standing. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

First Five Steps. Takes 5 or more short, distinct steps without any support. Arms are held apart and up for balance. May fall frequently. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

Please enter the date when this first occurred. If you aren't sure of the exact day, enter the month and year.

Month:
( ) January -- ( ) December

Day:
( ) 1 -- ( ) 31

Year:
( ) 2012 -- ( ) 1993

How did you know this date?
( ) I remembered
( ) I checked a diary that I kept
( ) I looked at a dated video recording
( ) Other

Walks alone more than 3m. Walks alone for more than 3m (10 ft). Arms are usually below chest level or at sides. Has [CHILD NAME] ever done this?
( ) Yes
( ) No
( ) Not sure

MCDI Gesture Use
MCDI Level 1 Vocabulary
MCDI Level 2 Vocabulary
IBQ-R
ECBQ

About Your Child

When was [CHILD NAME] born?

Day:
( ) 1 -- ( ) 31

Month:*
( ) January -- ( ) December

Year:*
( ) 2002 -- ( ) 2015

Was [CHILD NAME] born on, before, or after the due date?
( ) On due date
( ) Before
( ) After

How many days before or after the due date was [CHILD NAME] born?
____

We have some questions about [CHILD NAME]'s birth size. Do you prefer to use metric or imperial (U.K., U.S.) measurements?
( ) metric
( ) imperial

What was [CHILD NAME]'s birth weight? (grams)
____

What was [CHILD NAME]'s birth weight? (lbs)
____

What was [CHILD NAME]'s length at birth? (inches)
____

Was [CHILD NAME] a single or multiple birth?
( ) Single birth
( ) Twins
( ) Triplets
( ) More than triplets

1) Was [CHILD NAME] born head first?
( ) Yes
( ) No
( ) Don't know

Did [CHILD NAME] receive special medical care immediately following birth?
( ) No
( ) Intensive care
( ) Ventilation/Oxygen
( ) Transferred to specialized hospital
( ) Other
( ) Don't Know

Child Feeding
We would like know a little bit about [CHILD NAME]'s feeding experiences.

Has [CHILD NAME] ever breast-fed, even if only for a short time?
( ) Yes
( ) No
( ) I don't know

2) Is [CHILD NAME] currently breast-feeding?
( ) Yes
( ) No
( ) I don't know

Child's Health
Now we would like to ask you about [CHILD NAME] 's health.

In general, would you say [CHILD NAME] 's health is:
( ) Excellent
( ) Very Good
( ) Good
( ) Fair
( ) Poor

In the past 12 months was [CHILD NAME] injured seriously enough to require medical attention, by a doctor, nurse or dentist?
( ) Yes
( ) No

How many times was [CHILD NAME] injured and required medical attention?
( ) 1
( ) 2
( ) 3
( ) 4
( ) 5

For the most serious injury, what type of injury did [CHILD NAME] have?

( ) Broken or Fractured Bones
( ) Burn or Scald
( ) Dislocation
( ) Sprain or Strain
( ) Cut, Scrape or Bruise
( ) Concussion
( ) Poisoning by substance or liquid
( ) Internal Injury
( ) Dental Injury
( ) Other
( ) Multiple Injuries

Has a health professional diagnosed [CHILD NAME] with any of the following long-term conditions (expected to last 6 months or more)?

	Yes	No
Food or digestive allergies?	( )	( )
Respiratory allergies such as hay fever?	( )	( )
Any other allergies?	( )	( )
Bronchitis?	( )	( )
Gout	( )	( )
Heart condition or disease?	( )	( )
Epilepsy?	( )	( )
Cerebral Palsy?	( )	( )
Kidney condition or disease?	( )	( )

Other	( )	( )

About You
To better understand the results of this study, we need to know about those who participated. For this reason we would like to ask you some questions about yourself.

What is your gender?
( ) Female
( ) Male

In what year were you born?*
( ) 1930 -- ( ) 2001

What is your relationship to [CHILD NAME]?
( ) Biological Parent
( ) Step Parent
( ) Adoptive Parent
( ) Legal Guardian
( ) Other

What is your current marital status?
( ) Married
( ) Living Common-Law
( ) Separated
( ) Divorced
( ) Widowed
( ) Never Married
( ) Other

What is the highest grade or level of education you have attended or completed?
( ) No schooling
( ) Elementary (1 to 8 years)
( ) Some high school
( ) Graduated high school
( ) Some - trade, technical or vocational school, or business college
( ) Some - community college, CEGEP or nursing school
( ) Some - university
( ) Diploma or certificate from - trade, technical or vocational school, or business college
( ) Diploma or certificate from - community college, CEGEP or nursing school
( ) Bachelor's or undergraduate degree, or teacher's college (for example, B.A., B.Sc., LL.B.)
( ) Master's degree (for example, M.A., M.Sc., M.Ed.)
( ) Degree in Medicine, Dentistry, Veterinary Medicine or Optometry (for example, M.D., D.D.S., D.M.D., D.V.M., O.D.)
( ) Earned doctorate (for example, Ph.D., D.Sc., D.Ed.)
( ) Other education or training

Which best describes your religious beliefs?
( ) Christian
( ) Jewish
( ) Muslim
( ) HIndu
( ) Buddhist
( ) Chinese Traditional
( ) African Traditional
( ) Shamanist, Pagan, or Animist
( ) Sikh
( ) Secular, Agnostic, or Athiest
( ) Other religious beliefs

Think of the ladder below as representing where people stand in society. At the top of the ladder are those who are best off, at the bottom are those who are worst off. Click the rung where you think you stand at this time in your life.
( ) Best off
( )
( )
( )
( )
( )
( )
( )
( )
( ) Worst Off

How many children under 10 years old, other than [CHILD NAME], currently live in your home?

