Social Disadvantage Gets Inside the Family:
Exploring Biopsychosocial Family Processes in the
Emergence of Developmental Health Inequalities

by

Dillon Thomas Browne

A thesis submitted in conformity with the requirements
for the degree of Doctor of Philosophy

Department of Applied Psychology and Human Development
Ontario Institute for Studies in Education
University of Toronto

© Copyright by Dillon Thomas Browne 2016
Social Disadvantage Gets Inside the Family: Exploring Biopsychosocial Family Processes in the Emergence of Developmental Health Inequalities

Dillon Thomas Browne
Doctor of Philosophy
Department of Applied Psychology and Human Development
University of Toronto
2016

Abstract

Children raised in socially disadvantaged settings often exhibit poorer developmental health in a variety of domains, including socioemotional, medical and cognitive functioning. This relationship appears to operate in part via a cascade linking poverty and cumulative environmental adversity to early biological risk and interpersonal family process. Moreover, these mechanisms are suggested to function over-and-above the direct effects of material investments in children’s healthy development and wellbeing. Despite this knowledge, there remains a need for longitudinal developmental research examining the nature in which environmental risk in early life impacts multiple and distinct intermediary mechanisms that are manifest within the proximal family environment. In order to address this limitation, the present dissertation provides three separate empirical studies outlining the nature in which social disadvantage impacts family process (in the form of interpersonal sensitivity), and early biological risk (in the form of birth weight). Data for the present dissertation came from the Kids, Families and Places Study, which is a population-based prospective birth cohort of newborn infants and their families from Toronto and Hamilton, Ontario, Canada (N=501 families). The present dissertation demonstrates that social disadvantage (1) impacts cognitive functioning in a
number of domains at the time of school entry via maternal sensitivity and material investments, (2) disrupts the receipt of cognitive sensitivity during family interactions across multiple dyads, particularly for younger siblings, and (3) simultaneously increases developmental risk for multiple siblings-per-family and tends to increase sibling differences in developmental experience. To conclude, implications for the study of developmental health and family science are discussed.
Dedication

To my Big Brother, Joseph.

You inspire these pages and everything I do.

“Awakening, the morning offered a sunburst promise of spring. Of you, my kindred, I mused… pondering your reflections and resonance in a land far away. For pursuit of Brethren’s unbounded presence, I cycled through Mission and seaside, forging over the Golden Twins – our unitary conduit, connecting ancient ores and rich lands of shared birth. Ascending the headlands, I found myself immersed in radiant, translucent white. Behold, my Brother! The Sky is your Canvas… and below, a predictable Pacific lauds and testifies, repetitiously. How blessed I am to have you here with me.”

(March 19th 2016, Marin Headlands, California)
Acknowledgments

It has been my experience that any substantial work is inherently of the collective varietal. Accordingly, sincere acknowledgements are indicated, outlining the numerous individuals and entities that supported the successful completion and defense of this dissertation. First and foremost, I must articulate gratitude, thanks, and respect for my graduate school supervisor, Dr. Jennifer Jenkins. Your dedication, support, kindness, and intellect are truly an inspiration. The past seven years have been the most challenging, stimulating, and generative of my personal and professional life. Thank you for being my guide through the dynamic zone of proximal development. You taught me how to think.

Thanks to Mira Boskovic for being the steadfast rock that you are. Your support for the Jenkins Lab and the Kids, Families and Places Study permitted this dissertation to be. Also thanks to my committee members, departmental staff, and training supervisors, especially George Leckie, Michal Perlman, Judy Wiener, Mary Caravias, Nancy Link, Michele Peterson-Badali, Katreena Scott, Laurie Costaris, Brendan Andrade, Ken Zucker, Alice Charach, and John Farragher.

Thank you to my family, Joseph Aloysius Browne II, Regina Maria Browne, and Joseph Aloysius Browne III. Mom and Dad, you have always provided the selfless and secure base that permitted my individuation, growth, and maturation. Moreover, through example, you have unwaveringly modelled compassion, goodness, and empathy for all God’s children, especially the Poor in Spirit. This dissertation is but another testament to the familial enterprise of caring. You taught me of the importance of having a personal relationship with God, and your energy is present with me always. As you wish, I will pay it forward for the rest of my life. I love you.

Big Brother Joe! Thank you for being the best brother I could have ever hoped for. I remember when we built a rocket ship in the backyard to fly into outer space. You were in the driver seat. I have always looked up to you and drawn emotional strength from your love. Also, witnessing your remarkably creative and awesome mind has been a gift and an inspiration. I am so proud of all your work and accomplishments! You are the finest man I know. Thanks to Emma Corosky for being the sister I always wanted. Emma, you are a Golden Orchid and a
shining light in my life. The love of you and my brother reminds me of The Goodness. Thank you for your contributions to my brother, me, and our family. I love you both so, so much!

Thank you to all my friends who have been sources of love, companionship, and merriment, especially Lindsay Smart. Your presence is a tremendous source of joy and comfort. Oh, the adventures we have had! To my lab-mates turned life-long friends, especially Heather Prime, Mark Wade (collectively, with I, “The Triumverate”), Sharon Pauker, and Aarti Kumar. You made graduate school so stimulating and enjoyable! We are connected at the hip forever through the Jenkins Lab. I look forward to many more intellectual and geographic journeys together. Thank you to my classmates, especially Alan Rokeach, Richard Rubenstein, Sofia Puente-Duran, and my entire MA/PhD cohort. We sure had a good time!

Much gratitude is owed to Pauline Young, Ralph Ateyo, John Clayton, Carolyn Byrne and the Byrne-Whyte Family, Ruth Milne, Ruth Pallister, Robin Weir, June Jobson, Brian Jobson and the Weir-Jobson family. You helped raise me and have been a constant presence in my life since the day I was born. I am grateful for you and love you all. Also, thank you to my extended Kentucky family, especially the Tonini and Woodson arms, my aunt and Godmother Sister Mary Declan, Godfather Father George Schneider, and all my cousins, aunts and uncles. You are the roots to my personal tree of being. We are forever connected through your love and kindness during my early years, which continues to this very day.

There have been many collective entities that supported my journey to this point. I am grateful for your benevolent organization. I owe great appreciation to the School and Clinical Child Psychology Program at the Ontario Institute for Studies in Education at the University of Toronto, the Psychology Department at the University of Guelph (Karl Hennig, Heidi Bailey, Harvey Marmurek, Michael Grand), The System Linked Research Unit at McMaster University (Carolyn Byrne, Lehana Thabane, Maria Wong), Assumption Roman Catholic Secondary School (Mr. Noack, Mrs. Nicassio, Mr. Campbell, Mr. Diani (x2), Mr. Fuller, Mrs. Black, Mrs. Ianni, Mrs. Mazetti), Holy Rosary Catholic School and Parish (Mr. Walmsley, Ms. Cullen, Father Cote, Father Beretta, Father Dan, Sister Rosanne), and all other organizations that promote the development and wellness of young persons. It takes a village.
# Table of Contents

Dedication ...................................................................................................................................... iv  
Acknowledgments ........................................................................................................................... v  
Table of Contents .......................................................................................................................... vii  
List of Tables .................................................................................................................................. x  
List of Figures ................................................................................................................................ xi  
List of Appendices ........................................................................................................................ xii  

Chapter 1: Social Disadvantage Gets Inside the Family ................................................................. 1  
1.1 Introduction ............................................................................................................................ 1  

Chapter 2: School Readiness Amongst Urban Canadian Families: Risk Profiles and Family Mediation ................................................................................................................................. 6  
2.1 Background ............................................................................................................................ 6  
  2.1.1 Social Disadvantage, Cognitive Outcomes and School Readiness ....................... 8  
  2.1.2 Mechanisms of Social Disadvantage ................................................................. 8  
  2.1.3 Considering Social Disadvantage from a Person-Centered Perspective .......... 11  
  2.1.4 The Current Study (Study # 1) ....................................................................... 12  
2.2 Methods .............................................................................................................................. 13  
  2.2.1 Participants ............................................................................................................. 13  
  2.2.2 Measurement ......................................................................................................... 14  
  2.2.3 Analysis .................................................................................................................. 19  
  2.2.4 Analysis of Attrition ............................................................................................. 20  
2.3 Results ................................................................................................................................. 21  
  2.3.1 Family Risk Profiles at 2 Months Identified via Latent Class Analysis ............ 21  
  2.3.2 Impact of Risk Profile on Cognition via Maternal Sensitivity and Family Investments ................................................................. 25  
2.4 Discussion ........................................................................................................................... 29
Chapter 3 : Observed Sensitivity During Family Interactions: A Study of Multiple Dyads Per Family

3.1 Background

3.1.1 Observed Cognitive Sensitivity during Family Interactions

3.1.2 Isolating the Role of Families, Individuals and Dyads using the Social Relations Model

3.1.3 Development of an Autonomous Cognitive Sensitivity

3.1.4 Cumulative Risk and Family Process

3.1.5 The Current Study (Study #2)

3.2 Methods

3.2.1 Participants

3.2.2 Measures

3.2.3 Analysis

3.2.4 Analysis of Attrition and Missing Data

3.3 Results

3.3.1 Question 1 - To what extent are sensitive interactional styles primarily a characteristic of families, individuals or dyads?

3.3.2 Question 2 - Is cumulative risk particularly deleterious for sensitivity levels in certain relationships (e.g. parent-child, sibling)?

3.4 Discussion

3.4.1 Cognitive sensitivity operates across hierarchical levels of family organization

3.4.2 Impact of cumulative risk on cognitive sensitivity across hierarchical levels of the family

3.4.3 Limitations and Future Directions

Chapter 4 : Socioeconomic Status and the Augmentation of Within-Family Risk

4.1 Background

4.1.1 Biological and Contextual Consequences of Low Socioeconomic Status
List of Tables

Table 2.1. Study 1 – Latent Class Analysis Model Fit........................................Page 22

Table 2.2. Study 1 – Descriptives and Correlations..........................................Page 25

Table 2.3. Study 1 – Indirect Effects.................................................................Page 28

Table 3.1. Study 2 – Descriptives.................................................................Page 52

Table 3.2. Study 2 – Correlations.................................................................Page 53

Table 3.3. Study 2 – Social Relations Model Output.......................................Page 55

Table 3.4. Study 2 – Variance Partitioning Output.........................................Page 58

Table 4.1. Study 3 – Descriptives and Correlations.........................................Page 82
List of Figures

Figure 1.1. Outline of empirical studies...............................................................Page 5

Figure 2.1. Study 1 – Distal risk, proximal process and school readiness.................Page 7

Figure 2.2. Study 1 – Risk probability by profile membership.................................Page 23

Figure 2.3. Study 1 – Mediation model of school readiness....................................Page 26

Figure 3.1. Study 2 – Variance partitioning of cognitive sensitivity.........................Page 59

Figure 4.1. Study 3 – SES, birth weight and sensitivity path model........................Page 82

Figure 4.2. Study 3 – SES and birth weight between and within families...............Page 85

Figure 5.1. Summary of study findings.................................................................Page 93

Figure 5.2. Conceptual synthesis of study findings..............................................Page 98
List of Appendices

Appendix 1: Measurement Appendix for Chapter 2……………………………………...Page 128
Appendix 2: Measurement Appendix for Chapter 3…………………………………..….Page 136
Appendix 3: Statistical Appendix for Chapter 3…………………………………….....…Page 141
Appendix 4: Statistical Appendix for Chapter 4……………………………….…………Page 148
Chapter 1:
Social Disadvantage Gets Inside the Family

1.1 Introduction

Policy makers have called for the reduction of health inequalities by addressing the
determinants of wellbeing outside the healthcare system (Canadian Standing Senate Committee
on Social Affairs, Science, and Technology, 2009; UNICEF, 2005; Wagstaff, 2002). Many of
these influences are operative within the family and are disproportionately prevalent amongst
socially disadvantaged households (Conger, Conger, & Martin, 2010; Marmot, 2007; Repetti,
Taylor, & Seeman, 2002; Wilkinson, 2003). Historically, researchers have suggested that
children from risky backgrounds experience poorer developmental outcomes due to harmful
lifestyle choices and an absence of material resources or enrichment opportunity (Bradley &
Corwyn, 2002). However, following improvements in the understanding of socioeconomic
gradients (Keating & Hertzman, 1999), and the physiological consequences of intrauterine and
early experiences (Gunnar & Quevedo, 2007; O’Connor et al., 2005; O’Donnell et al., 2013;
Rutter, 2002), scientists now highlight role of pathogenic socialization contexts in the disruption
of developmental health (Conger et al., 2010; Conger & Donnellan, 2007; Evans & Kim, 2012;
Hertzman & Boyce, 2010). To date, there remains a paucity of literature examining the complex
and multiple bio-psychosocial mediating mechanisms through which families convey social
disadvantage to children (Repetti, Wang, & Saxbe, 2009; Shonkoff et al., 2012). Thus, the
proposed dissertation seeks to explore the multiple ways in which social disadvantage “gets
inside the family” (Conger, n.d.). In terms of child outcomes, focus will be placed on child
cognitive development – an identifiable early predictor of civic success and health across the
lifespan (Batty & Deary, 2004; Conger & Donnellan, 2007; Moffitt et al., 2011). In terms of
mechanisms of influence, both psychosocial (relational or interactional) and biological (intrauterine) pathways will be considered across levels of family organization.

Three separate empirical studies will elucidate the multiple ways in which social disadvantage impacts development via the proximal family milieu (see Figure 1.1). Study 1 (Chapter 2) will be a longitudinal replication and extension of previous literature highlighting the primacy of interpersonal family processes as a substantive link between cumulative risk and developmental health. Using cognitive outcomes at the time of school entry (i.e. school readiness) as an exemplar, observed maternal sensitivity at 18 months will be evaluated as a mediator of the relationship between cumulative risk in four overarching domains (maternal history of adversity, current household and caregiver functioning, socioeconomic risk and neighbourhood functioning) at birth and child functioning at 4.5 years. A unique combination of person-centered and variable-centered analytical techniques will permit the isolation of particular groups of families who are at risk, in addition to the mechanisms of influence through which child developmental health is impacted. Of note, this study will isolate the unique relationship between sensitivity and school readiness by adjusting for the amount of material investments children receive. That is, material investment in child development will be considered as an independent and parallel mediating pathway. Furthermore, utilization of the Kids, Families and Places prospective birth cohort will allow the identification of risk profiles and mediating pathways amongst a diverse group of urban Canadian immigrants and non-immigrants. Given the hypothesized role of sensitivity in driving outcomes at school entry, Study 2 (Chapter 3) will seek to better understand the manifestation of sensitivity within the family unit, and the way this is altered under settings of cumulative adversity. By examining multiple dyads per family, Study 2 will ascertain the extent to which sensitivity is a characteristic of entire families, individuals, or specific dyads. Moreover, the impact of early risk on sensitivity across these hierarchical levels
of family organization will be considered, where families were observed interacting when younger and older siblings were approximately 1.5 years and 4 years, respectively. Finally, Study 3 (Chapter 4) will consider the risk-influenced child factors that predict sensitive parenting across the family unit. Specifically, the impact of social disadvantage on early biological risk will be considered amongst siblings, whereby birth weight is used as a proxy for quality of the intrauterine environment. Here, the extent to which risk increases sibling differences in early biological risk will be considered, and the corresponding impact of this on sensitivity will be evaluated. Associations will be considered at the family level (i.e. are siblings more differentiated in high risk families, overall?) and at the child level (i.e. how is a particular child impacted relative to his or her other sibling?). In sum, the present dissertation is intended to elucidate the nature in which social disadvantage impacts children’s developmental experiences in a complex fashion – operating via multiple mechanisms, across hierarchical levels of family analysis, and considering factors than span bio-psychosocial ecology.

Before proceeding to the empirical investigations, brief description will be offered surrounding measurement. Across the three presented studies, the central interpersonal family phenomenon and construct of interest is observed sensitivity during real-time interactions. In Studies 1 and 3, maternal sensitivity is considered, in addition to its associations with contextual risk and the developmental health of children. In these investigations, a rigorous coding system is described and implemented (Deater-Deckard, Pylas, & Petrill, 1997; Matias, 2006), with the purpose of quantifying the amount of sensitivity mothers direct towards children during structured play, free play, and a picture-book reading task (see Measures sections Study 1/Chapter 2 and Study 3/Chapter 4). In Study 2, the observed and directed sensitive behaviour of multiple family members is considered: mothers towards children, children towards mothers, and siblings towards one another (see Measures Study 2/Chapter 3). Due to the substantial time
commitment and financial cost of coding videotaped interactions, Study 2 employs a “thin slice” impressionistic coding system that quantifies levels of expressed sensitivity of all family members during a challenging block-building task. Extant validation studies and other investigations have demonstrated excellent psychometric properties and substantial overlap between both coding systems, in addition to analogous convergence with other constructs of interest (Browne & Jenkins, 2012; Meunier, Boyle, O'Connor, & Jenkins, 2013; Prime et al., 2015; Prime, Perlman, Tackett, & Jenkins, 2014). Specifically, both measures of sensitivity yield expected associations with distal social disadvantage (e.g. cumulative psychosocial risk, socioeconomic status, maternal depression, maternal abuse history, family size), child developmental health (e.g. theory of mind, receptive vocabulary, behavior and emotional problems, general health), and other interpersonal and relational phenomena (e.g. sibling cooperation during challenging tasks).

The studies presented in the current dissertation were derived from an ongoing project by my supervisor, Dr. Jenny Jenkins. Accordingly, it should be noted that I was not involved in the overall project design, measurement selection, or data collection, as this longitudinal investigation was underway prior to my joining the Jenkins Lab. For the studies presented below, I have been responsible for conceptualization, data analysis, interpretation, and writing. Additionally, Study 1 has “revise and resubmit” status with the Journal of Educational Psychology, Study 2 is accepted for publication with Developmental Psychology, and Study 3 has been submitted to Developmental Psychology. This work is beyond the publication of 23 articles, 2 chapters, and 32 presentations at conference/meetings since joining the Jenkins Lab. Furthermore, I have been responsible for the development of observation coding measures, management of reliability coding, and supervision of junior students and research assistants.
Figure 1.1. Outline of Empirical Studies.

Three studies will be conducted in order to better understand the association between social disadvantage and developmental health via family process and intrauterine experience, irrespective of the effects of family material investments in child development.

Study 1
Family profiles of contextual risk impact school readiness via maternal sensitivity independent of material investments

Study 2
Sensitivity during family interactions is operative across hierarchical levels of family organization and is impacted by contextual risk

Social Disadvantage (Cumulative Risk, Low SES)

Family Process (Sensitivity)

Family Investments (Material Resources)

Developmental Health (School Readiness)

Intrauterine Experience (Child Birth Weight)

Note
*Study 2 involves multiple dyads while study 3 involves sibling pairs. Conversely, Study 1 involves a single child. Given this, it is not appropriate to test the above in a single model.
Chapter 2:
School Readiness Amongst Urban Canadian Families: Risk Profiles and Family Mediation

2.1 Background

The pathways between distal contextual risk and cognitive outcomes at school entry are suggested to operate, at least in part, via family experiences (Boivin & Bierman, 2013; Conger et al., 2010; Duncan & Magnuson, 2012). Such mechanisms include: (a) a family investments pathway, including resource-based and material investments in child development, in addition to the physical quality of the home environment (e.g. access to books, toys, educational or cultural enrichment, and a clean and safe living space); and (b) a family process pathway, which includes stress-influenced parenting practices and interpersonal socialization experiences (Bradley & Corwyn, 2002; Conger et al., 2010). To date, several studies suggest that investments are a stronger mediator for child cognition (Guo & Harris, 2000; Linver, Brooks-Gunn, & Kohen, 2002; Yeung, Linver, & Brooks-Gunn, 2002). This conclusion is based on operationalizing family processes as general parenting practices or styles, often measured through brief ratings or self-reports. However, studies connecting observed maternal sensitivity with cognitive development, as well as social disadvantage, suggest that family processes may also serve as a mediator (Allhusen et al., 2005; Mistry, Biesanz, Chien, Howes, & Benner, 2008; Raviv, Kessenich, & Morrison, 2004). Currently, there is a paucity of literature examining the family mediation of broad contextual risk on multiple domains of school readiness (Vernon-Feagans, 2013), especially amongst urban, multicultural and immigrant samples, who are faced with a number of unique contextual stressors and challenges following resettlement (Gazso & Waldron, 2009; Perreira, Chapman, & Stein, 2006). The present study addresses this limitation in a prospective birth cohort using a combination of person- and variable-centered techniques. The
impact of distal risk on multiple domains of cognition at school entry is examined via family investment and family process pathways, the latter being defined as observed sensitive parenting that is synchronous, supportive and stimulating. Figure 2.1 provides a schematic illustration of the conceptual and empirical arguments in the current manuscript.

**Figure 2.1. Conceptual model for Study 1.**

*Hypothesized associations from distal and contextual risk to school readiness via family process and family investment pathways in the proximal environment.*
2.1.1 Social Disadvantage, Cognitive Outcomes and School Readiness

Cognitive functioning around the time of school entry serves as a keystone predictor of developmental health and wellness across the life course (Boivin & Bierman, 2013). Accordingly, the importance of identifying the pathways towards school readiness has been emphasized, referring to a multidimensional set of cognitive and socio-emotional skills that determine school success. These include the interconnected abilities of language, self-regulation (e.g. executive functioning, EF), social understanding (e.g. theory of mind, ToM), and early literacy and numeracy (Boivin & Bierman, 2013; Duncan et al., 2007). To date, deficits in EF and language have been most strongly tied to SES variation (Hart & Risley, 1992; Noble, Norman, & Farah, 2005). However, difficulties in social cognition may also be related to individual variation in EF and language (Astington & Jenkins, 1999; Hughes, 1998). It is important to understand the etiological sources of variation in school readiness, given that disparities in these multiple concomitant abilities amplify over time, contributing to social discrepancies in educational success (Sirin, 2005). For example, using six longitudinal data sets, Duncan and colleagues (2007) demonstrated that academic ability (e.g. math and reading) and attention at school entry provided the strongest prediction of achievement in later years. Such findings highlight the importance of exploring the mechanisms through which cognitive variability emerges before children enter school.

2.1.2 Mechanisms of Social Disadvantage

Evidence citing the importance of monetarily based, material investments in cognitive development is sizable and available elsewhere (Conger et al., 2010; Gennetian & Miller, 2002; Guo & Harris, 2000; Mistry et al., 2008; Yeung et al., 2002). Consistent with literature reviewed by Gennetian and Miller (2002) and Yeung and colleagues (2002), this mechanism has been called resources, human capital, or investments. In the current study, this pathway is identified
using the *family investments* label. The other mediating mechanism of interest concerns the impact of economic stress on non-financial aspects of family life, such as the psychological adjustment of caregivers and the consequences of this for parent-child interaction quality. Previous literature has described this pathway as socialization, family stress, the psychological model, or family process. The *family process* label is adopted for this study.

Despite compelling evidence linking early rearing and cognition in human (Sroufe, Egeland, Carlson, & Collins, 2005) and animal models (Blair & Raver, 2012), the role of family processes, or more specifically parenting, as a relational predictor of school readiness remains surprisingly unclear. This is likely due to differences in parenting measurement. For example, using brief interviewer-rated parenting items from the HOME Inventory (Bradley, 1994), Yeung and colleagues (2002) found that parenting did not mediate the impact of SES on academic achievement over and above family investments, but did have an impact on child behavior problems. Guo and Harris (2000) found significant but small effects for parenting on child cognition using similar methodology, but concluded that family investments were the most influential. Studies that assess other aspects of parenting, such as authoritative and authoritarian rearing styles, have similarly failed to find a mediating role of parenting on cognition (Linver et al., 2002). Conversely, studies that examine *maternal sensitivity* during observed and coded interactions find a strong relationship between parenting and cognitive outcomes, with evidence suggestive of mediation (Allhusen et al., 2005; Mistry, Benner, Biesanz, Clark, & Howes, 2010; Mistry et al., 2008; Vernon-Feagans, 2013) (NICHD Early Child Care Research Network, 2005; Mistry et al., 2008; Mistry, Benner, Biesanz, Clark, & Howes, 2010; Vernon-Feagans, 2013). Currently, no studies have examined this pathway amongst a Canadian sample of immigrants and non-immigrants. Immigrant families are faced with a number of unique contextual stressors and challenges following migration and resettlement (Gazso & Waldron, 2009; Koury & Votruba-
Drzal, 2014; Perreira, Chapman, & Stein, 2006). Moreover, no studies have performed direct statistical comparison of indirect effect sizes via family investment and family process pathways, where family process is defined as maternal sensitivity. The current study will address this limitation, thereby shedding further light on the links between social disadvantage and school readiness.

Several subcomponents of maternal sensitivity have been emphasized, and there appears to be phenomenological convergence amongst these constituent parts (de Rosnay & Murray, 2012). Consistent with previous research (Meunier et al., 2013), the current study organizes these components into three overarching domains, all of which have been robustly linked to various aspects of child cognitive and psychosocial development. First, sensitivity refers to the decoding of children’s behavioral cues for the purpose of responding to child needs in a contingent fashion, in addition to the presence of affective warmth during interactions (Claussen & Crittenden, 2000). In the present investigation, aspects of sensitivity included responsiveness to the child’s verbal and non-verbal overtures, child-focused engagement, child mindedness, and responsive facilitation. Second, mutuality describes the synchrony and quality of dyadic interactions, including positive shared attention, shared affect, turn-taking, and conversational fluidity (Ensor, Spencer, & Hughes, 2011; Feldman, 2006; Kim & Kochanska, 2012). Finally, positive control describes parental bids for control and the manner in which parents shape child behavior with the use of specific praise, explanation, elaboration, suggestion, and open-ended questioning (Deater-Deckard et al., 1997; Deater-Deckard et al., 2001). There is overlap between this aspect of sensitivity and what others have called autonomy-support or scaffolding (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Bernier, Carlson, & Whipple, 2010).
A number of converging frameworks outline the mechanisms linking responsive caregiving and cognitive development. Most of these accounts are consistent with prominent theoretical models suggesting that psychological ontogenesis is a product of the internalization of interpersonal experience (Fernyhough, 2008; Vygotsky, 1978). That is, responsive maternal behavior during parent-child interactions facilitates the co-activation of inter-subjective processes that serve as precursors to autonomous cognitive abilities (Blair & Raver, 2012). Across repeated experience, these dyadic phenomena become increasingly represented within individual cognition. The internalization of interpersonal experience has been described as experiential canalization or, more generally, the experience-dependent “selective optimization” of particular cognitive functions based on certain rearing environments (Blair & Raver, 2012). For example, Bernier and colleagues (2010; 2012) have shown that the emergence of self-regulation reflects a gradual internalization of responsive and co-regulated parent-child interactions. Moreover, there is interdependence amongst self-regulatory capacity and the development of math and reading, language, social competence, and theory of mind (Benson, Sabbagh, Carlson, & Zelazo, 2013; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014). That is, high-quality dyadic exchanges seem to promote the emergence of a cognitive set that facilitates self-directed learning and successful interpersonal exchanges by the time of school entry.

2.1.3 Considering Social Disadvantage from a Person-Centered Perspective

Studies of social disadvantage often employ univariate economic indices as a proxy for environmental adversity, including family income, education, or income-to-needs ratios. Another approach to modeling distal risk is the cumulative risk perspective, which suggests that the aggregation of risks contributes to developmental consequences as opposed to their presence in isolation (Evans & Kim, 2012; Vernon-Feagans, 2013). While there is substantial evidence to
support these methodologies, there are a few limitations to such variable-centered approaches. Specifically, relying on basic metrics or simply counting-up risks can obscure the existence of subtypes of social disadvantage in the population. This may be especially true amongst heterogeneous groups, characterized by diversity in terms of immigration history, refugee status, life history, ethnicity and culture (Gazso & Waldron, 2009; Perreira, Chapman, & Stein, 2006). Using person-centered approaches, a handful of researchers have suggested that such risks may not simply accumulate, but may combine in prototypical ways to create discrete family risk profiles that are differentially related to developmental outcomes (Brody et al., 2013; Lanza, Rhoades, Nix, & Greenberg, 2010). Such methodology has public health relevance, as analyses can help identify and target homogenous subgroups of persons who are differentially at risk based on readily identifiable characteristics. To date, no studies have identified person-centered family risk profiles in relation to the mediation of social disadvantage on school readiness via the parallel pathways of family investments and family processes.

2.1.4 The Current Study (Study # 1)

The purpose of the current study is to compare family investment and family process pathways in explaining the relationship between social disadvantage and school readiness amongst a diverse group of urban, multicultural Canadian families (see Figure 2.1). This investigation adds to the aforementioned literature by incorporating a number of substantive and methodological components into a single design. These include the (a) identification of person-centered profiles of social disadvantage, around birth, and in a number of domains (i.e. maternal history of adversity, immigration history, current household and caregiver functioning, SES and neighborhood risk); (b) inclusion of multiple cognitive outcomes underlying school readiness (early academics, receptive vocabulary, EF and ToM); (c) utilization of a prospective birth cohort design over 4-years; (d) inclusion of multi-informant measurement, including videotaped
coding, in-home observations, direct assessment, and linkage with the national census; and (e) formal comparison of the relative importance of family investment and family process pathways via estimates of indirect effect size and model parameter constraints.

2.2 Methods

2.2.1 Participants

Participants are derived from the Intensive sample of the Kids, Families Places (KFP) Study. All women giving birth in Toronto and Hamilton, Ontario between April 2006 and September 2007 were considered for participation. Families were recruited through Healthy Babies Healthy Children, a program in which parents of all newborns are contacted within a week of their birth. Inclusion criteria included the presence of an English-speaking mother, a newborn greater than 1500 grams, agreeing to be filmed in the home, and the presence of at least two children who are less than 4 years. Multiparous mothers were exclusively recruited given that the current study was embedded within a larger longitudinal study, the goals of which were to examine genetic and environmental influences on children’s socio-emotional development through the investigation of within-family differences. Only the target (youngest) child was included in order to track children from birth to school entry. Reasons for non-enlistment included inability to contact families and refusals. The University of Toronto Research Ethics Board approved all procedures, including informed consent. We compared our sample (N=501) with the general population of Toronto and Hamilton using 2006 Census Data, limiting the census to women between 20-50 years and having at least one child. Families were compared on immigrant status, number of persons in the home, family type, maternal income, and educational level. Families were of similar size ($M = 4.52, SD = 1.01$ vs. $M = 4.13, SD = 1.22$) and maternal income (median C$30,000–39,999 vs. census population mean = C$30,504.16, SD =
C$37,808.12). As our sample was recruited so shortly after childbirth, there are fewer non-intact families than in the population (5% vs. 16.8% lone-parent families; 4.3% vs. 10.3% stepfamilies). The ratio of Canadian born to immigrants was somewhat higher in the current sample (57.7% vs. 47.6%), likely due to the language requirement for participation. Also, more study mothers had earned a bachelor’s degree or higher (53.3% vs. 30.6%). Of participating mothers, 56.5% self-identified as being of European descent, 14.6% as South Asian, 9.3% as Black, 12% as East Asian and 8.6% as other.

Of participating families, 74.1% of families were 2 child families, 18.8% were 3 child families, and the remaining 7.2% had 4 or more children. Mean child age at baseline was 2.00 months (SD = 1.06) and 49.3% of children were female. Families were initially followed-up when children were 1.60 years (SD = .16) and 397 (79.2%) families remained, and again when children were at the age of school-entry (4.79 years old, SD = .28) and 323 (64.5%) families remained. For simplicity, these time points are referred to as “birth, 18 months, and school entry”. In the KFP study, there is an intermediary follow-up that corresponds to approximately 36 months. However, this time-point was not included since individual differences in outcomes at the time of school entry (i.e. school readiness) were of interest. Retained families were somewhat higher functioning in a number of areas, as is often the case in longitudinal research (see below). Best practice procedures were followed for missing data (i.e. multiple imputation across 25 datasets) in order to minimize the effect of attrition.

2.2.2 Measurement

2.2.2.1 Distal Risk Factors

Due to the large number of distal risks examined, risk measures are presently described in brief and comprehensive descriptions are available in the supplementary appendix. Risks factors
were assessed at birth in the domains of early maternal history (e.g. witnessing or experiencing abuse, familial history of psychopathology and substance abuse), current caregiver factors and household risk (e.g. immigration status, maternal depression, marital conflict, single-parenthood), socioeconomic risk (e.g. income under $20,000, absence of post-secondary education, recipient of income supplement), and neighbourhood risk (e.g. poor observed neighbourhood quality, victimization, high concentration of low-income housing). Measures were predominantly maternal report, though home visitors made reliable neighbourhood observations based on the Block Environment Inventory (McGuire, 1997) as detailed in the appendix. Additionally, families were linked to the 2006 Canadian National Census using the first three characters of their postal-code, providing additional neighbourhood information (e.g. census tract poverty and unemployment rates). Thirty-two risks across these domains were coded as being either present (1) or absent (0) based upon naturally occurring criteria (e.g. teenage parenthood) or distributional cut-offs (i.e. +1 standard deviation towards the risky or adverse pole). Please see the supplementary appendix for additional information.

2.2.2.2 Family Mediating Variables

Mediating variables were assessed during the home visits at 18 months. The family investment pathway was assessed as quality of the home environment and material investments, indexed using the observer-response items of the HOME inventory, while the family process pathway was measured as maternal sensitivity during videotaped mother-child interactions (and will henceforth be referred to as the maternal sensitivity pathway). Trained interviewers used an adapted version of the HOME scale (Bradley, 1994). The standard HOME scale is a mixture of observer and parental report. We only used the observer items in order to avoid parental response bias and in order to avoid contamination amongst assessments of the process and investment pathways. In total, observers rated 10 items on a 3- or 4-point scale across two over-arching
domains. The first domain assessed order, cleanliness, and safety of physical environment. The second domain assessed the amount of toys and educational materials available to the children. Negatively worded items were reverse coded and all items were averaged to create a composite reflecting family investment ($\alpha = .68$).

Also at this time, mothers were videotaped interacting with the target child for 15 minutes. There were three different tasks, each of which lasted 5 minutes. First, there was a free play with no toys, where mothers were instructed to play with children as they normally would but without any play materials. Second, there was a structured teaching with toys, where dyads were given a pegboard with circles and squares of different colors and instructed to copy a picture. Specifically, mothers were asked to teach their children how to construct the pattern in the picture, where the pattern was intentionally beyond the child’s developmental level in order to elicit maternal teaching. Finally, there was a reading task, during which the mother was asked to make up a story to a wordless picture book. These tasks were selected in order to assess mother’s capacity to engage the child positively during common tasks of early childhood and to challenge the child’s attention and self-regulatory abilities.

Maternal sensitivity was assessed using the sensitive responding and mutuality scales of the Coding of Attachment Related Parenting scheme (Matias, 2006) and the positive control scale of the Parent-Child Interaction System (Deater-Deckard et al., 1997). Sensitive responding measures the ability of mothers to display awareness of their child’s needs, to be sensitive to the child’s signals, and demonstrate perspective taking from the child’s vantage point. Mutuality is a dyadic code that reflects conversational reciprocity, sharing of affect, joint engagement during tasks, and open physical posture. The positive control scale assesses positive aspects of a mother’s style of directing or influencing child behavior, including praise and open-ended
questions. A composite was computed by averaging the sensitive responding, mutuality and positive control subscales across all tasks. Internal consistency was $\alpha = .85$ and interrater reliability, assessed by having an expert coder double-score 10% of all videos, was .94. Interrater reliability was assessed throughout the coding period to minimize rater drift.

### 2.2.2.3 Child Cognitive Outcome Variables

Cognitive outcomes were assessed when children were at the age of school entry. *Receptive vocabulary* was assessed with the Peabody Picture Vocabulary Test – Fourth Edition (PPVT-IV) (Dunn & Dunn, 2007). During the task, an examiner presents a series of stimulus cards with four images and reads a word aloud. The child is required to indicate the picture that corresponds best to the target word. The PPVT-IV is a norm referenced test and was validated on a representative sample.

*Theory of mind (ToM)* was measured using an adaptation of the scale described by Wellman & Liu (2004) (Wellman & Liu, 2004). The first three tasks assessed children’s understanding of diverse desires and beliefs, and knowledge and ignorance, followed by tasks that assessed more sophisticated ToM understanding such as false belief, belief-based emotion, and real-apparent emotion. If children failed two consecutive tasks, testing was stopped. For all ToM tasks, stories were enacted for children with the use of puppets and props. A total score across all tasks (pass or fail) was computed. Internal consistency was $\alpha = .87$.

*Executive functioning (EF)* was assessed using the Bear-Dragon task (Reed, Pien, & Rothbart, 1984) and the Dimensional Change Card Sort (Zelazo, 2006). For the *Bear-Dragon* task, children were instructed to do what they were told by the nice bear (e.g., “touch your nose”), but not to do what they were told by the mean dragon. Children were scored for total number of correct responses (0–10) on five dragon and five bear trails. For the DCCS, children
were required to sort a series of bivalent test cards, first according to one dimension (e.g., color), and then according to the other (e.g., shape). Children who pass the post-switch phase of the standard version of the DCCS may proceed immediately to the border version, which uses the same target cards as the standard version. The border version consists of 12 trials. Children are required to sort cards based on “border” criteria (“If there’s a border, play the color game. If there’s no border, play the shape game”). Previous studies have shown that Bear-Dragon and DCCS load onto the same latent factor measuring set shifting, working memory, and inhibitory control (Bernier et al., 2012). Both measures were correlated in the current study, $r = .34$, $p < .001$. Thus, the two tasks were Z-scored and combined into a composite EF variable. Higher scores represented better EF.

Finally, child \textit{academic skills} at school entry were assessed using three selected subtests from the Woodcock-Johnson Third Edition – Tests of Educational Achievement (WJIIIACH) (Woodcock, McGrew, & Mather, 2007). Age equivalents from these subtests were combined into a composite score. Print and sight-word recognition was assessed using the Letter-Word Identification subtest, which required children to name letters and words aloud from a list. Reading comprehension was assessed with the Passage Comprehension subtest, which required children to read a partially incomplete passage and identify the missing word. Finally, numeracy and mathematical ability was assessed using the Applied Problems subtest. Children had to respond to math problems that were read to them aloud, and some items have accompanying visual stimuli. The WJIIIACH is widely used in research and clinical settings, as it provides reliable and valid yet brief assessment of early academic functioning. Similar to the PPVT-IV, the WJIIIACH was normed on a large, representative and diverse sample.
2.2.2.4 Covariates

Covariates were selected based upon their relation with cognitive outcomes in children, including child birth weight (Landry, Smith, & Swank, 2006), maternal language (Hoff, 2003), and gender (Zambrana, Ystrom, & Pons, 2012). Thus, analyses adjusted for child gender (female = 1), whether or not English was spoken in the home (1 = yes, 0 = no), birth weight (kilograms and grams), and age at final follow-up in years.

2.2.3 Analysis

Analyses were conducted in two steps: (1) latent class analysis identifying profiles of distal risk at birth and (2) path analysis identifying the effects of risk profile on child cognition at school entry via family mediators (family investments and maternal sensitivity) at 18 months. First, the 32 risk factors across domains of adversity at birth (maternal history, current caregiver and household characteristics, socioeconomic status (SES) and neighbourhood risk) were recoded into being either present (1) or absent (0) in accordance with criteria described above and outlined in the appendix. These 32 risk variables were treated as categorical observed indicators and subjected to latent class analysis, where solutions fitting between 2 and 6 classes were compared. Guidelines for selecting the best fitting number of classes were followed (Asparouhov & Muthen, 2012). When model fit is optimal and the entropy statistic is approaching 1, there is little ambiguity in class membership. Thus, participants were assigned to the latent class to which they had the highest probability of membership. The resulting nominal class membership variable was recoded into a series of dichotomous dummy variables, and the class with the lowest probability of endorsing overall distal risk (i.e. low-risk group) was treated as the reference category. These dummies then served as the global indicators of distal risk, which were hypothesized to impact child cognitive outcomes at school readiness via family mediators at 18 months. To evaluate this, a path model was constructed that (a) regressed
mediators onto the class dummies, and (b) regressed cognitive outcomes onto mediators and class dummies. All pathways in this model controlled for covariates. Once the final model was specified, the indirect effects were independently evaluated for each class using the Sobel method (Sobel, 1988). There are multiple effect sizes that can be reported in mediation, and selecting an appropriate statistic is not always simple (Preacher & Kelley, 2011). For example, the mediation proportion is often reported (i.e. ratio of the indirect effect or $a*b$ path to the total effect or $c$ path), though it is not really a proportion since it can take values greater than 1.0 or be negative depending on its relation to $c$. Thus, we report the partially standardized indirect effect ($ab_{ps}$), taken as the product of the unstandardized indirect pathways divided by the standard deviation of the outcome variable ($a*b/\sigma_Y$). This allows us to quantify the relative difference in child outcomes in standard deviation units for a one-unit increase in the dummy-variable risk indicator (i.e. being in a risk group, relative to the low risk group), operating indirectly via the family mediators. Finally, individual model constraints and Wald tests were used to examine the null hypothesis that indirect effect sizes (i.e. pathways via family investment and maternal sensitivity) for a particular risk group and outcome were equivalent.