____

How many days per week do you spend in the same household with [CHILD NAME]?

____

Describe Yourself (TIPI)
The following questions, which are about you, have been used in many other traditional studies (paper-and-pencil, telephone). Through your participation we can see if the results from web studies are similar to those from traditional studies. Thus, we hope you will take a few moments to complete the following questions. As you can appreciate, you should answer honestly and to the best of your ability.

Please select the button that indicates the extent to which you agree or disagree with that statement. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

Exit Page

APPENDIX E

Study Two Recruitment campaigns

Google Ads. The following six Google text ads were run all initially. Ads were monitored for the effectiveness and only ads that produced the most traffic the study website were retained. Note that Google has strict policies on the number of characters in each line, and each ad line is at or very close to the limit for that line. Moreover, the Google algorithm compared the content of the ad to the content of the website. Each as was written that it refers to some element of the study content. A click on the ad transferred the prospective participant to the description of the study.

> Early words experiences
> are the focus of a university study
> on infant milestones. Please help.
> www.milestoneshome.org.

Keywords. Google Ads were triggered by keywords. The initial list of keywords and phrases that triggered an ad is listed below.

infant development
child development
toddler development
motor milestones
language development
toddler vocabulary
early vocabulary
early gesture use
toddler gesturing
toddler pointing
infant and toddler development
infant development
child development
toddler development
motor milestones
language development
toddler vocabulary
early vocabulary
early gesture use
infant milestones
toddler milestones
baby milestones
baby development
when do toddlers walk
when do babies sit
walking development
sitting development
crawling
crawling development
when do babies crawl
early milestones
when should baby walk
when should baby sit

Personal invitations. The following text was used for personal invitations with email and/or social media:

It's fun to see children developing new skills like crawling, walking and talking! I'm involved in a new online research study about babies and toddlers. A child's parent would participate by answering questions about the milestones that have been reached, words the child can say, the child's personality, toilet training experiences, pregnancy, child's health, and the family circumstances. It would only take (INSERT MIN), so if you're interested, just go to think link to learn more www.milestoneshome.org. *Feel free to pass this information to other parents with a baby or toddler.*

APPENDIX F

Gesture Regression Models

First communicative gestures predicted by child characteristics, SES, and mother age.

	Younger (3 to 16 mos)[a]			Older (> 17 mos)[b]		
Covariate	Parameter Estimate	*SE*	*F*	Parameter Estimate	*SE*	*F*
Intercept			158.27***			953.36***
Gestational age	0.39	0.23	3.05	-0.00	0.15	0.00
Child Gender	-0.71	0.61	1.39	-0.34	0.45	0.59
Number of siblings	-0.20	0.42	0.22	-0.07	0.31	0.05
SES	0.17	0.18	0.89	0.10	0.14	0.57
Mother age	-0.06	0.06	1.05	-0.06	0.04	2.63

Note. Sample contains only monolingual households, *bilingual* = 1; *p<.05, **$p < .01$., ***$p < .001$.
[a]Younger group: N = 103, R^2 = 0.06, F(5, 97), 1.33, p > 0.05.
[b]Older group: N = 54, R^2 = 0.08, F(5, 48), 0.85, p > 0.05.

Games and routines gestures predicted by child characteristics, SES, and mother age.

	Younger (3 to 16 mos)[a]			Older (> 17 mos)[b]		
Covariate	Parameter Estimate	*SE*	*F*	Parameter Estimate	*SE*	*F*
Intercept			101.19***			308.65***
Gestational age	0.26	0.13	4.07*	0.00	0.11	0.00
Child Gender	-0.62	0.35	3.13	0.02	0.32	0.00
Number of siblings	-0.13	0.23	0.31	-0.37	0.22	2.67
SES	0.17	0.10	2.83	-0.09	0.10	0.73
Mother age	-0.03	0.04	0.79	0.00	0.27	0.01

Note. Sample contains only monolingual households, *bilingual* = 1; *p<.05, **$p < .01$., ***$p < .001$.
[a]Younger group: N = 107, R^2 = 0.10, F(5, 101), 2.31, p = 0.05.
[b]Older group: N = 54, R^2 = 0.06, F(5, 48), 0.66, p > 0.05.

Actions with objects gestures predicted by child characteristics, SES, and mother age.

	Younger (3 to 16 mos)[a]			Older (> 17 mos)[b]		
Covariate	Parameter Estimate	*SE*	*F*	Parameter Estimate	*SE*	*F*
Intercept			67.71***			544.15***
Gestational age	0.78	0.32	6.21**	-0.09	0.26	0.11
Child Gender	-0.51	0.86	0.35	0.38	0.75	0.26
Number of siblings	-0.18	0.58	0.09	0.51	0.52	0.94
SES	0.56	0.25	5.02*	0.16	0.23	0.49
Mother age	-0.10	0.09	1.35	-0.10	0.06	2.57

Note. Sample contains only monolingual households, *bilingual* = 1; *p<.05, **$p < .01$., ***$p < .001$.
[a]Younger group: $N = 108$, $R^2 = 0.10$, $F(5, 101)$, 2.31, $p = 0.05$.
[b]Older group: $N = 54$, $R^2 = 0.07$, $F(5, 48)$, 0.76, $p > 0.05$.