2.2.4 Analysis of Attrition

Of the initial 501 families, 323 (64.5%) remained at the school entry follow-up. Retained families were compared to those who dropped-out on all baseline risk indicators included in the latent class analysis. Mothers lost to follow-up were higher risk in a number of areas, including the following: mothers’ fathers had a drug or alcohol problem, teenage motherhood, unemployment, incomes less than $20,000, and not owning their home. Both mothers and partners lost to follow-up were significantly less likely to have post-secondary education. The neighborhoods of non-completers were viewed as significantly less trusting and rated by home visitors to be of lower quality. These neighborhoods also had significantly higher rates of census
assessed lone parenthood and poverty. Notably, there was an equal proportion of immigrants retained (44.6%) versus lost to follow-up (50.0%), \( \chi^2 (1) = 1.35, p = .26 \). Baseline indicators of missingness were included in models that compared individuals on outcomes via Multiple Imputation in MPlus (25 imputation sets), making the Missing-at-Random assumption tenable and reducing the likelihood of systematic bias associated with missingness.

2.3 Results

2.3.1 Family Risk Profiles at 2 Months Identified via Latent Class Analysis

In order to derive risk profiles, Latent Class Analyses were conducted on the 32 environmental risk indicators. Model fit information is presented in Table 2.1.
Table 2.1. LCA Model Fit.

Fit indices for latent class models examining 32 risk indicators as a function of one categorical latent variable identifying risk profile membership

<table>
<thead>
<tr>
<th># Classes</th>
<th>AIC</th>
<th>BIC</th>
<th>aBIC</th>
<th>Entropy</th>
<th>p (LMR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>12674.98</td>
<td>12953.27</td>
<td>12743.79</td>
<td>0.874</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>3</td>
<td>12320.51</td>
<td>12742.17</td>
<td>12424.76</td>
<td>0.862</td>
<td>0.10</td>
</tr>
<tr>
<td>4</td>
<td>12169.16</td>
<td>12734.19</td>
<td>12308.86</td>
<td>0.858</td>
<td>0.05</td>
</tr>
<tr>
<td>5</td>
<td>12320.51</td>
<td>12742.17</td>
<td>12424.76</td>
<td>0.862</td>
<td>0.19</td>
</tr>
<tr>
<td>6</td>
<td>11954.03</td>
<td>12805.78</td>
<td>12164.62</td>
<td>0.890</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Note: A 4-class solution was evaluated to be the best fitting model. AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion, aBIC = Sample Size Adjusted Bayesian Information Criterion, p(LMR) = p value of the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test for k versus k – 1 classes.

A 4-class solution was selected as the best fitting model due to improvements in the Akaike, Bayesian and Sample-size Adjusted Bayesian Information Criteria, an acceptable entropy statistic, and a statistically significant Lo-Mendell-Rubin Likelihood-Ratio Test. The Bayesian Information Criterion has its lowest value for the 4-class solution, suggesting that this model may be optimal in terms of balancing parsimony and specificity. Random starts and final stage optimizations were increased, to which the optimal loglikelihood (-5950.58) was robust. The Parametric Bootstrapped Likelihood Ratio Test was then conducted in order to replicate the solution, reconfirming that the 4-class solution is preferred over the 3-class model. The final four
latent classes are visually depicted in Figure 2.2. Probability of each risk being present is plotted as a function of latent class membership (i.e. risk profile).

**Figure 2.2. Family Risk Profiles.**

*Probability of risk factor by risk profile membership. Each bar represents the probability that an individual in the indicated group endorsed the dichotomized risk factor in question.*

<table>
<thead>
<tr>
<th>Domain</th>
<th>Risk Factor</th>
<th>Low SES - Multilevel n=60</th>
<th>Low SES - Immigrant n=139</th>
<th>Abuse History n=78</th>
<th>Low Risk n=224</th>
<th>Total N=501</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal History</td>
<td>Witness Verbal Abuse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mom's Mom Mental H.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mom's Parents Separated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical Abuse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mom's Dad Mental H.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mom's Dad Substance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sexual Abuse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Witness Physical Abuse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mom's Mom Substance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Immigrant</td>
<td>Immigrant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caregiver &amp; Household</td>
<td>Mom Unemployed (1 yr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 or More Kids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marital Conflict</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mom Depressed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Previous Marry/Cohabit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Refugee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mom Single</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teenage Mom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Socio-Economic Status</td>
<td>Income &lt; $20,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Don't Own Home</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High School or Less (Mom)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High School or Less (Dad)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Home Subsidized</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighborhood Factors</td>
<td>Victimization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor Observed Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low Neighbor Trust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Many Unemployed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High Household Poverty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Many Welfare Recipients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Many Without High School</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Many Lone Parents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low Sense of Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
One class had a high probability of endorsing most all risks. This group was called *Low SES-Multilevel Risk* (n=60, 12%). These families had mothers who grew up in risky homes, where there was parental psychopathology, observed and experienced abuse, and family dissolution. They had the highest probability of being headed by a single-parent mother and had the highest probability of marital conflict. Thus, when there is a partner present, the relationship tends to be acrimonious, making this a class characterized by hostile and ineffective relationships. Additionally, these families had high probabilities of endorsing economic risk indicators. The second group had elevated probabilities of endorsing risks that were almost exclusively in the maternal history domain. This group was called *Abuse History* (n=78, 15.6%). Mothers from this group also grew up in risky homes, where there was parental psychopathology, observed abuse, and family dissolution. Interestingly, mothers in this group were less likely to be a target of abuse, compared to the low SES-multilevel risk group. This group also did not endorse risk factors in other domains that measure current levels of adversity, such as depression or marital conflict, nor were they of low SES. A third group had mothers with the highest probability of being born outside of Canada. These families were called *Low SES-Immigrant Risk*, as they also had high probabilities of endorsing economic risk indicators (n=139, 27.7%). By examining maternal history risk factors, it is clear that these families were not at measurable risk before coming to Canada (i.e. no history of family psychopathology, abuse or family separation). Teenage parenthood, homemaking (maternal unemployment), and larger family size may be culturally normative, as well. However, these families were presently living in neighborhoods that were of poorer quality. Finally, there was a group that had low probability of endorsing all risk factors that was called *Low Risk* (n=224, 44.7%). Of note, class assignment was unambiguous, as indicated by the entropy statistic approaching 1 (Table 2.1) and examination of the posterior probabilities of class membership (not shown).
2.3.2 Impact of Risk Profile on Cognition via Maternal Sensitivity and Family Investments

Descriptive statistics are presented in Table 2.2.

**Table 2.2. Descriptive Statistics.**

*Descriptive Statistics and Intercorrelations amongst Covariates, Hypothesized Mediators and School Readiness Outcome*

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Girl</td>
<td>-.03</td>
<td>-.12</td>
<td>--</td>
<td>.11</td>
<td>.01</td>
<td>.02</td>
<td>.01</td>
<td>.14</td>
<td>.03</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2 Age</td>
<td>.00</td>
<td>.14</td>
<td>.10</td>
<td>-.02</td>
<td>.27</td>
<td>.10</td>
<td>.24</td>
<td>.26</td>
<td>4.78</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>3 Birthweight (kg)</td>
<td>.14</td>
<td>.22</td>
<td>.12</td>
<td>.06</td>
<td>.30</td>
<td>.10</td>
<td>.15</td>
<td>3.41</td>
<td>0.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 English Spoken</td>
<td>.19</td>
<td>.21</td>
<td>.02</td>
<td>.31</td>
<td>.15</td>
<td>.13</td>
<td>--</td>
<td>--</td>
<td>2.36</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>5 Sensitivity</td>
<td>.38</td>
<td>.36</td>
<td>.46</td>
<td>.38</td>
<td>.36</td>
<td>3.48</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Investments</td>
<td>.27</td>
<td>.40</td>
<td>.27</td>
<td>.22</td>
<td>2.36</td>
<td>0.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Achievement</td>
<td>.38</td>
<td>.31</td>
<td>.37</td>
<td>5.01</td>
<td>0.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Vocabulary</td>
<td>.41</td>
<td>.53</td>
<td>103.39</td>
<td>12.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Theory of Mind</td>
<td>.37</td>
<td>3.65</td>
<td>1.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Executive Function</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. All correlations in bold are significant at $p < .05$. 
Estimation of the path model in Figure 2.3 permitted tests of mediation hypotheses.

Figure 2.3. Path Model.

Indirect effects of risk profile membership at 2 months on school readiness outcomes at 4.5 years via investments and sensitivity at 18 months. Model Fit: $\chi^2 (3) = 2.257, p = .521, \text{RMSEA} = .006, CFI = 1.00, \text{SRMR} = .007$. Standardized coefficients are presented. Risk profiles are modeled as dummy variables, with the Low Risk profile serving as the reference category. Only significant paths at the $p < .05$ level are displayed. All implied indirect pathways of risk profile on outcomes are statistically significant. Also, all within-time covariances were positive and significant.

Households characterized by the low SES-immigrant risk and low SES-multilevel risk profiles had significantly lower levels of investments and sensitivity relative to the low risk profile. Family investments were significantly and positively associated with academic
achievement, receptive vocabulary and ToM, while maternal sensitivity was positively associated with all child outcomes. The maternal history of adversity profile did not significantly differ from the low risk group in terms of the proposed mediators or outcomes, with the exception of executive functioning. Interestingly, there was a direct effect whereby children from these households had significantly higher levels of EF. All implied indirect pathways in Figure 2.3 were statistically significant (see Table 2.3), and can be interpreted in a similar fashion. For example, membership in the low SES-multilevel risk group versus the low risk group is associated with ToM scores that are .17 standard deviation units lower via investments, and .15 units lower via sensitivity. The Wald test examining the null hypothesis that assumes statistical equivalence across investment and sensitivity pathways is not rejected, $\chi^2 (1) = .10, p = .75$, suggesting that the respective paths are not significantly different in size. Analogous results were obtained for most pathways, where family investments and sensitivity offer significant and similarly small-sized indirect effects. There are two exceptions. First, for the low SES-multilevel risk group, the Wald test is approaching significance when receptive vocabulary is the outcome ($p = .09$), suggesting that the investment pathway is marginally larger. Secondly, for EF, only sensitivity was a significant predictor. However, the non-significant Wald test indicates that the indirect effects do not significantly differ from one another, likely due to small absolute effect sizes of the indirect pathway. Finally, as an exploratory analysis, the magnitudes of the indirect effects via sensitivity were compared across low SES-immigrant risk and low-SES multilevel risk groups. All comparisons were non-significant ($p$’s > .13) suggesting the impact of risk via maternal sensitivity is of similar size for both risk groups.
Table 2.3. Indirect Effects.

*Summary of mediation effect sizes as partially standardized indirect effects and Wald tests examining equivalence of effects through investments versus sensitivity*

<table>
<thead>
<tr>
<th>Risk Profile</th>
<th>Outcome</th>
<th>Mediator</th>
<th>$ab_{ps}$ (SE)</th>
<th>p</th>
<th>Wald (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 months 4.5 Years</td>
<td>18 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low SES-Immigrant</td>
<td>Achievement</td>
<td>Investments</td>
<td>-.09 (.04)</td>
<td>.02</td>
<td>.16 .69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>-.07 (.03)</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Immigrant Risk</td>
<td>Vocabulary</td>
<td>Investments</td>
<td>-.12 (.04)</td>
<td>.00</td>
<td>.84 .36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>-.07 (.03)</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Theory of Mind</td>
<td>Investments</td>
<td>-.10 (.04)</td>
<td>.02</td>
<td>.18 .67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>-.07 (.04)</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Executive Function</td>
<td>Investments</td>
<td>-.04 (.03)</td>
<td>.21</td>
<td>.55 .46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>-.07 (.03)</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Low SES-Multilevel</td>
<td>Achievement</td>
<td>Investments</td>
<td>-.16 (.06)</td>
<td>.01</td>
<td>.08 .78</td>
</tr>
<tr>
<td>Risk</td>
<td>Vocabulary</td>
<td>Investments</td>
<td>-.21 (.06)</td>
<td>.00</td>
<td>2.81 .09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>-.14 (.05)</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Theory of Mind</td>
<td>Investments</td>
<td>-.17 (.07)</td>
<td>.01</td>
<td>.10 .75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>-.15 (.05)</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Executive Function</td>
<td>Investments</td>
<td>-.07 (.06)</td>
<td>.21</td>
<td>.99 .31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>-.15 (.05)</td>
<td>.01</td>
<td></td>
</tr>
</tbody>
</table>

Note: Indirect effects are calculated using the Sobel Method. Partially standardized indirect effects ($ab_{ps}$) are given as the product of the unstandardized indirect pathways divided by the standard deviation of the outcome variable ($a\times b/\sigma_Y$). Wald tests examine the null hypothesis that the investment and sensitivity indirect effect sizes for a particular outcome and risk group are equivalent. The indirect effect of risk via sensitivity on executive functioning is presented, even though the $b$ path is not significant, in order to facilitate the Wald Test.
2.4 Discussion

Theoretical models describing the impact of environmental risk on child development often emphasize the importance of two family mediating mechanisms: (a) resource-based family investments, described as material investments in child enrichment and quality of the home environment, and (b) stress-influenced family processes, referring to parenting, socialization practices and supportive and attentive relationships (Bradley & Corwyn, 2002; Conger, Conger, & Martin, 2010). The current findings add to a growing body of research suggesting that contextual influences on cognitive functioning and school readiness operate simultaneously and independently through both mechanisms (Mistry et al., 2008; Raviv et al., 2004; Vernon-Feagans, 2013; Yeung, Linver, & Brooks–Gunn, 2002). Moreover, the present investigation adds to this literature by providing a unique methodology for parsimoniously linking a host of environmental risks with multiple outcomes via parallel family processes. To date, there has been some debate surrounding the contribution of family processes to early cognitive development in children. When conceptualized as maternal sensitivity during real-time, dyadic exchanges, the current study suggests that family processes do, in fact, provide a measurable and dynamic contribution. That is, responsive exchanges are positive and development-enhancing social experiences, associated with the emergence of cognitive competencies that prepare children for school achievement. Given the stability of early and later cognitive development (Stanovich, 1986), children with these skills are more likely to experience social, educational, economic, and occupational success across the life course (Almedom, 2005).

Findings from the current study replicate both Bernier and colleagues (2010) and Vernon-Feagans (2013), suggesting that sensitivity is particularly important for the development of EF. Specifically, the present study demonstrated that there was not a significant pathway between
family investments and EF, though there was a significant effect of sensitivity. Consistent with previous research, highly attuned exchanges appear to facilitate the emergence and internalization of self-regulation. Through such experiences, children become able to negotiate tasks requiring response inhibition and set shifting, in addition to the coordination of intentional and cooperative interactions which are linked to the emergence of social cognition and theory of mind (Tomasello & Carpenter, 2007). Concurrently, and consistent with previous research, sensitivity is also linked to skills in the areas of mathematics, reading and language capacity when children are beginning school (Benson, Sabbagh, Carlson & Zelazo, 2013; Fitzpatrick, McKinnon, Blair & Willoughby, 2014). Unfortunately, these experiences were less likely to take place in the low-SES Immigrant Risk and low-SES Multilevel Risk homes, putting these children at a relative disadvantage in school readiness. Thus, the present study extends previous research, providing evidence that sensitivity is, in fact, an important mechanism connecting environmental risk and child cognition for a variety of outcomes at the time of school entry. As others have argued, environmental experiences result in the experiential canalization of particular cognitive functions and, although reversals are possible, the arguments for the endurance of these individual differences are strong (Blair & Raver, 2012).

Our results add specificity to variable-centered studies that examine family pathways using dimensional metrics of SES or cumulative risk. Specifically, the present findings identify difficulties amongst a unique group of Canadian immigrants. It appears that there is a deleterious impact of SES (and corresponding neighborhood risk) on child cognition via investments and sensitivity within urban immigrant households, even when other risks are absent (e.g. maternal depression, divorce, or marital conflict). It is noteworthy that the multilevel risk homes are also of low SES. In other words, it is possible that low SES, per se, is the driving force of distal risk in both of these risk groups. That is, financial stress may be sufficient to activate the ecological

...
transmission of risk via both family investment and family process pathways, even when other risks are absent. Empirical models arguing for the primacy of poverty in the family mediation of contextual risk have been successfully demonstrated (Evans & Kim, 2012). However, if risk in the immigrant homes simply reflected absence of funds, one may expect these households to only display lower levels of family investments (i.e. not maternal sensitivity), given that the former pathway directly implicates a family’s economic access to goods and services. Stated differently, this would mean that immigrant risk only operated via the family investment pathway and not via the family process pathway. However, consistent with the family stress model whereby parenting becomes disrupted due to psychosocial stressors (Conger et al., 2010), we see that mothers in risky immigrant families also display lower levels of sensitivity. Indeed, there are parenting disruptions despite the fact that there is a low probability of many other psychosocial risks being endorsed.

Immigrant families are faced with a number of challenges, especially economic hardship, which may be greater when individuals are minorities (Gazso & Waldron, 2009) and parents (Perreira, Chapman, & Stein, 2006). There is evidence that, despite these challenges, many children of immigrants thrive throughout this remarkable transition and may even surpass their host-country counterparts (Coll & Marks, 2012). However, contrary to earlier beliefs, North American immigrants in the 21st century are not always catching up economically to the general population (Walks & Bourne, 2006). Such families often end up in neighborhoods that are proximal to the residences of the host-country poor, and fail to experience upward social mobility and resettlement. It is conceivable that functional families that immigrate to North America, who are met with marginalization and socioeconomic immobility, are at the outset of a multi-generational cycle of economic risk and developmental morbidity.
In addition to importance of neighborhood stress and the psychological impact of economic challenge, it is possible that other unmeasured psychosocial challenges are influencing parenting ability for individuals in the low SES-immigrant and low SES-multilevel risk groups. For example, the current study did not employ measurement in the domain of parental stress, or stress associated with specific childrearing tasks and responsibilities (Abidin, 1995), which tends to be higher in low SES settings (Pinderhughes, Dodge, Bates, Pettit, & Zelli, 2000).

Nevertheless, our findings contribute to family stress theory, suggesting that family processes (i.e. sensitivity) can be disrupted due to economic stress, even in the absence of broadband and crosscutting psychosocial risk. Moreover, such findings echo other empirical investigations and theoretical frameworks that emphasize the influence of macro-economic conditions on family dynamics and developmental health, including recession (Lee, Brooks-Gunn, McLanahan, Notterman, & Garfinkel, 2013) and income inequality (Wilkinson & Pickett., 2009).

Given the identification of an immigrant risk group, it is worth mentioning that there appears to be cross-cultural validity in the maternal sensitivity construct. While Western definitions of attachment related parenting and parenting styles have been called into question, particularly amongst Eastern and collectivist societies (Rothbaum, Weisz, Pott, Miyake, & Morelli, 2000), evidence suggests that the sensitivity dimension, per se, is important across multiple, diverse groups. For example, a large body of work by Bornstein and colleagues describes a core set of interactional behaviors that appear to generalize across cultural contexts, including responsiveness to infant cues, sensitivity, and warmth (Bornstein, 2013; Bornstein & Cheah, 2006). Moreover, there is cross-cultural predictive validity of such behavior, whereby maternal sensitivity is associated with positive developmental outcomes in western and non-western groups (Gunning et al., 2004; Huang, Lewin, Mitchell, & Zhang, 2012; Kermani & Brenner, 2000).
Similar to Lanza and colleagues (2010), the present study identified a particular group of families comprised of mothers who had developmental histories of substantial risk and adversity in their birth homes. However, unlike Lanza, these mothers were not currently single and their children were not experiencing difficulties. In fact, children in these homes had higher EF, and similar achievement, vocabulary and ToM compared to families in the low risk profile. The pathway from membership in the abuse history profile history to higher EF was independent of measured family investment and process pathways. Intergenerational studies have demonstrated that individuals who grow up in dysfunctional homes but marry into healthy relationships break cycles of deprivation (Conger & Conger, 2002; Conger, Schofield, & Neppl, 2012). Indeed, functional paternal and sibling relationships can promote positive development, over-and-above the effects of positive interactions with maternal caretakers (Dunn, Davies, O'Connor, & Sturgess, 2000; Gass, Jenkins, & Dunn, 2007). Moreover, it is possible that genetic factors have created phenotypic similarity amongst high functioning children and mothers who are able to overcome adversity (Doyle et al., 2005).

2.4.1 Strengths and Limitations

This prospective birth-cohort study benefited from the employment of multi-method multi-informant data, including mother report, interviewer and videotaped observation, assessment, and national census data. Findings operated across assessment modalities, reducing the likelihood of shared method variance bias. However, despite the unique findings for immigrants, the current study did not address other cultural processes such as beliefs, values, customs and parental cognitions. While links between parenting and child outcome did not vary significantly between multilevel-risk and low SES immigrant families, it is possible that different mediation processes would have been uncovered if other cultural measures were included. Second, the sample demonstrated higher education than the population, reducing
generalizability. However, given that the sampling resulted in diminished variation on risk, yet substantial variance in child outcomes was explained (between 18-26%), it is possible that greater representativeness may have yielded even stronger effects in the prediction of school readiness. Thirdly, all child outcomes were measured contemporaneously, preventing an examination of the temporal primacy of certain skills. Finally, the current study did not include any measurement surrounding the family process contributions of fathers. Future studies will continue to benefit from research integrating person-centered studies of resilience (e.g. Brody et al, 2013) and process-oriented family designs. Moreover, findings surrounding challenges for immigrants highlight the continued need to reduce barriers for service amongst low-income immigrant populations, while providing access to culturally sensitive screening, assessment, and interventions. The current study suggests that this should include interventions that promote maternal sensitivity, even if there does not appear to be systematic family difficulties or a long history of dysfunction.
Chapter 3:
Observed Sensitivity During Family Interactions: A Study of Multiple Dyads Per Family

3.1 Background

According to family systems theory, the family-unit is an emergent and dynamic entity that is not reducible to its component parts. It is characterized by organizational complexity in terms of function and structure (Minuchin, 1981; Nichols & Schwartz, 2001). Surprisingly, in spite of the prolific history of family systems theory and family therapy practice (Carr, 2012), there is a relative paucity of empirical literature that conceptualizes family functioning using these systemic organizing principles (Cook & Kenny, 2005; Eichelsheim, Deković, Buist, & Cook, 2009). In the present study, we employ a methodology that can differentiate between sources of influence in families, and determine whether interactional behaviors are mainly attributable to individuals, particular dyadic combinations or whole families. Specifically, we consider this issue with respect to observed sensitivity. Sensitivity is the interactional behavior that has been shown to be the best predictor of social and emotional outcomes in the infancy and early childhood periods. Thus, it is a critical relationship skill, though we do not currently understand the contextual influences on sensitivity within dyadic relationships or through the larger family context.

3.1.1 Observed Cognitive Sensitivity during Family Interactions

Observed sensitivity during family interactions operates as a keystone predictor of multiple domains of child development (Belsky & Fearon, 2002; Bernier et al., 2010; Kramer & Conger, 2009; Landry et al., 2014; Prime et al., 2015; Vernon-Feagans, 2013). To date, the vast majority of research on interpersonal sensitivity in early life has focused on mothers. Maternal sensitivity during infancy and early childhood has been linked to a myriad of developmental
outcomes, including emotion and anger regulation (Feldman, Dollberg, & Nadam, 2011; NICHD, 2003), joint attention and attentional control (Belsky, Pasco Fearon, & Bell, 2007; Gaffan, Martins, Healy, & Murray, 2010), infant communication (Gunning et al., 2004), early cognitive development (Bernier et al., 2012), child adrenocortical responses and other physiological indicators (Feldman, 2006; Sethre-Hofstad, Stansbury, & Rice, 2002), compliance to caregivers (Feldman & Klein, 2003), and attachment security (NICHD, 2001). In later childhood, Belsky and Fearon (2007) demonstrated that early attachment security and maternal sensitivity impact problem behavior, social competence, expressive language, receptive language, and school readiness. Maternal sensitivity is higher across all children in households when mothers are positively adjusted and when families are living in less risky environments (Atzaba-Poria, Pike, & Deater-Deckard, 2004; Browne, Meunier, O'Connor, & Jenkins, 2012; Jenkins, Rasbash, & O'Connor, 2003; Meunier et al., 2013)

Historically speaking, the majority of research on maternal sensitivity has focused on contingent responding to infant affective signals (Bakermans-Kranenburg, Van Ijzendoorn, & Juffer, 2003; Sroufe, 2005). A more recent line of research has emphasized maternal sensitivity towards a child’s cognitive states (Bernier et al., 2010; Landry, Smith, Swank, Assel, & Vellet, 2001; Laranjo, Bernier, & Meins, 2008; Meins et al., 2002). In order to assess this phenomenon, Prime and colleagues (2015) have developed a construct called cognitive sensitivity (CS), describing “the extent to which a mother responds [contingently] to her child’s inferred cognitions” (p. 489). This phenomenon can be readily assessed when children and caregivers are engaged in cognitively challenging and demanding tasks. A tripartite model of CS has been theoretically and empirically demonstrated, comprised of mutuality building (i.e. reciprocal interactions characterized by turn-taking and a positive valence), mind reading (i.e. consideration of a child’s understanding and adjustment of responses to a child’s specific needs), and
communicative clarity (i.e. the provision of non-ambiguous verbal and non-verbal guidance to promote awareness surrounding task demands). CS during parent-child interactions is lower in the presence of a variety of risk factors (e.g. maternal abuse history and depression, large family size), is predictive of a number of child outcomes (e.g. theory of mind, executive functioning and psychopathology), and mediates the relationship between contextual risk (e.g. low socioeconomic status) and later cognitive functioning (e.g. receptive vocabulary; Prime et al, 2015).

The construct of sibling sensitivity (and specifically sibling CS) has only recently been developed. Like maternal sensitivity, sibling cognitive sensitivity explains children’s developmental outcomes. For example, Prime and colleagues (2014) have developed a complementary coding paradigm for CS during sibling interactions, with similar psychometric properties including predictive and convergent validity. Other studies have demonstrated that the presence of siblings promotes child cognitive and psychosocial development in domains such as theory of mind, false belief understanding, communicative abilities and social skills (Downey & Condron, 2004; McAlister & Peterson, 2007). Indeed, cooperative sibling interactions are linked to enhanced social abilities (Brown, Donelan-McCall, & Dunn, 1996; Hughes, Fujisawa, Ensor, Lecce, & Marfleet, 2006; Kramer & Conger, 2009). Thus, as there is evidence to suggest that both maternal and sibling cognitive sensitivity are linked to developmental outcomes, it becomes important to understand contextual (whole family or dyadic) and individual influences in its development, as well as whether such influences vary as a function of developmental stage and family role.
3.1.2 Isolating the Role of Families, Individuals and Dyads using the Social Relations Model

Before proceeding, it is important to describe the manner in which the social relations model (SRM) can isolate variability in cognitive sensitivity at the family, individual and dyadic levels (Kenny, Kashy, & Cook, 2006). Of note, it is required for sensitivity data to be directed and dyadic. This means that family members interact with one another in a pair, and are each rated for the sensitivity that the person directs towards their partner. Subsequently, family, individual and dyadic-specific effects are identified and their relative importance can be summarized and contrasted. First, a *family effect* is isolated, referring to the average amount of CS in a given household. This estimate quantifies the extent to which sensitivity is operative as an ambient household climate. Second, individuals are distinguished by ‘role’ (mother, older sibling, younger sibling) and separate ‘actor’ and ‘partner’ effects are identified for each individual. The *actor effect*, measures the average amount of CS a particular individual directs towards others, while the *partner effect*, measures the average amount of CS an individual receives from others. Third, after isolating family and individual effects, it becomes possible to identify a directed *dyad effect*, or the level of sensitivity a family member exhibits towards another after accounting for what is normal for both individuals. For example, the mother-to-older sibling dyad effect would be the amount of CS a mother expresses towards an older sibling after accounting for the overall family effect, her actor effect and the child’s partner effect. These estimates reflect the extent to which directed sensitivity scores are a component of the specific relationship constellation. The relative importance of family, individual (as actors and as partners), and dyad effects as sources of influence on CS are summarized by their variance components, quantifying the degree to which each set of effects varies in the population.
There are two more general parameters that are identified in SRM studies. These reflect the reciprocity of family members at the individual and dyad-specific levels of analysis. First, *generalized reciprocity* or the *actor-partner correlation* represents the general correspondence between the CS individuals “give off” and “get back” across all their relationships. For example, it may be that mothers who exhibit higher levels of sensitivity compared to other mothers, on average, receive more CS from their children in return (i.e., positive generalized reciprocity). Second, at the dyadic-level, the *dyadic reciprocity correlation* indicates correspondence between the CS that two family members show each other. For example, it is possible for a mother to exhibit greater levels of sensitivity to one particular child, and for this child to respond to the mother accordingly, relative to the average for those individuals (i.e., positive dyadic reciprocity).

Given that there are no SRM studies of sensitivity in early childhood, hypotheses regarding the importance of families, individuals and dyads in influencing CS are somewhat difficult to make. However, existing self-report SRM studies and observational studies of adolescent youth provide guidelines surrounding the expected variance partitioning across the family, individual and dyadic levels of analysis. Eichelsheim and colleagues’ (2009) systematic review of self-report family SRM studies indicates that family differences account for 8% to 18% of the variability in ratings, suggesting that there is modest but important similarity in relational processes within families. In terms of individual differences, 34% to 47% of the variability in interactions is attributable to what individuals “give off” or direct towards others (i.e. actor variance), while 12% to 18% of the variability in behavior concerns what individuals “get back” or receive from others (i.e. partner variance). This suggests that, after accounting for significant between-family differences, individuals play an important role in influencing family interpersonal climate, although this influence is greater in terms of what individuals direct.
towards others rather than what they receive. Furthermore, 26% to 32% of the variability in behavior occurs at the dyad level. In other words, after accounting for family-level and individual-level differences, there is still a large amount of variability in behavior that is attributable to the unique components of a particular relationship. In terms of reciprocity effects, Eichelsheim and colleagues’ (2009) systematic review reported “no clear pattern” in terms of generalized reciprocity across studies, often due to the presence of non-significant partner effects. However, dyadic reciprocities tend to be positive and significant, particularly when interpersonal warmth is the response in question. That is, when a family member exhibits or reports particularly high levels of warmth towards another family member, the family member in question typically reports higher levels of warmth in return.

There are two SRM studies of observed interactions among families with adolescents, yielding findings similar to self-report investigations (Ackerman, Kashy, Donnellan, & Conger, 2011; Rasbash, Jenkins, O'Connor, Tackett, & Reiss, 2011). Ackerman and colleagues (2011) conducted an SRM on a sample of families including mothers, fathers and two children, where younger and older children were approximately 11 and 13 years old, respectively (N≈400). This study examined family positive engagement, defined as “an interpersonal style characterized by attentiveness, warmth, cooperation, and clear communication (p. 1).” In a similar four-person SRM, Rasbash and colleagues (2011) examined positivity during family interactions defined as warmth, assertiveness, communication, involvement and self-disclosure. Siblings were between 10 and 18 years of age, and not more than four years apart (N≈700). Both studies identified significant family clustering in relationships (16% to 24%), suggesting that there is indeed an ambient family effect in observed interactions. Also, there was significant and sizeable actor variance for mother and child family roles (27% to 33% for younger siblings, 20% to 55% for older siblings, and 28% to 38% for mothers). These findings may imply that there should be
similar variability at the family and individual levels in CS for mothers and their young children. However, Rasbash and colleagues (2011) compared variance components as a function of role, finding some evidence for larger maternal versus child variances for positivity but not negativity. It is possible that the unique developmental context of the present investigation would augment these differential findings as a function of family role.

3.1.3 Development of an Autonomous Cognitive Sensitivity

The behaviors of children in early life are heavily guided by the interpersonal behaviors of their counterparts in the proximal social environment (Bronfenbrenner & Morris, 2006; Lerner, 2006). In addition to CS, a variety of complementary processes have been articulated in order to describe this phenomenon, including mother-child synchrony (Feldman, 2006), mutually responsive orientation (Kochanska, 2002), and transactional co-regulation (Sameroff, 2010). Inherent in all of these conceptual models is the notion that young children’s sensitive responding during interactions is inextricably tied to the responsiveness of others. Indeed, Kochanska argues that there is a developmental shift in the nature of sensitivity across early childhood, whereby parents play a larger role driving interactions in early life due to the existence of an asymmetry in terms of parental versus child competence (Kochanska & Aksan, 2004). In fact, it has been argued that these sensitive interactions are the very experiences that provide children with the opportunity to internalize an autonomous social skill-set, contributing to the development of individual agency and a variety of corresponding cognitive and socioemotional abilities (Blair & Raver, 2012; Goldberg, Grusec, & Jenkins, 1999). That is, parents serve to guide children through challenging interpersonal interactions, which is facilitative of individual mental and social development across ontogenesis (Fernyhough, 2008; Vygotsky, 1978).
In SRM nomenclature, the aforementioned findings would imply that the CS of young children would be more attributable to the environment (i.e. effects of the ambient family climate and the particular dyad in which they are operating), versus the individual (i.e. child actor effects). Conversely, the sensitivity of mothers would be operative primarily at the individual level, which is consistent with findings articulating the primacy of family-wide or shared influences in maternal sensitivity towards twins (O'Connor & Croft, 2001). This hypothesized patterning is further supported by theory of mind investigations and the particular developmental stage of children in the present study. That is, child CS is developing in the family social context around three and four years of age, as indicted by theory of mind development and children’s emerging abilities to consider the mental states of others (Fernyhough, 2008). Specifically, the emergence of theory of mind occurs as children engage with cognitively sophisticated partners who facilitate, guide and scaffold the development of shared social understanding (Fernyhough, 2008). Over time, however, there appears to be a systematic reallocation of the variability in self-versus other-regulation during interactions, as these co-activated interpersonal processes become increasingly represented within individual cognition (Clancy & Raver, 2012; Sameroff, 2010). This suggests that CS would become a characteristic of the individual (i.e. actor) versus the context (i.e. the family and dyad) as children become increasingly self-directed, self-organizing and agentic. Indeed, it appears that child effects, or children’s influence on their interactional counterparts, increase in importance from infancy and across early childhood (Bell, 1968; Kochanska & Aksan, 2004; Sameroff, 2010; Zadeh, Jenkins, & Pepler, 2010). Thus, it was hypothesized that the individual actor components in CS would be larger for older versus younger siblings, though still not as large as individual components for mothers. To date, the absence of a SRM investigation of CS in early life has precluded the direct empirical testing of these hypotheses. Note that we have omitted making hypotheses about partner components, at
the individual level, since these effects are usually of relatively small magnitude in family SRM studies (Eichelsheim et al, 2009).

### 3.1.4 Cumulative Risk and Family Process

A large body of research has described the influence of cumulative and environmental risk factors on a variety of child developmental outcomes (Evans & Kim, 2012b). Evidence suggests that a substantial component of this risk is conveyed or mediated by dysfunctional family relations (Repetti et al., 2002), however no empirical studies have examined the effects of cumulative risk on family interactions across dyadic, individual and family-wide level of analysis (Browne, Plamondon, Prime, Puente-Duran, & Wade, 2015). The central tenet of the cumulative risk perspective is that individual risks convey little-to-no harm when present in isolation, though they convey great harm as they accumulate, with evidence citing effects in both a linear and multiplicative fashion. A comprehensive review of cumulative risk in the context of child development is beyond the scope of this paper and available elsewhere (Evans, Fuller-Rowell, & Doan, 2012; Shonkoff, Boyce, & McEwen, 2009), including the recommendations for the employment of cumulative risk methodology in family-wide studies (Browne et al, 2015). However, while it is clear that cumulative risk partially impacts developmental outcomes by making mother-child interactions less sensitive and stimulating (Vernon-Feagans, 2013), it is not clear how this phenomenon unfolds across multiple levels of the family. It is possible that cumulative risk impacts the entire family climate, though it is also possible that particular individuals or dyads are most affected, consistent with non-SRM studies demonstrating that shared psychosocial risk partially influences family climate by increasing variability in non-shared or child-specific environments (Jenkins et al., 2003; Plomin, 2011). Such limitations are due to the majority of studies employing single-dyad designs (i.e. one mother-child pair).
3.1.5 The Current Study (Study #2)

The present study examined CS during interactions amongst three dyads per family (mother-older child, mother-younger child, and sibling). CS data were dyadic, meaning that each dyad has two directional sensitivity scores (e.g. mom’s sensitivity towards a child and the child’s sensitivity towards his or her mother). The following research questions and hypotheses were articulated: *Question 1 – To what extent are sensitive interactional styles primarily a function of families, individuals or dyads?* Consistent with the systematic review of self-report SRM’s by Eichelsheim and colleagues (2009), and the existing SRM’s on observed family positivity during adolescence (Ackerman et al, 2011; Rasbash et al, 2011) we hypothesized a small family component and a large dyad-specific or relationship component. In terms of individual effects, we hypothesized large actor effects for mothers (i.e. mothers are consistent in the amount of CS they exhibit across family members) but comparatively smaller actor effects for children, and small partner effects for all roles (i.e. these is less consistency in terms of the amount of CS an individual receives across family members). *Question 2 - Is cumulative risk particularly deleterious for CS levels in certain relationships (e.g. parent-child, sibling)?* In accordance with research linking psychosocial risk with parent-child interactions and child behavior at the family-average and child-specific levels (e.g. Jenkins et al, 2003), we expected all relationships to be less sensitive under conditions of cumulative risk. However, we expected maternal sensitivity to be especially hampered, given the notable body of theoretical and empirical literature demonstrating the impact of contextual risk on maternal resources and mothering behavior (Belsky, 1984; Henderson, Hetherington, Mekos, & Reiss, 1996).
3.2 Methods

3.2.1 Participants

Multiparous women who had given birth between 2006 and 2008 in the cities of Toronto and Hamilton, Canada were considered for participation. Mothers were contacted by the Healthy Babies Healthy Children (HBHC) public health program (run by Toronto and Hamilton, Ontario, Public Health Units). Inclusion criteria for the intensive sample of Kids, Families Places was as follows: (1) English-speaking mother; (2) a newborn weighing at least 1500g; (3) two or more children less than 4 years old in the home, including the newborn; and (4) agreement to the collection of observational and biological data. Thirty-four percent of mothers whose information was passed by HBHC consented to participate in the study. Reasons for non-enlistment included inability to contact families, ineligibility once contacted and refusals. Multiparous mothers were exclusively recruited given that the present investigation was concerned with family-wide, individual, and relationship specific influences on child development.

The University of Toronto Research Ethics Board approved all procedures, including informed consent. We compared our initial sample (N=501) with the general population of Toronto and Hamilton using 2006 Census Data, limiting the census to women between 20-50 years and having at least one child. Families were compared on immigrant status, number of persons in the home, family type, maternal income, and educational level. Families were of similar size (M = 4.52, SD = 1.01 vs. M = 4.13, SD = 1.22) and maternal income (median C$30,000–39,999 vs. census population mean = C$30,504.16, SD = C$37,808.12). As our sample was recruited shortly after childbirth, there are fewer non-intact families than in the population (5% vs. 16.8% lone-parent families; 4.3% vs. 10.3% stepfamilies). The ratio of
Canadian born to immigrants was somewhat higher in the current sample (57.7% vs. 47.6%), likely due to the language requirement for participation. Also, more study mothers had earned a bachelor’s degree or higher (53.3% vs. 30.6%). Of participating mothers, 56.5% self-identified as being of European descent, 14.6% as South Asian, 9.3% as Black, 12% as East Asian and 8.6% as other.

In the KFP Study, 74.1% of families were 2 child families, 18.8% were 3 child families, and the remaining 7.2% had 4 or more children. Only the youngest two children are considered in the current study due to the labor and financial cost of observational coding and measurement burden on mothers and families. Demographic measures and environmental risk variables were measured at baseline when younger children were a mean age of 2.00 months (SD = 1.06) and older children were 2.58 years (SD = 0.76); 49% of children were female. Family dyads were filmed interacting with one another at follow-up when younger children were 3.15 years (SD= 0.27), older children were 5.57 years (SD= 0.77), and 385 (76%) of families remained. Retained families were somewhat higher functioning in a number of areas, as is often the case in longitudinal research, and there was some additional missing data on measures of CS (see section on attrition and missing data below).

3.2.2 Measures

3.2.2.1 Cumulative Risk.

Distal psychosocial risk and disadvantage was measured using a cumulative risk index, which is a composite of dichotomized risk factors typically employed to indicate the number of risks present in a family’s context. Cumulative risk indexes are used based upon the widely replicated finding that few risks in isolation convey little to no harm, though many concurrent risks convey great harm (Evans & Kim, 2012; Rutter, 1983). Risk factors that were naturally
dichotomous (e.g. single parent mothering) were scored as “1” or “0”, where a score of “1” indicated the presence of the risk. Risks that were measured continuously (e.g. maternal depression) were dichotomized at one standard deviation above the mean towards the risky or adverse pole, which corresponds to the 85th percentile based on the normal distribution (i.e. the riskiest 15% of the distribution would be given a score of “1” to indicate the risk). A mean of all dichotomous indicators was taken, yielding a composite ranging from 0 to 1, which is reflective of the proportion of measured risks present in a family’s life. Ten risk indicators were measured in the current study: presence of any physical or sexual abuse in a mother’s life, teenage parenthood, maternal depression, single-parent mother household, marital conflict, income less than C$20,000, no post-secondary education for mothers, poor observed neighborhood quality, high rates of neighborhood poverty in the census tract area, and high rates of single-parent households in the census tract area. Comprehensive measurement description for the 10 risk indicators is available in the Supplementary Appendix. The cumulative risk index ranged from .00 to .90, ($M = .20, SD = .20$).

3.2.2.2 Cognitive Sensitivity.

Cognitive sensitivity (CS) was assessed in a cooperative building task paradigm, adapted from Aguilar and colleagues (2001). Specifically, each dyad (mother-younger sibling, mother-older sibling, younger-older sibling) was asked to work together for 5 minutes to copy a developmentally challenging design from a picture using Duplo building blocks. Each member of the dyad was only allowed to use two of four available colors in order to promote turn taking, cooperation and challenge. The data were directional and in a round-robin design. That is, each dyad has two directional scores, resulting in 6 cognitive sensitivity scores per family.
Sensitivity during dyadic interactions was assessed using the \textit{Cognitive Sensitivity} (CS) coding scheme developed by Prime and colleagues for parent-child interactions (Prime et al., 2015) and sibling interactions (Prime, Perlman, Tackett, & Jenkins, 2014). A thin slice methodology (Ambady, 2010), which uses impressionistic ratings based on brief observations of behavior, was used to quickly assess the extent to which each individual sensitively responded to the inferred cognitive states of their interactional partner. The CS construct is comprised of 3 underlying features, not themselves mutually exclusive: (1) mutuality, which describes an individual’s tendency to promote reciprocity in exchanges, evidenced by the provision of positive feedback and the encouragement of turn-taking; (2) mind reading, which describes an individual’s tendency to consider the knowledge of a partner, evidenced by the rephrasing of information and responsiveness to requests for help; and (3) communicative clarity, which describes the tendency for an individual to communicate in a way that limits ambiguity, evidenced by the provision of verbal and non-verbal directions and the promotion of a joint understanding of the goals and rules of the task. Raters were directed to watch the video of the 5-minute interaction once, use all available information and to rate quickly based on general impressions. Raters provided codes on each of 11 items indexing mutuality, mind reading and communicative clarity (see Prime et al., 2014; 2015 for a full list of items) using a 5-point Likert scale, ranging from ‘Not at all true’ (1) to ‘Very true’ (5). A mean of the 11 items was calculated and used as the final score.

The validation studies for parent-child and sibling CS scales yielded good psychometric properties, including internal consistency, and convergent validity with expected constructs. Internal consistency for the parent-child coding scheme was $\alpha=.92$ and interrater reliability was
α=.84. For the sibling scheme, internal consistency was α=.90 and interrater reliability was α=.75.

### 3.2.3 Analysis

CS data were modeled using a 3-person multilevel social relations model with roles (mother, older child and younger child (Cook, 2005; Kenny et al., 2006; Snijders & Kenny, 1999). In this design, the unit of analysis is not the individual or dyad, but the directed relationship score (i.e. six directed scores per family). Multilevel models are comprised of two general elements: (1) the fixed part of the model, where estimated parameters are analogous to coefficients in ordinary least squares regression, and (2) the random part of the model, where variances are estimated reflecting the variability in sensitivity across, in the present case, the family, individual and dyadic effects of the SRM. Modeling took place in two steps. First, a null model was fit where estimates reflect the average levels of CS irrespective of cumulative risk. In the fixed part of the model, the mean directed CS scores for each of the 6 directed relationships was estimated with corresponding 95% confidence intervals. In the random part of the model, individual effects (actor and partner) are estimated for each of the 3 roles, and dyad effects are estimated for each directed score. The actor, partner and dyad effects are random effects with corresponding variances that reflect their variation across individuals (for actor and partner variances), or within-individuals across relationships (dyad variances). Comparing the relative magnitudes of these variance components can allow us to ascertain the extent to which sensitivity is a function of individuals (actors and partners) or particular dyads (relationships). For each role, an actor-partner correlation or generalized reciprocity is also estimated. Finally, dyadic reciprocity correlations are estimated for each dyad. For example, the sibling dyadic reciprocity correlation reflects the correlation of the siblings directed scores towards one another.
Note that in a standard 3-person social relations model, it is not possible to estimate family effects and their corresponding variance if all other components are estimated (Kenny, Kashy & Cook, 2006). However, alternative model parameterizations are possible if certain parameters are constrained to zero. In the current study, and as described above, family effects were of substantive interest. Moreover, a systematic review of SRM studies revealed that partner effects are often modest (see Eichelsheim et al, 2009). In the current study, exploratory analyses revealed that, when estimated, partner effects and corresponding generalized reciprocity correlations were not significantly different than zero. For this reason we constrained the partner random effects and their associated variances to zero, and instead estimate a family effect and its variance.

The aforementioned null model was used to partition the variance in sensitivity attributable to family, individual, and dyad effects, separately for each family role. For example, the proportion of actor variance for mothers’ directed sensitivity scores would be taken algebraically as her raw actor variance relative to the total raw variance for her expressed sensitivity (i.e. the overall family variance plus the maternal actor variance plus the average of the mother-to-younger and mother-to-older variances). By computing these Variance Partitioning Coefficients, the variability in sensitivity for each family role attributable to family, individual and dyad components can be expressed as a percentage (i.e. out of 100%). Furthermore, 95% confidence intervals around these estimates can be used to communicate statistical uncertainty. Note that confidence intervals are approximate 95% confidence intervals derived via the Delta method.

After fitting the initial model, shared family risk (i.e. cumulative risk) will be permitted to freely impact each relationship score independently. This will allow us to understand the
level(s) of the family that are impacted by such risks without any imposed model constraints. That is, fixed effects of cumulative risk on each directed sensitivity score will be estimated in the fixed part of the model. Furthermore, in order to determine whether cumulative risk is primarily impacting sensitivity at the family, individual, or dyadic specific levels, proportional drops in these respective variances will be computed. See Appendix for an explication of the models in the current study. Furthermore, a technical Appendix is included in order to outline the estimation of these models using the runmlwin command (Leckie & Charlton, 2013), which calls the MLwiN (Rasbash, Browne, & Healy, 2013) multilevel modelling package from within Stata.

3.2.4 Analysis of Attrition and Missing Data

Of the initial 501 families, 385 (76%) remained at follow-up. Retained families were compared to those who dropped-out on demographics and cumulative risk. Mothers lost to follow-up were higher risk in a number of areas, including the following: teenage motherhood, unemployment, incomes less than $20,000, and not owning their home. They were also significantly less likely to have post-secondary education, as were their partners. The neighborhoods of non-completers were viewed as significantly less trusting and rated by home visitors to be of higher risk. These neighborhoods also had significantly higher rates of census assessed lone parenthood and poverty. Of these 385 families, there was additional missing data for CS (6% for maternal sensitivity scores towards children, 9% for sibling sensitivity scores towards one another). We addressed these additional missing data using multiple imputation (5 imputation sets) as implemented in Stata 12. We included a wide set of covariates in the imputation model to make the missing at random assumption as plausible and to therefore reduce the likelihood of any systematic bias associated with the missingness (Graham, 2009). All
models were run separately across the 5 imputed datasets and results were combined according to Rubin’s Rules (Rubin, 1987).

3.3 Results

Descriptive statistics and variable intercorrelations are presented in Table 3.1 and 3.2.

Table 3.1. Descriptive Statistics.

*Descriptive Statistics for Cumulative Risk (CR) Index and Cognitive Sensitivity for directional sensitivity scores (e.g. S1>S2 is the sensitivity the younger child directs towards the older child)*

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>Valid N</th>
<th>% Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR</td>
<td>0.18</td>
<td>0.19</td>
<td>0.00</td>
<td>0.90</td>
<td>385</td>
<td>0.00</td>
</tr>
<tr>
<td>M&gt;S1</td>
<td>3.56</td>
<td>0.77</td>
<td>1.18</td>
<td>5.00</td>
<td>367</td>
<td>4.68</td>
</tr>
<tr>
<td>M&gt;S2</td>
<td>3.48</td>
<td>0.72</td>
<td>1.36</td>
<td>5.00</td>
<td>359</td>
<td>6.75</td>
</tr>
<tr>
<td>S1&gt;M</td>
<td>1.35</td>
<td>0.36</td>
<td>1.00</td>
<td>3.09</td>
<td>367</td>
<td>4.68</td>
</tr>
<tr>
<td>S2&gt;M</td>
<td>1.80</td>
<td>0.59</td>
<td>1.00</td>
<td>3.82</td>
<td>359</td>
<td>6.75</td>
</tr>
<tr>
<td>S1&gt;S2</td>
<td>1.85</td>
<td>0.48</td>
<td>1.00</td>
<td>3.27</td>
<td>349</td>
<td>9.35</td>
</tr>
<tr>
<td>S2&gt;S1</td>
<td>2.73</td>
<td>0.71</td>
<td>1.27</td>
<td>4.55</td>
<td>349</td>
<td>9.35</td>
</tr>
</tbody>
</table>

Note: Sample N=385.
Table 3.2. Intercorrelations of Study Variables.

*Intercorrelations for Cumulative Risk (CR) Index and Cognitive Sensitivity for directional sensitivity scores (e.g. S1>S2 is the sensitivity the younger child directs towards the older child)*

<table>
<thead>
<tr>
<th></th>
<th>M&gt;S1</th>
<th>M&gt;S2</th>
<th>S1&gt;M</th>
<th>S2&gt;M</th>
<th>S1&gt;S2</th>
<th>S2&gt;S1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR</td>
<td>-.34*</td>
<td>-.32*</td>
<td>-.03</td>
<td>-.09</td>
<td>-.11*</td>
<td>-.18**</td>
</tr>
<tr>
<td>M&gt;S1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.67**</td>
<td>.19**</td>
<td>.08</td>
<td>.21**</td>
<td>.15**</td>
<td></td>
</tr>
<tr>
<td>M&gt;S2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.06</td>
<td>.17**</td>
<td>.14**</td>
<td>.14**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1&gt;M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.23**</td>
<td>.17**</td>
<td></td>
</tr>
<tr>
<td>S2&gt;M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>.05</td>
<td>.18**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1&gt;S2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.51**</td>
<td></td>
</tr>
<tr>
<td>S2&gt;S1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05, **p < .01

Results of the SRM are presented in Table 3.3. See Model A for SRM components irrespective of cumulative risk (i.e. the null model). In the fixed part of the model (top), it is possible to see the mean for each directed relationship. For example, the average CS score for mothers towards younger siblings is 3.57 (95%CI = 3.49, 3.65). These means show that directed relationships are more sensitive when family members are older (mothers more than older children, older children more than younger children). Variance estimates are presented in the random (bottom) part of the model. Separate variances are estimated for the family,
individual/actor, and dyad effects. Estimates reflect the extent to which CS varies at that level of analysis. For example, the significant family variance indicates that there are statistically significant between-family differences in CS, or that some families exhibit higher sensitivity across all their relationships than others.
Table 3.3. SRM Output.

Output from 3-Person Social Relations Model with roles (mother, younger sibling [S1] and older sibling [S2]) without (Model A) and with (Model B) the effects of Cumulative Risk

<table>
<thead>
<tr>
<th></th>
<th>Model A</th>
<th>(95%CI)</th>
<th></th>
<th>Model B</th>
<th>(95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td></td>
<td></td>
<td>Estimate</td>
<td></td>
</tr>
<tr>
<td>Mom→S1</td>
<td>3.57**</td>
<td>(3.49, 3.65)</td>
<td></td>
<td>3.83**</td>
<td>(3.73, 3.93)</td>
</tr>
<tr>
<td>Cum. Risk</td>
<td></td>
<td></td>
<td>-1.40**</td>
<td></td>
<td>(-1.78, -1.02)</td>
</tr>
<tr>
<td>Mom→S2</td>
<td>3.48**</td>
<td>(3.40, 3.55)</td>
<td></td>
<td>3.71**</td>
<td>(3.61, 3.80)</td>
</tr>
<tr>
<td>Cum. Risk</td>
<td></td>
<td></td>
<td>-1.24**</td>
<td></td>
<td>(-1.61, -0.88)</td>
</tr>
<tr>
<td>S2→S1</td>
<td>2.72**</td>
<td>(2.65, 2.79)</td>
<td></td>
<td>2.86**</td>
<td>(2.76, 2.96)</td>
</tr>
<tr>
<td>Cum. Risk</td>
<td></td>
<td></td>
<td>-0.76**</td>
<td></td>
<td>(-1.17, -0.35)</td>
</tr>
<tr>
<td>S2→Mom</td>
<td>1.80**</td>
<td>(1.74, 1.86)</td>
<td></td>
<td>1.85**</td>
<td>(1.77, 1.94)</td>
</tr>
<tr>
<td>Cum. Risk</td>
<td></td>
<td></td>
<td>-0.29**</td>
<td></td>
<td>(-0.61, 0.03)</td>
</tr>
<tr>
<td>S1→S2</td>
<td>1.83**</td>
<td>(1.79, 1.88)</td>
<td></td>
<td>1.89**</td>
<td>(1.82, 1.97)</td>
</tr>
<tr>
<td>Cum. Risk</td>
<td></td>
<td></td>
<td>-0.32**</td>
<td></td>
<td>(-0.62, -0.02)</td>
</tr>
<tr>
<td>S1→Mom</td>
<td>1.36**</td>
<td>(1.32, 1.39)</td>
<td></td>
<td>1.37**</td>
<td>(1.32, 1.42)</td>
</tr>
<tr>
<td>Cum. Risk</td>
<td></td>
<td></td>
<td>-0.07</td>
<td></td>
<td>(-0.27, 0.12)</td>
</tr>
<tr>
<td>σ² (Family)</td>
<td>.03**</td>
<td>(.01, .04)</td>
<td></td>
<td>.02**</td>
<td>(.01, .04)</td>
</tr>
<tr>
<td>σ² (Mom Actor)</td>
<td>.34**</td>
<td>(.27, .40)</td>
<td></td>
<td>.28**</td>
<td>(.23, .34)</td>
</tr>
<tr>
<td>σ² (S2 Actor)</td>
<td>.06**</td>
<td>(.02, .09)</td>
<td></td>
<td>.05**</td>
<td>(.02, .09)</td>
</tr>
<tr>
<td>σ² (S1 Actor)</td>
<td>.00</td>
<td>(-.01, .02)</td>
<td></td>
<td>.01</td>
<td>(-.01, .02)</td>
</tr>
<tr>
<td>σ² (Mom→S1)</td>
<td>.22**</td>
<td>(.17, .27)</td>
<td></td>
<td>.22**</td>
<td>(.16, .26)</td>
</tr>
<tr>
<td>σ² (Mom→S2)</td>
<td>.15**</td>
<td>(.10, .20)</td>
<td></td>
<td>.16**</td>
<td>(.11, .21)</td>
</tr>
<tr>
<td>σ² (S2→S1)</td>
<td>.41**</td>
<td>(.33, .48)</td>
<td></td>
<td>.40**</td>
<td>(.32, .47)</td>
</tr>
<tr>
<td>σ² (S2→Mom)</td>
<td>.28**</td>
<td>(.22, .33)</td>
<td></td>
<td>.29**</td>
<td>(.23, .34)</td>
</tr>
<tr>
<td>σ² (S1→S2)</td>
<td>.20**</td>
<td>(.16, .23)</td>
<td></td>
<td>.19**</td>
<td>(.16, .23)</td>
</tr>
<tr>
<td>σ² (S1→Mom)</td>
<td>.10**</td>
<td>(.08, .12)</td>
<td></td>
<td>.10**</td>
<td>(.08, .12)</td>
</tr>
<tr>
<td>σ (Mom/S1)</td>
<td>.03*</td>
<td>(.00, .05)</td>
<td></td>
<td>.03*</td>
<td>(.00, .05)</td>
</tr>
<tr>
<td>σ (Mom/S2)</td>
<td>.04*</td>
<td>(.00, .07)</td>
<td></td>
<td>.04*</td>
<td>(.00, .07)</td>
</tr>
<tr>
<td>σ (S1/S2)</td>
<td>.14**</td>
<td>(.10, .18)</td>
<td></td>
<td>.14**</td>
<td>(.10, .17)</td>
</tr>
<tr>
<td>-2(Loglikelihood)</td>
<td>3692.10</td>
<td></td>
<td></td>
<td>3620.78</td>
<td></td>
</tr>
</tbody>
</table>

* p < .05, ** p < .01, σ² = variance, σ = covariance.
3.3.1 Question 1 – To what extent are sensitive interactional styles primarily a characteristic of families, individuals or dyads?

The estimated variance components presented in Table 3.3 do not directly convey the relative amount to which families, individuals, or dyads influence CS, nor how this may differ as a function of family role. This is reflected in the Variance Partitioning Coefficients (see Table 3.4 and Figure 3.1.) There is a significant family variance component for all family members. This indicates that some families are more sensitive than other families and so unobserved family-level factors are important in determining how CS unfolds across families, regardless of role. However, there is variability in the magnitude of the family component across roles, whereby the family variance is relatively smaller for mothers’ and older siblings’ interactions, but larger for the youngest child. This indicates that family-wide factors are a more important source of variation in the sensitive behavior of youngest children compared to mothers and older siblings. The opposite pattern is true for the individual actor variance, whereby CS for maternal behavior is largely attributable to mothers’ individual-level effects. In other words, after accounting for family-level variation, some mothers are substantially more sensitive compared to other mothers. Furthermore, these individual effects are the most important source of variability in maternal CS. That is, the results show maternal CS is primarily a function of the individual. Actor variances are also significant for older siblings, indicating that some older siblings display more CS than other older siblings, on average, after accounting for family differences. However, variability in older sibling sensitivity is substantially less compared to that of mothers. There is no significant actor variance for youngest siblings. In other words, individual effects do not appear to play a role in determining how sensitive younger children are, on average, during interpersonal interactions. Finally, there are significant and sizable relationship variances for all roles, indicating that dyad effects are important in determining how CS unfolds during
interpersonal family exchanges. That being said, the proportion of this relationship variance is twice as large for children, suggesting that the unique relationship context is more influential in determining the sensitive behavior of youngsters versus mothers. Overall, CS during family interactions is a function of families, individuals and dyads, though the relative importance of these components varies across roles. Specifically, CS of family members tend to be more informed by individual effects when individuals are older, which may also be reflective of greater interpersonal competence (especially mothers). Conversely, the CS of children is more informed by family and dyad characteristics (especially youngest children).
Table 3.4. SRM Variance Partitioning.

Variance partitioning results examining the proportion of sensitivity for each role attributable to family, actor or dyad effects

<table>
<thead>
<tr>
<th>Role</th>
<th>Variance Proportion</th>
<th>(95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mother</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family</td>
<td>0.05**</td>
<td>(0.02, 0.08)</td>
</tr>
<tr>
<td>Actor</td>
<td>0.58**</td>
<td>(0.52, 0.65)</td>
</tr>
<tr>
<td>Dyad</td>
<td>0.37**</td>
<td>(0.31, 0.43)</td>
</tr>
<tr>
<td><strong>Older Sibling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family</td>
<td>0.06**</td>
<td>(0.03, 0.10)</td>
</tr>
<tr>
<td>Actor</td>
<td>0.13**</td>
<td>(0.04, 0.21)</td>
</tr>
<tr>
<td>Dyad</td>
<td>0.81**</td>
<td>(0.72, 0.90)</td>
</tr>
<tr>
<td><strong>Younger Sibling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family</td>
<td>0.16**</td>
<td>(0.08, 0.25)</td>
</tr>
<tr>
<td>Actor</td>
<td>0.02</td>
<td>(~0.08, 0.12)</td>
</tr>
<tr>
<td>Dyad</td>
<td>0.81**</td>
<td>(0.72, 0.91)</td>
</tr>
</tbody>
</table>

* p < .05, ** p < .01.

Note: Variance estimates are taken from Model A in Table 1 (i.e. the null model). Approximate 95% Confidence intervals were derived using the Delta method.
There were significant dyadic reciprocity correlations for each unique dyadic combination. That is, when one dyad-member tended to be highly sensitive towards the other member, accounting for family and actor effects, it was reciprocated with a correspondingly high degree of sensitivity. These correlations are calculated from the covariance and variance terms pertaining to the dyadic relationship in question. For example, the mother-youngest dyadic reciprocity is $r = .20$ (i.e. $0.20 = 0.03 / \sqrt{[0.22 \times 0.10]}$). There were also significant dyadic reciprocities for mother-oldest, $r = .20$, and sibling, $r = .49$, dyads. Note that reciprocity is substantially greater within sibling dyads (large effect size) compared to mother-child dyads.
(moderate effect size). This suggests that interpersonal contingency (in terms of CS) is much greater within sibling exchanges, versus those that involve a child and a mother, which is also consistent with the large mother actor variance.

3.3.2 Question 2 - Is cumulative risk particularly deleterious for sensitivity levels in certain relationships (e.g. parent-child, sibling)?

The effect of cumulative risk on CS during dyadic exchanges was evaluated by separately allowing each directed relationship score to vary as a function of cumulative risk. Results are presented in Model B of Table 3.3. For mothers, cumulative risk is associated with significantly lower levels of CS directed towards both children. For older siblings, cumulative risk is associated with significantly lower levels of CS directed towards younger siblings and, less so, for mothers. Finally, for younger siblings, cumulative risk is associated with significantly lower levels of CS directed towards older siblings, but not mothers. Based on the patterning and magnitude of fixed effects, it appears that directed CS scores are most disrupted in situations where actors are older or in a position of relative competence (i.e. mothers towards children and somewhat less-so for older siblings towards younger siblings). Older siblings are less sensitive towards their mothers, as younger siblings are less sensitive to their older siblings, when cumulative risk is higher, though these effects are of smaller magnitude. Finally, there is no measurable impact of cumulative risk on younger sibling’s behavior towards mothers.

Another way to explore the impact of cumulative risk on CS during family interactions is to examine the drop in variance components after the cumulative risk variable was entered into models, relative to the initial value of the variance. Comparison of Models A and B in Table 3.3 reveals that the effects of cumulative risk on CS are primarily operative at the family-level and at the individual or actor-level for mothers and older siblings. That is, 12.17% of the overall family-level variability in CS is attributable to cumulative risk (.1217 = [.0263 - .0231] / .0263; decimal
places suppressed to two spaces in tables). Conversely, 27.82% of the variability in maternal actor variance is attributable to cumulative risk \((.2782 = [.3328 - .2783] / .3328)\), and 5.40% of the variability in the older sibling actor variance \((.0540 = [.0537 - .0508] / .0537)\). Thus, when considering the fixed effects and drops in variances, it appears that cumulative risk primarily impacts CS at the family-level, followed by the individual level for mothers and older siblings, respectively. This is congruent with findings highlighting the importance of family-level influences for all roles (especially youngest children) and individual or actor effects for mothers and oldest siblings.

3.4 Discussion

The current study is the first SRM investigation examining observed family interactions when children are in early childhood. Findings provide novel insight into the way in which CS unfolds within real-time interactions and across levels of family organization, adding evidence to the theoretical principles outlined by family systems theory (Carr, 2012; Minuchin, 1981), in addition to existing SRM literature (Ackerman et al., 2011; Eichelsheim et al., 2009; Rasbash et al., 2011), and studies of cumulative risk and family process (Evans & Kim, 2012; Repetti et al., 2002). Contributions to these substantive areas are presently discussed in relation to the outlined research questions.

3.4.1 Cognitive sensitivity operates across hierarchical levels of family organization

CS during family interactions is simultaneously a function of family, individual and dyadic variability. This general finding is consistent with existing SRM studies of observed positivity in families with adolescent children (Ackerman et al., 2011; Rasbash et al., 2011). Results suggest that there are multiple and relatively distinct components of the family system in
which CS unfolds when children are in early childhood. However, in the current study, the relative size of these components across roles is in contrast with previous literature. For example, Ackerman and colleagues (2011) and Rasbash and colleagues (2011) yielded actor variances for mothers and children that were sizable and relatively similar. In the present study, maternal actor variances were large (58%), and child actor variances were either small but significant (only 6% for older siblings), or not statistically significant at all (for youngest children.)

As hypothesized in the present investigation, the small or non-significant actor effects for children likely reflect the unique developmental context of sensitivity in early life. That is, CS in children (not unlike theory of mind and self-regulation) can be conceptualized as a developmental skill that becomes increasingly autonomous throughout the context of repeated social interaction (Fernyhough, 2008; Sameroff, 2010; Vygotsky, 1978). This ontogenic rearrangement, whereby the loci of influence in sensitive behavior transitions from the context to the organism, is implied by the SRM components in the current study and previous SRM research. Specifically, we observe actor variances that are smaller when children are younger and asymmetrically influenced by others (i.e. family and relationship effects are proportionally larger), and actor effects that are larger when individuals are older and becoming increasingly volitional (i.e. family and relationship effects are proportionally smaller). Such a patterning is consistent with theoretical models of human development, especially Sameroff’s transactional regulation model (Sameroff, 2010), and other systemic theories that emphasize the influence of increasingly bidirectional person-context interactions in shaping and canalizing internal psychological phenomena over the course of development (Bronfenbrenner & Morris, 2006; Lerner, 2006). Sameroff notes that much of what is described as “self-regulation” in early life (e.g. a child acting sensitively during challenging tasks, as measured in the present study) “mainly occurs in a social surround that is actively engaged in ‘other’ regulation” (p. 14). This
statement is consistent with the absence of actor variance for youngest siblings, which translates into the absence of “self” or individual-level stability across interpersonal contexts. Moreover, the “other” regulation may take the form of sensitive modeling and guidance from mothers or older siblings, who may be relatively stable in their behavioral tendencies (i.e. actor effects) or may specifically tailor their behavior to the particular relational demands (i.e. dyad effects). Also, other-regulation for children may take the form of an ambient family climate, consistent with the family systems tenet of holism (Jenkins & Bisceglia, 2011), empirical and theoretical discussions of family-wide functioning (Epstein, Baldwin, & Bishop, 1983; Georgiades, Boyle, Jenkins, Sanford, & Lipman, 2008), and previous findings from family SRMs (Ackerman et al, 2011; Eichelshiem et al, 2009; Rasbash et al, 2011). Indeed, family components were approximately three-times larger for youngest children versus older children and mothers in the present study. Unlike single-dyad research, the current study suggests that the developmental impact of sensitivity on young children occurs at the ambient family level in addition to the unique dyadic context.

Over time, the transactional co-regulation of self and other becomes increasingly embedded within the individual (Sameroff, 2010). This likely permits the emergence of relatively consistent social scripts and intentional behavior across interpersonal contexts – behavior that appears to be rooted in autonomous psychological regulatory capacities that evolve via interpersonal relationships (Bernier et al., 2012; Clancy & Raver, 2012). In SRM nomenclature, this could potentially reflect the “development” of actor effects over the course of early childhood via reciprocal relationships with other family members. Microgenetic longitudinal SRM research in early childhood is needed to fully test this hypothesis.

Large maternal actor variances are consistent with non-SRM developmental literature which highlights the person-level variability of maternal behavior. For example, the present
findings are consistent with O'Connor and Croft’s (2001) behavioral genetic study of attachment security in preschool-aged twins, where 32% of the variability in attachment security was attributable to shared environmental influences (and notably, there was not a significant genetic component). Authors concluded that environmental concordance in attachment may be partially attributable to twins’ similar environmental experiences of maternal sensitivity. Stated differently, maternal sensitivity was deemed to be largely a function of maternal factors. Similar between-family differences in mothering have been observed in studies of differential parenting, where approximately half of the variance in sensitivity is attributable to mothers (Browne et al., 2012; Meunier et al., 2013). Moreover, this large maternal variance effect is consistent with self-report SRM’s of maternal affect, whereby mother actor components tend to account for a sizeable amount of variability in mother-child interactions (Eichelsheim et al, 2009). Furthermore, results are consistent with a multitude of single-dyad research, whereby variability in sensitivity is explained by a variety of maternal characteristics and experiences including exposure to childhood adversity (Berlin, Appleyard, & Dodge, 2011; Lyons-Ruth & Block, 1996; Van IJzendoorn, Juffer, & Duyvesteyn, 1995), poor psychological functioning (Elgar, McGrath, Waschbusch, Stewart, & Curtis, 2004; Feldman, 2007), personality (Clark, Kochanska, & Ready, 2000), and genetic polymorphisms (Bisceglia et al., 2012; Feldman et al., 2012). Moreover, because parenting in single dyad studies is relatively stable (Bigelow et al., 2010; Kochanska & Aksan, 2004), some scholars have described sensitivity as trait-like over time.

3.4.2 Impact of cumulative risk on cognitive sensitivity across hierarchical levels of the family

Cumulative risk is particularly deleterious for the CS of individuals who are older or in a position of relative interpersonal competence (i.e. mothers to children, older to younger sibling). This finding is consistent with theoretical and empirical arguments suggesting that cumulative
psychosocial risk recapitulates from the distal environment to the proximal context. That is, environmental adversity “gets inside the family” (Conger, n.d.) and disrupts the interpersonal behavior of family members (Browne et al., 2015; Repetti et al., 2002), particularly mothers and older children. This appears to occur in a “spillover” fashion (Nelson, O’Brien, Blankson, Calkins, & Keane, 2009), whereby adversity and stress in one family setting (i.e. the contextual environment) directly transfers to another setting (i.e. the proximal interpersonal behavior of mothers and children). Findings are consistent with other programs of research identifying spillover effects linking family adversity and family interpersonal climate. For example, Repetti and colleagues have demonstrated that parents are more socially and emotionally withdrawn, distracted, angry, irritable and less responsive towards the entire family after having a stressful day (Repetti et al., 2009). Analogous spillover processes have been observed for structural family risks. That is, parents who report higher levels of marital dissatisfaction and household chaos also report being less supportive and responsive to their children’s negative emotions (Nelson et al., 2009).

The present investigation extends the spillover literature, demonstrating that this phenomenon is occurring in a downward-cascade fashion. That is, risk exhibits the greatest influence on the directed sensitivity scores of interpersonal counterparts who are older and in a relative position of competence or authority, both between generations (mothers to children) and within generations (older to younger siblings). Moreover, this spillover is occurring across levels of family organization, whereby the effects of risk are primarily operative at the family level and at the individual or actor level for mothers and older siblings. Similar to the current findings, Repetti and colleagues (2009) have identified spillover effects for children, where youngsters report more aversive interpersonal relationships at home when experiencing social and academic difficulties at school. It is possible that this is particularly the case for older siblings, given their
increased responsibility and challenge for guiding the interpersonal interactions with younger, and perhaps less competent, siblings.

Environmentally-induced stress reactions and negative mood can enter the home from extra-familial settings due to the direct transfer of physiological stress reactions from one setting to another (Evans & Kim, 2012; Story & Repetti, 2006). Furthermore, contextual adversities tend to deplete an individual’s psychological resources over time. That is, coping facility is exhausted while negotiating challenge outside the home, making individuals less capable of navigating and managing family interactions – especially demanding ones (Hetherington & Blechman, 2014). This phenomenon likely explains the patterning of findings, whereby cumulative risk is most impactful on directed sensitivity that operates down the age gradient. Consistent with the concept of interpersonal scaffolding, it is the challenging role of more sophisticated and advanced family members to guide younger individuals through complex social interactions (Vygotsky, 1978). In conjunction with the present findings, previous literature has demonstrated that maternal scaffolding behavior is lower when mothers have less formal education (Carr & Pike, 2012). The current study extends the link from social disadvantage to sibling sensitivity, as well. That is, the double-disadvantage for youngest children in risky homes complements findings surrounding family resource dilution associated with the birth of additional children and risk associated with lower birth order (Downey, 2001; Lawson & Mace, 2009). In other words, younger children are experiencing substantially less sensitivity from both mothers and siblings under settings of risk.

3.4.3 Limitations and Future Directions

The present study is the first SRM to examine observational measures of family interactions during early childhood. There are a number of other notable strengths, including the employment of a large and diverse sample of multiple dyads per family, observational data on
CS and sophisticated and informative statistical methodology. That being said, there are limitations that should be addressed in future research studies. First, while the inclusion of observational CS data in early life for multiple dyads is novel, sensitivity data on certain dyads were unavailable due to measurement burden and cost (i.e. marital, father-child, and other sibling dyads). Future SRM studies should broaden the scope of measurement in order to increase the generalizability of findings. Secondly, there are multiple and substantively distinct interpersonal processes that manifest early in the family life cycle beyond sensitivity. Specifically, and in accordance with the SRM of families with adolescents by Rasbash and colleagues (2011), there is a need for SRM investigations examining observed negativity, hostility and reactivity amongst families with young children. Future studies that address these limitations will continue to shed light on the way in which interpersonal processes unfold across levels of family organization, and the manner in which cumulative risk disrupts harmonious exchanges within the family.
Chapter 4: Socioeconomic Status and the Augmentation of Within-Family Risk

4.1 Background

Early biological risk factors tend to cluster in settings of low socioeconomic status, including low birth weight, preterm delivery and perinatal complication (SES) (Kramer, 1987; Shonkoff et al., 2009). Similarly, low SES increases contextual risk, where poorer families experience more interpersonal dysfunction, caregiver depression, and disrupted parent-child interaction (Conger et al., 2010; Dong, 2004; Evans, 2004; Repetti et al., 2002). The clustering of both biological and contextual risk increases the likelihood that children in low SES homes experience problems in developmental health (Hertzman & Boyce, 2010). However, most studies in this area are based on one child-per-family. This is problematic given that many children are raised alongside siblings (Kramer & Conger, 2009). That is, developmental processes within the family emerge when multiple siblings are present, and these phenomena explain adjustment beyond the processes studied in single-child designs (Browne et al., 2015). For example, sibling differences in risk are augmented in settings of low SES (Jenkins & Bisceglia, 2011; Plomin, 2011). Stated differently, low SES corresponds to greater differences in what siblings’ receive from their parents (Atzaba-Poria & Pike, 2008; Jenkins et al., 2003). However, there is a paucity of literature examining the factors that explain the emergence of these differences (Jenkins, McGowan, & Knafo-Noam, 2016). Theoretical models suggest that conditional responses from caregivers are evoked by variation in early child biological risk (Bell, 1968; Granic & Patterson, 2006; Sameroff, 2010). Certain siblings may select themselves into particular interactions with parents, which further increase sibling differences across ontogeny. In order to explore these mechanisms, the present investigation sought to (1) evaluate the relationship between SES and
sibling differences in early biological risk indexed via child birth weight; and (2) explore connections between sibling differences in birth weight and sibling differences in the receipt of parenting.

4.1.1 Biological and Contextual Consequences of Low Socioeconomic Status

The mechanisms linking low SES and developmental health operate across biological and contextual level of analysis (Bradley & Corwyn, 2002; Repetti et al., 2002; Shonkoff et al., 2009). In terms of biological risk, there is much evidence to suggest that intrauterine experiences are disrupted under settings of low SES (Gluckman, Hanson, & Buklijas, 2010; Gluckman & Hanson, 2004; Gluckman, Hanson, Cooper, & Thornburg, 2008; Meaney, Szyf, & Seckl, 2007; O'Connor et al., 2005; O'Connor, Monk, & Fitelson, 2014; O'Donnell, O'Connor, & Glover, 2009; Pluess & Belsky, 2011). Quality of the in utero environment and biological risk is often indexed using birth weight, given its association with various developmental outcomes including medical health, socioemotional functioning, and cognitive development (Asbury, Dunn, & Plomin, 2006; Conley & Bennett, 2000; Jefferis, Power, & Hertzman, 2002; Matte, Bresnahan, Begg, & Susser, 2001). Lower birth weight under settings of low SES may be directly related to maternal and fetal nutrition (Gluckman et al., 2010), in addition to psychological stress (Borders, Grobman, Amsden, & Holl, 2007; Rondo et al., 2003), the latter mechanism operating via hormone signaling (O'Connor et al., 2005). Beyond prenatal biological risk, there is much evidence to suggest that postnatal psychosocial and contextual environments are disrupted under settings of low SES due to parental stress (Evans, 2004; Evans & English, 2002), especially in the case of parent-child interaction (Raviv et al., 2004; Repetti et al., 2002; Yeung et al., 2002). It is important to further understand the biological and contextual consequences of family economic disadvantage given their widely replicated association with multiple aspects of
developmental health (Hertzman & Boyce, 2010; Repetti et al., 2002). However, these mechanisms are seldom explored in the context of multiple siblings per family, potentially obfuscating the nature of their influence on development across the family system.

4.1.2 Considering Multiple Siblings per Family

There are a variety of emergent processes within the family system that exist because multiple siblings are present (Carr, 2012; Fiese & Spagnola, 2007; Kramer & Conger, 2009). These within-family processes cannot be accessed using single child designs (Dillon T Browne et al., 2015). For example, family emotional climate or sibling relationships can serve as important sources of developmental influence (Carr, 2012; Gass et al., 2007). Similarly, sibling differences in the receipt of caregiving can also drive developmental outcomes – a phenomenon known as differential parenting or differential treatment (Atzaba-Poria & Pike, 2008; Henderson et al., 1996; Jenkins et al., 2003). Sibling differences in the receipt of parenting are deleterious for disfavored children. For example, disfavored children exhibit poorer outcomes in academic functioning (Asbury et al., 2006), socioemotional problems (Burt, McGue, Iacono, & Krueger, 2006; Meunier et al., 2013), personality, temperament, and behavior (Conger & Conger, 1994; Turkheimer & Waldron, 2000), and general medical health (Browne & Jenkins, 2012). Moreover, there is evidence to suggest that sibling differences in the receipt of parenting are harmful for all children within a family, possibly due to the creation of a negative emotional climate or due to sibling contagion (Boyle et al., 2004; Feinberg, 2003; Meunier, Bisceglia, & Jenkins, 2012). Furthermore, a modest number of studies have demonstrated that sibling differences in the receipt of parenting are increased under settings of low SES (Browne et al., 2012; Browne et al., 2015; Henderson et al., 1996; Jenkins et al., 2003), highlighting the need to consider this process in the emergence of developmental health inequalities.
Given the natural clustering of multiple siblings within the family context, it is useful to conceptualize the family system as a multilevel and hierarchical entity (Browne et al., 2015; Jenkins et al., 2016). First, this has the advantage of differentiating family processes and developmental outcomes that are unique to particular children (i.e. *child-specific factors*) versus those that are common to all children in a household (i.e. *family-wide factors*). Moreover, associations can be disambiguated across these levels of organization. For example, one could explore if family-wide contextual risks impact all children in a family similarly, or if particular siblings are uniquely disadvantaged in terms of developmental outcomes. Finally, such methodology permits the robust testing of associations amid child-specific predictors and outcomes, eliminating possible confounding at the family-wide level (i.e. sibling comparison design). There have been numerous calls for family based designs that permit the isolation of these hierarchical processes (D’Onofrio, Lahey, Turkheimer, & Lichtenstein, 2013), including in the study or early economic risk and associated developmental sequelae (Browne et al., 2015; Jenkins et al., 2016).

### 4.1.3 SES and Sibling Differences in Birth Weight

It is important to consider the developmental processes that give rise to the relationship between SES and sibling differences in the receipt of parenting. Perhaps there are other socioeconomically-informed sibling differences that operate as a mediator in this relationship? One early developmental factor that may predict sibling differences in the receipt of parenting is birth weight. This is often used as a general proxy for biological risk due to its replicated association with general health, behavior, socioemotional functioning, and cognitive development (Asbury et al., 2006; Conley & Bennett, 2000; Jefferis et al., 2002; Matte et al., 2001) across the life course (Colman, Ploubidis, Wadsworth, Jones, & Croudace, 2007). Moreover, it is predicted by SES (Finch, 2003) and is known to differ within women, across
pregnancies (Lunde, Melve, Gjessing, Skjaerven, & Irgens, 2007), making it a good candidate mechanism in this pathway.

Environmentally induced sibling variation in biological ontogenesis is evident as early as fetal development (Gluckman et al., 2010; Lunde et al., 2007). For example, siblings who experience more favorable in utero environments – indexed by maternal weight gain during pregnancy – tend to grow more during gestation and are heavier at birth, irrespective of genetic effects (Hutcheon, Platt, Meltzer, & Egeland, 2006; Ludwig & Currie, 2010). Presently, no studies have tested the hypothesis of increased sibling differences in birth weight under low SES conditions. Behavioral genetic studies provide insight into this possible mechanism. Using an intergenerational and genetically informative sample of ≈75,000 families that permitted the isolation of genetic and environmental influences on birth weight, Lunde and colleagues (2007) identified the following variance components: 30% fetal genetic, 20% maternal genetic, 10-15% family-wide or shared environment, and 30-35% child-specific or non-shared environment. Measured environmental effects on infant birth weight may be the same or different for siblings (de Bernabé et al., 2004; Dubay, Joyce, Kaestner, & Kenney, 2001; Kearney, Munro, Kelly, & Hawkins, 2004). There are some environmental influences that likely persist across multiple pregnancies (e.g. persistent poverty, access to prenatal care and universal healthcare), and factors that could potentially differ (e.g. maternal nutrition, placenta functioning, smoking, pregnancy stress, and maternal mental health). Importantly, family risks that are the same for all siblings can partially operate to increase the amount of sibling differences in risk exposure (Browne et al., 2015; Jenkins & Bisceglia, 2011; Plomin, 2011). In fact, in the study of birth weight, it has been suggested that certain factors may increase differences in the environmental influences across pregnancies, including the presence of a new partner or family reconstitution between the births of siblings (Lunde et al., 2007).
Given that family dysfunction and health behaviors are associated with broad contextual influences such as SES (Bradley & Corwyn, 2002), it is conceivable that low family SES serves to increase sibling differences in fetal environments and birth weight. Indeed, the tenuous and unpredictable nature of economic disadvantage may lead to differential resourcing of children during gestation (Hutcheon et al., 2006). While low SES is often conceptualized as chronic and persistent, there is also evidence to suggest that low SES families experience bouts of stress that may coincide with relatively acute events, including workplace challenge, job insecurity, and periods of marital strife (Brooks-Gunn, Schneider, & Waldfogel, 2013; Repetti et al., 2009). Thus, the effects of SES on maternal functioning during the peripartum period may not be equivalent for all children in a family. As a result, in the context of multiple pregnancies over time, it is reasonable to expect that economic deprivation will have differential effects on siblings’ development during in utero growth. Thus, the present study first sought to examine the link between SES and sibling differences in birth weight. Such effects would presumably be over-and-above the marked effects of SES at the family level, whereby all siblings in a family have lower birth weight, on average, due to shared environmental risks (Finch, 2003; Kelly et al., 2009; McLoyd, 1998).

4.1.4 Sibling Differences in Birth Weight and Parenting

If SES partially operates to make siblings more different in early biological risk (i.e. birth weight), one must consider how increased sibling variability impacts the caregiving environment. It is possible that early sibling differences in birth weight account for later differences in parenting, commensurate with theoretical perspectives outlining the reciprocal influences between children and parents across ecological and biological levels of analysis (Bronfenbrenner & Morris, 2006; Lerner, 2006; Sameroff, 2010). Extended to the family system, this implies that highly variable siblings would elicit highly variable responses from their
caregivers (Jenkins et al., 2016). Moreover, associations may reflect absolute sibling differences (e.g. greater sibling differences in parenting, overall, when siblings are more different in birth weight) and relative sibling differences (e.g. heavier children receiving more or less of a particular response compared to his or her sibling). Thus, a secondary goal of the present study was to consider the link between sibling differences in birth weight (as an early index of biological risk) and sibling differences in early psychosocial environments. In line with previous literature, we selected one of the most commonly studied early parenting environments – namely sensitive parenting in the context of the mother-child relationship (Bowlby, 1988; Claussen & Crittenden, 2000; De Wolff & van Ijzendoorn, 1997).

Parental responses to child individual differences have been considered under the framework of resource allocation (Becker & Tomes, 1994; Gaviria, 2002). Resources have been broadly measured via self-report metrics of material investments or self-reports of parent-child relationship quality. Conversely, other studies have employed proxy metrics of resource allocation such as breastfeeding, school attendance, medical care, and duration of parent-child contact. Notably, self-report measures are subject to recall and personal bias, and may be more reflective of parental attitudes and beliefs than actual behavior during real-time interactions (Gardner, 2000). Similar validity concerns can be raised for retrospective recalls of psychosocial and material resource provision (Henry, Moffitt, Caspi, Langley, & Silva, 1994). To date, no studies have prospectively examined the association between sibling differences on birth weight and parenting using observational measures, which provide a more objective assessment of the behavior in question (Gardner, 2000). This is a salient omission in the developmental literature given the plethora of literature citing contingency between mother and child responding during real-time interactions (Feldman, 2012; Kochanska, 2002). Thus, the present study sought to explore this issue using an intensive observational coding system.
Maternal sensitivity is a suitable metric of parental resource allocation, given the complex and demanding nature of this phenomenon and its association with developmental success in a number of areas. These include emotion and anger regulation (Feldman et al., 2011; NICHD, 1999), joint attention and attentional control (Belsky et al., 2007; Gaffan et al., 2010), early communication (Gunning et al., 2004), cognitive development (Bernier et al., 2012), adrenocortical responses and other physiological indicators (Feldman, 2006; Sethre-Hofstad et al., 2002), compliance to caregivers (Feldman & Klein, 2003), and attachment security (Jay Belsky & Fearon, 2002; NICHD, 2001). Given that heavier siblings exhibit fewer behavior problems (Asbury et al., 2006), and siblings with fewer behavior problems experience more sensitivity (Browne et al., 2012), we hypothesized that heavier infants would receive more sensitivity.

4.1.5 The Current Study (Study #3)

The current sought to test the following four hypotheses in a single empirical model amongst a prospective birth cohort of families: (1) SES will be associated with greater sibling differences in birth weight, (2) absolute sibling differences in birth weight will predict sibling differences in sensitivity, (3) SES will be associated with sibling differences in parenting via sibling differences in birth weight, and (4) relatively heavier siblings will experience greater levels of maternal sensitivity.

4.2 Methods

4.2.1 Participants and Data

Multiparous women giving birth to infants in the cities of Toronto and Hamilton between 2006 and 2008, who had been contacted by the Healthy Babies Healthy Children (HBHC) public health program (run by Toronto and Hamilton, Ontario, Public Health Units), were considered
for participation. Inclusion criteria for the intensive sample of Kids, Families Places were as follows: (1) English-speaking mother; (2) a newborn weighing at least 1500g; (3) two or more children less than 4 years old in the home; and (4) agreement to the collection of observational and biological data. Thirty-four percent of mothers whose information was passed by HBHC consented to participate in the study. Reasons for non-enlistment included inability to contact families, ineligibility once contacted, and refusals. Multiparous mothers were exclusively recruited given that the present investigation was concerned with family-wide, individual, and relationship-specific influences on child development.

The University of Toronto Research Ethics Board approved all procedures, including informed consent. We compared our initial sample ($N=501$) with the general population of Toronto and Hamilton using 2006 Census Data, limiting the census to women between 20-50 years and having at least one child. Families were compared on immigrant status, number of persons in the home, family type, maternal income, and educational level. Families were of similar size ($M = 4.52, SD = 1.01$ vs. $M = 4.13, SD = 1.22$) and maternal income (median C$30,000–39,999 vs. census population $M = C$30,504.16, $SD = C$37,808.12). As our sample was recruited so shortly after childbirth, there are fewer non-intact families than in the population (5% vs. 16.8% lone-parent families; 4.3% vs. 10.3% stepfamilies). The proportion of Canadian born to immigrants was somewhat higher in the current sample (57.7% vs. 47.6%), likely due to the language requirement for participation. Also, more study mothers had earned a bachelor’s degree or higher (53.3% vs. 30.6%). Of participating mothers, 56.5% self-identified as being of European descent, 14.6% as South Asian, 9.3% as Black, 12% as East Asian and 8.6% as other.
In the KFP Study, 74.1% of families were 2 child families, 18.8% were 3 child families, and the remaining 7.2% had 4 or more children. To minimize burden on families we only collected observational data on the target child and the next in age older sibling. Demographic measures and SES were measured at baseline when younger children were newborns ($M_{age} = 2.0$ months, $SD = 1.06$) and older children were on average 2.58 years ($SD = 0.76$); 49% of children were female. At follow-up, the mother and children were filmed interacting when the child was approximately 18 months ($M_{age} = 1.06$ years, $SD = .16$), and the older child was about 4-years-old ($M_{age} = 4.05$ years, $SD = 1.05$). Due to attrition, 397 (79%) families remained at this stage of assessment (see analysis section for description of missing data management).

4.2.2 Measures

4.2.2.1 Socioeconomic Status

SES was created as a composite variable reflecting family levels of income and assets. Parents responded to the following items: “how many rooms do you have in your house”; “Do you own or co-own this home/apartment/unit, even if still making payments: yes =1, no =2”; “Do you own or co-own a car, even if still making payments: yes =1, no =2”. These questions, in addition to a question asking parents to identify annual household income on a scale from 1 (‘no income’) to 16 (‘$105,000 or more’). These variables were re-scaled and standardized so that all variables were going in the same direction, where higher scores were indicative of higher SES. Items had an internal consistency of $\alpha = .79$.

4.2.2.2 Birth Weight

Mothers reported on the birth weight of their two youngest children in kilograms and grams. Nationally representative studies have demonstrated that maternal recall of infant birth weight is a suitable proxy for recorded and documented birth weight at the time of birth (Catov
et al., 2006; Walton et al., 2000). For example, one Scandinavian record linkage study
demonstrated nearly perfect maternal recall of documented weight when children were between
8-11 years, with virtually no difference in accuracy for children who were teens (Adegboye &
Heitmann, 2008). Thus, there is little concern with measurement bias as mothers reported on
birth weight for the youngest child 2 months after birth ($SD = 1.06$), and on the next-youngest
child when they were 4.05 years ($SD = .75$). This was done in order to minimize response burden
on families at Time 1.

4.2.2.3 Maternal Sensitivity

Mothers were videotaped interacting with both children (one at a time) for 15 minutes.
There were three different tasks, each of which lasted 5 minutes. First, there was a free play with
no toys, where mothers were instructed to play with children as they normally would but without
any play materials. Second, there was a structured teaching with toys, where dyads were given a
pegboard with circles and squares of different colors and instructed to copy a picture.
Specifically, mothers were asked to teach their child how to construct the pattern in the picture,
where the pattern was intentionally beyond the child’s developmental level in order to elicit
maternal teaching. Finally, there was a reading task, during which the mother was asked to make
up a story to a wordless picture book. These tasks were selected in order to assess mothers’
capacity to engage the child positively during common tasks of early childhood.

Maternal sensitivity was assessed using the sensitive responding and mutuality scales of
the Coding of Attachment Related Parenting scheme (Matias, 2006) and the positive control
scale of the Parent-Child Interaction System (Deater-Deckard et al., 1997). Sensitive responding
measures the ability of mothers to display awareness of their child’s needs, to be sensitive to the
child’s signals, and demonstrate perspective taking from the child’s vantage point. Mutuality is a
dyadic code that reflects conversational reciprocity, sharing of affect, joint engagement during tasks, and open physical posture. The positive control scale assesses positive aspects of a mother’s style of directing or influencing child behavior, including using praise, explanations, and asking open-ended questions. A composite was computed by averaging the sensitive responding, mutuality and positive control subscales across all tasks. Internal consistency was $\alpha = .85$ and inter-rater reliability, assessed by having an expert coder double-score 10% of all videos, was high ($\alpha = .94$). Inter-rater reliability was assessed throughout the coding period to minimize rater drift.

4.2.2.4 Covariates

Within-family analyses controlled for additional child specific confounding variables, including birth order (1=older, 0=younger), age, gender (1=female, 0=male), and preterm status (36 weeks or less = 1, 37 weeks or more = 0). These variables permitted the further isolation of the within-family association between birth weight and sensitivity. Between-family analyses controlled for the number of children in the family and sibship sex composition (same sex = 1, different sex =0; reported in text for simplicity of figure presentation).

4.2.3 Analysis

Multilevel path analysis was employed in order to estimate the hypothesized path model linking socioeconomic status, birth weight, and maternal sensitivity. Data took a two-level structure, whereby siblings (Level 1 or the child-specific level) were nested in families (Level 2 or family-wide level). First, a null model was estimated, fitting only child-specific and family-wide intercepts for birth weight and maternal sensitivity for the purposes of variance partitioning. From this model, variance partitioning coefficients were computed that reflect the proportion of family-wide variance to total variance. This conveys the amount of family clustering in outcome
variables. Stated differently, the family-wide variance reflects the amount of sibling similarity, while the child-specific variance reflects the amount of sibling differences for a particular outcome. Next, a multilevel structural path model was estimated in order to identify the hypothesized associations amongst response variables. A series of linear equations were simultaneously fit to estimate the hypothesized associations.

At the family-wide level, SES was hypothesized to predict sibling differences in birth weight, which was hypothesized to predict sibling differences in the receipt of parenting. Sibling differences were modeled as a family-standard deviation, which reflects the absolute magnitude of sibling differences for either birth weight or maternal sensitivity in a given family (in standard deviation units). We hypothesized a negative association between SES and sibling differences in birth weight (i.e. lower SES families have siblings who are more different in birth weight.) We also hypothesized a positive association between sibling differences in birth weight and sibling differences in receipt of parenting (i.e. greater birth weight discordance is associated with greater differences in siblings’ receipt of parenting.) For purposes of comprehensiveness, associations were also considered amongst SES and family-average levels of response variables. That is, SES was hypothesized to predict higher family-average birth weight, which was hypothesized to predict higher family-average levels of maternal sensitivity. Direct paths were also modelled and all of the implied indirect pathways at the family-wide level were tested for statistical significance using the Delta method (Mackinnon et al, 2002).

At the child-specific level, a sibling comparison model was employed in order to examine the relative association between a sibling’s birth weight and experiences of maternal sensitivity, compared to his or her sibling. This model is a robust test of this association, as it is free of possible between-family confounders such as shared maternal or contextual factors. Such models
have been effectively employed to examine the child-specific effects of environmental exposures (Jaffee, Van Hulle, & Rodgers, 2011) and in the study of relative sibling birth weight on parental investment (Lynch & Brooks, 2013). Maternal sensitivity was estimated as:

\[ MS_{ij} - M\bar{S}_j = \beta_1 (BW_{ij} - \bar{BW}_j) + \gamma_1 X_{ij} + e_{ij} \]

Here, child-specific differences from family-average maternal sensitivity, \( MS_{ij} - M\bar{S}_j \), was a function of the effect of child-specific differences from the family-average birth weight, \( \beta_1 \), controlling a vector of child-specific covariates, \( \gamma_1 \), which include gender, birth order, age and preterm status, and a child specific error term, \( e_{ij} \), that is zero centered and normally distributed with constant variance. The strength and direction of \( \beta_1 \) will determine if heavier siblings receive more or less maternal sensitivity, compared to the other sibling.

Of the initial 501 families in the KFP study, 397 (79%) remained at follow-up. As is often the case in longitudinal research, retained families were of higher SES. Of these 397, target variables were between 88.0% and 99.9% complete. There was one family with missing data on predictors and outcomes and was therefore excluded for a final study sample of N=396. In order to avoid artificially inflating the study N though missing data procedures, reported estimates are based on analyses where missingness was handled using Full Information Maximum Likelihood estimation up to maximum allowable sample of 396 families versus 501 (the original sample size at Time 1). Analyses were run on both 396 and 501 families and results were substantively identical. Model fit is based on the chi-square test of model fit, Root Mean-Squared Error of Approximation (RMSEA), the Comparative Fit Index (CFI), and the between- and within-family Standardized Root Mean Square Residual (SRMR). Analyses were conducted using Mplus 7 (Muthen, 1998-2010).
4.3 Results

Descriptive statistics are presented in Table 4.1.

Table 4.1. Descriptive Statistics.

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td><strong>Child-Specific</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1 Birth Weight</td>
<td>.15**</td>
<td>-.36**</td>
<td>-.14**</td>
<td>-.05</td>
<td>3.42</td>
<td>0.52</td>
</tr>
<tr>
<td>2 Sensitivity</td>
<td>.01</td>
<td>.05</td>
<td>.26**</td>
<td>3.73</td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td>3 Preterm</td>
<td>.03</td>
<td>--</td>
<td>--</td>
<td>29 (4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Girl</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>380 (48%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Birth Order</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>397 (50%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family-Average</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1 SES</td>
<td>.15**</td>
<td>.44**</td>
<td>-.16**</td>
<td>.06</td>
<td>0.18</td>
<td>0.77</td>
</tr>
<tr>
<td>2 Birth Weight</td>
<td>.10**</td>
<td>.00</td>
<td>.04</td>
<td>3.42</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>3 Sensitivity</td>
<td>-.12</td>
<td>.14**</td>
<td>3.73</td>
<td>0.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 SD Weight</td>
<td>.09</td>
<td>.31</td>
<td>0.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 SD Sens.</td>
<td>0.55</td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05, **p < .01

The primary analyses are presented in Figure 1. Before estimating the path model, a null model was fit which estimated only child-specific and family-wide intercepts for birth weight and maternal sensitivity. Variance Partitioning Coefficients revealed that 31% of the variance in birth weight was at family-wide, while 69% of the variance was child-specific. In terms of maternal sensitivity, 29% of the variance was at family-wide and 71% was at child-specific.
Thus, there was substantial familial clustering in both variables, though the majority of variance reflected sibling differences (which also include measurement error). Next, the hypothesized multilevel path model was fit (see Figure 1). Model fit statistics indicated that the model was a good fit to the data, $\chi^2 (2) = 5.07, p = .08$, RMSEA = .04, CFI = .99, within-family SRMR = .02, between-family SRMR = <.01

**Figure 4.1. Multilevel Path Model.**

*Multilevel path analysis highlighting the associations between family socioeconomic status, birth weight and maternal sensitivity*

* $p < .05$, ** $p < .01$, *** $p < .001$
4.3.1 SES and Increased Sibling Differences

At the family-wide level, lower SES was associated with significantly higher sibling differences in birth weight, overall. That is, siblings are more different in their birth weight status under settings of lower SES (see Figure 4.1 & 4.2). Furthermore, greater sibling differences in birth weight were associated with greater sibling differences in the receipt of maternal sensitivity. In other words, mothers who have children with highly discordant birth weights tend to parent towards their children more differentially, overall. There was no significant direct effect of SES on sibling differences in the receipt of maternal sensitivity. Also, despite the significant α and β paths in the implied mediation model, the indirect effect of family SES on sibling differences in maternal sensitivity via birth weight was not statistically significant, $\alpha\beta = -.01, z = -1.41, p = .131$, likely due to the relatively small magnitude of the aforementioned effects. Thus, SES is associated with increased sibling differences in birth weight, which is associated with increased sibling differences in the receipt of sensitivity, though the indirect effect was not significant.
Figure 4.2. Socioeconomic Status and Birth Weight.

*Higher socioeconomic status is associated with higher family-average birth weight and lower within-family variability in birth weight.*

4.3.2 SES and Family-Average Outcomes

Also at the family-wide level, higher SES was associated with significantly higher family-average birth weight. Moreover, higher family-average birth weight was significantly associated with higher family-average maternal sensitivity. There was also a large and significant direct effect of SES on family-average maternal sensitivity, whereby higher SES was associated with significantly higher family-average sensitivity, irrespective of family-average birthweight. The indirect effect of SES on family-average maternal sensitivity via family-average birth weight was just above conventional levels of significance, $\alpha \beta = .02, z = 1.92, p = .055$. Note that number of children in the family and sibship sex composition had no impact significant association with any of the aforementioned between-family (Level 2) pathways.
4.3.3 Child Specific Associations with Birth Weight and Sensitivity

At the child-specific level, siblings served as a source of comparison for one another. This relationship reflects the extent to which a sibling’s relative birth weight corresponds to relative differences in the receipt of maternal sensitivity. In other words, the estimate is free of potential family-level confounding of broad environmental variables. As hypothesized, this effect was statistically significant (see Figure 4.1), indicating that relatively heavier children at birth receive more maternal sensitivity, compared to their lower birth weight siblings. That is, a one standard deviation increment in child-specific birth weight corresponded to maternal sensitivity scores that were over one-tenth of a standard deviation higher, relative to one’s sibling. Older siblings were also substantially more likely to receive higher levels of sensitivity, relative to younger siblings.

4.4 Discussion

The present study is the first investigation to link social disadvantage, birth weight, and observed maternal sensitivity, where variability in sibling differences were of particular focus. Lower SES families had children with lower birth weights, overall, and siblings who were more variable. Additionally, mothers of birth weight discordant siblings tended to be more variable in their parenting, overall. Furthermore, SES demonstrated both direct effects on family-average sensitivity, and (nearly significant) indirect effects via lower birth-weight. Within-families, heavier siblings tended to experience greater maternal sensitivity. This investigation provides insight into the manner in which social disadvantage augments sibling differences in risk, evidently making siblings and their environments more different, while simultaneously clustering and increasing developmental risk between-families.

Previous studies have demonstrated that there are greater sibling differences in behavioral outcomes and parenting under settings of adversity (Jenkins et al., 2003; Meunier et al., 2013).
The present study extends these findings, suggesting that contextual adversity may increase observable sibling differences in development as early as the peripartum period, specifically in the form of birth weight, which is often used as a proxy for quality of fetal environment and biological risk (Asbury et al., 2006; Conley & Bennett, 2000; Jefferis et al., 2002; Matte et al., 2001). Complementary findings come from behavioral genetics, whereby the influences of child specific risks on behavioral development are thought to be augmented in high risk or “extreme” contexts (e.g. impoverished or abusive homes) (Plomin, 2011). Several genetically-informed studies have demonstrated increased environmental versus genetic effects under settings of risk for outcomes such as internalizing psychopathology (South & Krueger, 2011), antisociality (Tuvblad, Grann, & Lichtenstein, 2006), substance abuse and rule breaking (Legrand, Keyes, McGue, Iacono, & Krueger, 2008), and childhood and adolescent body mass index (Lajunen, Kaprio, Rose, Pulkkinnen, & Silventoinen, 2012). This hypothesis has not been tested for birth weight while totally controlling for genetic effects. In a genetically-sensitive nationally representative design, Lunde and colleagues (2007) demonstrated that 30-35% of the variance in birth weight is child-specific and reflective of non-genetic sibling differences. The current study suggests that the magnitude of sibling differences may vary across family contexts, being larger in size under settings of low SES.

As hypothesized, there was a significant association between sibling differences in birth weight and sibling differences in the receipt of maternal sensitivity. These operated for entire families (i.e. greater sibling differences in birth weight corresponded to greater sibling differences in maternal sensitivity, overall) and specific children (i.e. heavier children experienced higher levels of maternal sensitivity, compared to their siblings). The majority of research has examined sibling differences in parenting as a predictor of behavioural development in children (Boyle et al., 2004; McGuire, Dunn, & Plomin, 1995). However, there is evidence to
suggest a dynamic interplay between constitutional sibling differences and sibling variability in experiences with parents (Jenkins et al., 2016; Richmond, Stocker, & Rienks, 2005). Indeed, findings from the present study are consistent with bidirectional models of socialization between parents and children (Bell, 1968; Granic & Patterson, 2006; Sameroff, 2010). Sibling differences in the receipt of a particular parenting domain are viewed to be higher under settings of contextual risk because parental psychological resources are taxed. Consequently, caregivers may find it difficult to allocate equitable amounts of love, warmth, affection, time, and attention across all children within a family (Henderson et al., 1996; Jenkins et al., 2003). In the present study, the magnitude of sibling differences in birth weight could potentially operate as a shared contextual risk. That is, the presence of markedly different children within a family (i.e. high birth weight discordance) may engender differences in the way parents respond and react to their children. Twin comparison studies have demonstrated that relatively lower birth weight is causally associated with cognitive and behavioral challenges in childhood (Asbury et al., 2006; Stromswold, 2006). Thus, in highly birth weight discordant families, the presence of a child with more difficulties may overburden parents, thereby increasing the likelihood that they treat their children differently, overall.

Patterns of association provide further insight into the nature of the relationship between birth weight and parenting. Sibling comparison studies linking a child’s relative birth weight and experiences of self-reported parenting have been equivocal (Hsin, 2012; Lynch & Brooks, 2013). However, by using a more objective observational metric of maternal sensitivity, the present findings suggest that mothers are indeed more sensitive to siblings who are of relatively higher birth weight. Moreover, the employment of a sibling comparison design reduces the likelihood that the child-specific findings are attributable to family-level environmental confounds – as the relationship is entirely within families – and reduces the likelihood of genetic confounding
(D’Onofrio et al., 2013; Lahey & D’Onofrio, 2010). Additionally, as explicated above, the sibling comparison component of the model controlled for a variety of child-specific factors, birth order, gender, and preterm status. Thus, these effects represent a robust association that is more likely to represent a causal mechanism.

Children shape their own experience in part by evoking specific responses from their caregivers in a way that is consistent with their biobehavioral characteristics, with some children evoking more negativity and others evoking more nurturance. Evidence of these effects have been shown early in development. During early childhood, some children evoke more cognitively stimulating responses from their parents compared to their siblings (Tucker-Drob & Harden, 2012). Child influences may also occur during earlier periods of development, with more negative infants evoking more hostility compared to their siblings (Boivin et al., 2005). Given that birth outcomes are associated with later biobehavioral development, it is not surprising to find associations between birthweight and parenting (Camerota, Willoughby, Cox, Greenberg, & Investigators, 2015). Indeed, lower birth weight siblings may be more difficult to read, thereby altering or impacting caregiver’s perception and capacity to respond contingently to infant cues (Feldman, 2007).

Although not directly assessed in the current study, it is important to speculate on the mechanisms that account for the direct association between sibling differences in birth weight and observed maternal sensitivity. Our results are congruent with theories suggesting that parents reinforce children’s constitutional endowments with greater resource allocation in order to maximize their child’s human capital (Becker & Tomes, 1994). Birth weight may be conceptualized as an indicator of human capital, given its association with health and socioeconomic achievement over the life course (Conley & Bennett, 2000), in addition to cognitive and behavioral functioning in numerous domains (Jefferis et al., 2002; Matte et al.,
Moreover, normative variation in birth weight has been linked to neural functioning in key brain regions known to support executive, social-cognitive, and linguistic functioning (Raznahan, Greenstein, Lee, Clasen, & Giedd, 2012; Walhovd, Tamnes, & Fjell, 2014). In other words, it is plausible that more advanced children—who have a greater capacity for executive control, interpersonal awareness, communicative competence and behavioral regulation—recruit themselves into social exchanges and elicit more positive responses from caregivers.

Furthermore, one could argue that previous null findings from self-report studies are not entirely surprising, given that such metrics partially reflect parents’ attitudes about their children (Gardner, 2000)–it is unlikely that many parents would consciously appraise a heavier child more favorably, irrespective of other more salient explanations. Future sibling comparison designs that account for the mechanisms linking birth weight and sensitivity are indicated.

The present findings are in concert with literature citing the protective effects of responsive parenting interventions for children with biological risk based on birth weight variability (Landry et al., 2008), in addition to intervention models that account for influences across the sibling and family systems (Dishion & Stormshak, 2007). Given that there is substantial similarity in parenting across siblings (Madigan, Plamondon, Browne & Jenkins, 2016), and clustering in parenting at the family level (Browne et al., 2012), the effects of responsive parenting interventions may spill-over into other parent-child dyads in the household. However, as is presently the case, research also finds substantial variability in parenting within-families, which is exacerbated under settings of risk (Browne et al., 2015). Accordingly, targeted responsive parenting interventions for mothers in high risk families may be effectively tailored to manage the increased sibling variability in birth weight and receipt of parenting under conditions of low SES. Indeed, the challenge of parenting—by and large—is augmented in low SES homes, as these mothers are faced with the task of parenting children who are of lower birth weight,
overall, and who are increasingly differentiated. Future research should consider the best implementation of responsive parenting interventions, where sensitivity across multiple children-per-family is of particular focus.

4.4.1 Strengths and Limitations

The present study possesses a number of strengths, including the utilization of a prospective birth cohort, longitudinal follow-up, employment of a high-quality observational metric of maternal sensitivity, and multilevel methodology, including a sibling comparison design. That being said, there are a number of limitations that should be addressed in subsequent research. First, the absence of a twin design precludes the total isolation of genetic effects. There is a need for future behavioral genetic research that explores similar questions, thereby disentangling genetic, shared, and non-shared forms of developmental influence. Secondly, the measurement employed in the current study was limited to two children per family. This was largely due to the response burden of observational assessment for mothers and the cost of coding videotaped interactions. Thus, while the multilevel findings are informative, readers should exercise caution in generalizing findings beyond two children per family (though analyses did control for number of children). Finally, the parenting behavior of mothers was exclusively considered in analyses. It is important to remember that parental resource allocation often operates across an entire family system, which may include partners, grandparents, extended family members, and non-biological caretakers. Future studies may consider examining parental resource allocation within the context of broad and eclectic family definitions. In spite of these limitations, the present study represents an important contribution to the study of contextual risk and the augmentation of sibling differences in risk across early life.
Chapter 5: Concluding Remarks

5.1 Discussion

The purpose of the present dissertation was to explore the multiple and distinct biopsychosocial family mechanisms that convey the relationship between social disadvantage and developmental health. Embedded in dynamic person-context system, the cascade linking ecological risk and development operates, at least in part, by altering the nature of family life during the early years (Conger et al., 2010; Repetti et al, 2002). There are multiple pathways through which economically-informed risk impacts children, and these phenomena operate across levels of organization (Browne et al, 2015; Lerner, 2006). Indeed, the putative family-based mechanisms that convey developmental risk include dynamic interpersonal and relational processes, physical quality of the family socialization context, and alterations in prenatal biological development (among others). In this way, it can be said that social disadvantage “gets inside the family” (Conger, n.d.), by modifying a variety of proximal developmental processes.

The net result is the socioeconomic stratification of developmental morbidity across society, whereby children in poorer households exhibit poorer outcomes in a number of different domains (Keating & Hertzman, 1999).

Across the previously presented empirical studies, a number of specific findings elucidate the cascade that spans from economic risk to children’s developmental health (see Figure 5.1 and 5.2). First, in Study 1, we see that certain environmental risk factors cluster in prototypical ways for particular families. In other words, the aggregation of putative risk for developmental morbidity does not necessarily look the same for all households, and there may be characteristic patterns that differ as a function of structural or demographic characteristics. For example, a unique group of immigrant families were identified, where mothers do not report the patterns of
early adversity and current household dysfunction that are typically associated with the intergenerational transmission of risk and morbidity. However, following immigration and resettlement, these families are met with socioeconomic disadvantage and neighborhood risk, similar to non-immigrant families who experience adversity in a variety of domains. Given the associations amongst risk profiles and proximal environments, it appears that cumulative economic stress is particularly influential in disrupting family dynamics in the form of interpersonal processes (i.e. maternal sensitivity) and physical quality of the home environment (i.e. material investment). These factors are subsequently associated with key cognitive skills in early development (i.e. academic achievement, receptive vocabulary, executive functioning, and theory of mind), conceivably laying the foundation for accumulative and exacerbating disparities in developmental trajectories (in multiple domains) as a function of economically-informed risk and family disruption.

**Figure 5.1. Summary of key research findings from empirical studies.**

<table>
<thead>
<tr>
<th></th>
<th>1. Risk factors combine in different family profiles. However, cumulative socioeconomic risk is particularly deleterious in disrupting family environments in the form of maternal sensitivity and material investments in child development.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Cumulative risk impacts developmental health (e.g. school readiness in the form of early academics, receptive vocabulary, executive functioning, and theory of mind) via maternal sensitivity, independently of material investments.</td>
</tr>
<tr>
<td></td>
<td>3. Observed cognitive sensitivity during family interactions operates across hierarchical levels of family organization:</td>
</tr>
</tbody>
</table>
• Family-wide differences were important for levels of cognitive sensitivity across all family roles, but especially for younger children.

• Individual differences (i.e. actor effects) were more important for older family members, especially mothers. Cognitive sensitivity differed at the individual level for older siblings but not for younger siblings.

• Relationship-specific differences (i.e. dyad effects) were more important for the cognitive sensitivity that children display during interaction, compared to mothers.

• Overall, cognitive sensitivity becomes a function of the individual as family members increase in age. Among young children, it is predominantly attributable to context (i.e. family and dyad effects).

4. Cumulative risk impacts the cognitive sensitive behaviors of older, more competent family members towards younger family members.

5. Siblings born under settings of low socioeconomic status are more differentiated in terms of early biological risk (i.e. birth weight). In turn, sibling differences in birth weight are associated with sibling differences in the receipt of sensitive parenting.

6. Relatively heavier siblings may elicit or be exposed to more maternal sensitivity, compared to his or her lighter sibling.

Studies 2 and 3 elucidate the manner in which interpersonal processes, contextual risk, and individual outcomes manifest across the hierarchical layers of family life. Compared to single-dyad studies, these findings demonstrate that interpersonal “sensitivity”, per se, is not a
unitary relational phenomenon, directed from a mother towards a particular child. That is, sensitivity – as a reciprocal and dynamic relational interplay (Feldman, 2012; Kochanska, 2002) – operates within various mother-child dyads for a given family when multiple siblings are present. For mothers, expressed cognitive sensitivity is predominantly a characteristic of the mother. From a determinants of parenting perspective (Belsky, 1984), this means that individual differences reveal a great deal about the nature of maternal sensitivity within the household – but this is not the whole story. In Study 2, differences at the family-wide and relationship level are also influential in driving maternal cognitive sensitivity. Complementary patterns are observed amongst children. That is, cognitive sensitivity differs across the family, individual, and dyadic levels of analysis, for older siblings, and at the family and dyadic levels for younger siblings. By and large, these findings suggest that conceptualizations of sensitivity in family relationships should move beyond the determinants of parenting, and towards the determinants of interpersonal family life, whereby the recursive influences among individuals and contexts are viewed to operate across layers of family organization.

The patterning of variance partitioning across family roles implies that expressed cognitive sensitivity increasingly becomes an individual characteristic over development, likely through the direct and repetitive experience of sensitivity from other family members. Moreover, there is interpersonal contingency in cognitive sensitivity amongst all dyads. That is, when a mother is highly sensitive towards her child, the child tends to be highly sensitive, in return. Even stronger reciprocity patterns are observed amongst siblings. Furthermore, older siblings demonstrate an executive role during real-time interactions with their younger siblings, not unlike the way in which mothers guide their children through developmentally challenging tasks by exhibiting relatively higher levels of responsiveness, mind-reading, and communicative clarity. This top-down influence from older-to-younger family members may provide the sort of
in vivo sensitivity training children need in order to effectively engage in an increasingly social world.

Beyond the absolute partitioning of outcomes across layers of the family, Study 3 demonstrates that there are between-family differences in the amount of family clustering for both interpersonal processes and individual-level child outcomes. Some families had siblings who were more birth weight discordant than other families. Similarly, some families had siblings who were experiencing more differentiated levels of maternal sensitivity, compared to other families. Furthermore, siblings who were highly discordant in birth weight also tended to live in households where there was greater variability in the receipt of maternal sensitivity, overall. That is, mothers of children who are highly variable tend to be more differentiated in the amount of sensitivity they express across their siblings. The extent of these differences may be guided by factors external to the proximal family environment, such as social disadvantage and contextual risk.

Studies 2 and 3 demonstrate that interpersonal family processes and individual child outcomes are impacted by psychosocial adversity across levels of the family. Specifically, this means that risk can disrupt developmental processes for particular individuals, specific dyads, or entire families. At the individual level, we see that mothers tend to be less sensitive towards all children under settings of risk. At the dyadic level, we see that older family members tend to be less sensitive towards younger family members (mothers to children, older to younger siblings), and that mothers are less sensitive towards children who are of relatively lower birthweight. Finally, at the family level, we see that a substantial proportion of variability in sensitivity is attributable to cumulative risk. In other words, the ambient family climate is less sensitive under settings of adversity. Moreover, in low SES homes, all children tend to be of lower birth weight, and there is greater weight discordance across siblings, overall. In other words, low SES appears
to increase the challenge and difficulty of the task of parenting. That is, if children are more varied, parents are forced to problem solve and attempt to respond contingently across a further range of possibilities. In sum, the present dissertation reveals that social disadvantage recapitulates across levels of the person-family-context system, impacting multiple facets of family life, and ultimately disrupting the normative developmental experience of individuals.

Such processes are not ascertainable unless multiple children per family are considered and – accordingly – the family is conceptualized as a hierarchically entity, characterized by multiplicity in both structure and function.

A unique portrait of development emerges when human development is simultaneously considered from the perspectives of social determinants of health, family systems, and developmental psychology. This understanding moves beyond simple linear explanations, whereby individual differences in risk exposure are associated with individual differences in family mediators and outcomes. To use an analogy, we can conceptualize the family as a reservoir through which variegated risk passes, and unto which a variety of developmental processes are impacted, modified, and often disrupted. Findings from the present dissertation are conceptually and graphically summarized in Figure 5.2.
Figure 5.2. The developmental cascade linking cumulative risk and developmental health operates via biological risk and family processes across levels of ecological and family organization.

5.1.1 Significance and Future Directions

Canadian policy makers have been calling for scientists and practitioners to draw additional attention to the determinants of health outside of the health care system. To date, socioeconomically stratified variations in developmental health have been reported in a variety of convergent and complementary disciplines, including (developmental) psychology, physiology, epidemiology, medicine, nursing, population and public health, sociology, economics, and demography. Cutting across these domains lies a unified and cohesive refrain: *socioeconomic gradients in health outcomes represent one of the most replicated findings in all of the human sciences*. Over the past few decades, and commensurate with the preceding studies, an analogous consensus is solidifying in the aforementioned areas of inquiry: *any*
conceptualization of human health and development must consider economically influenced variations in family stress and functioning during the early years. Indeed, Boyce (2010) has concisely noted that “the family is still the patient [client].”

The present dissertation was a naturalistic, observational, and epidemiological investigation of families and their children. Though not an intervention-based program of study, the above findings provide guidance for the treatment of families who are living in settings of adversity, and for children who are struggling with the milestones of normative development and wellness. Given that sensitivity during interpersonal exchanges continues to emerge as a keystone developmental experience, and this phenomenon occurs across multiple children and intergenerational dyads, there is an ongoing need for interventions that focus on sensitivity, per se, across the family system. There are a number of evidence based interventions that aim to increase parental sensitivity during the early years, including Parent Child Interaction Therapy (McNeil & Hembree-Kigin, 2010), Play and Learning Strategies (Landry et al., 2006), and Child-Parent Psychotherapy (Lieberman, Van Horn, & Ghosh Ippen, 2005). While complexities across family the system (including multiple siblings and other subsystems) are implicit in these models, there remains a need for evaluations (including RCT’s) that examine the effects of these interventions across hierarchical levels of the family. One may ask, do interventions with various treatment targets (maternal sensitivity, cognitive development, parent-child attachment, behavior problems) offer differential change in impairment across the entire family, particular individuals, or specific dyads? This question has yet to be empirically tested in the context of family wide designs. While multi-dyad methodology has been employed in the context of individual family assessment in order to isolate family-wide, individual, and dyadic components of household function (Cook, 2005), an analogous approach has yet to be applied to larger scale intervention studies. Future empirical intervention research will shed light not only on the ways in which
families are impacted by risk in a complex fashion, but influenced by treatment efforts across the entirety of the family system.
References


Evans, G. W., & Kim, P. (2012). Childhood Poverty and Young Adults’ Allostatic Load The Mediating Role of Childhood Cumulative Risk Exposure. Psychological Science, 23(9), 979-983.


Appendices

Appendix 1: Measurement Appendix for Study 1

A trained interviewer conducted initial home visits when children were 2 months old. Information on risk factors was collected via maternal self-report, interviewer observation and by matching families to the national census. For the purposes of latent class analysis (i.e. deriving risk profiles), measured risk factors were either naturally categorical, dichotomized based upon informative cut-points, or continuous. For continuous variables, a cut-point was identified as close as possible to the most extreme 15% of the distribution towards the risky or adverse pole. This would correspond to +1 standard deviation above or below the mean, based on the normal distribution (i.e. the greatest risk or adversity, based on the metric in question). Of course, the categorization is going to vary as a function of the distribution. Each risk factor is described below:

<table>
<thead>
<tr>
<th>Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal History</td>
<td><strong>Maternal Family History of Mental Illness and Substance</strong></td>
</tr>
<tr>
<td>Risk Factors</td>
<td><strong>Abuse.</strong> Mothers were assessed for family history of risk using the</td>
</tr>
<tr>
<td></td>
<td>Family Demographics module of the Ontario Child Health Study Scales (OCHS;</td>
</tr>
<tr>
<td></td>
<td>Boyle et al., 1993). Women indicated whether or not their mother and father</td>
</tr>
<tr>
<td></td>
<td>had a history of mental illness and alcohol and substance abuse, yielding</td>
</tr>
<tr>
<td></td>
<td>four dichotomous variables. Parental history of problems ranged from 4%</td>
</tr>
<tr>
<td></td>
<td>(maternal substance abuse) to 18.2% (maternal mental illness).</td>
</tr>
</tbody>
</table>
**Maternal Birth-Family Composition.** Maternal birth family was coded as being “non-intact” if they described: (a) having parents who separated or divorced, (b) living in a stepfamily, (c) or if their father was not present (16.6% of mothers came from non-intact families).

**Maternal History of Adversity.** Maternal history of adversity was assessed using an adapted adult-version of the Childhood Experience of Violence Questionnaire (Walsh, MacMillan, Trocmé, Jamieson, & Boyle, 2008). Mother’s rated their witnessing of verbal and physical abuse (e.g. parents abusing one another or a sibling) and direct experience of physical and sexual abuse. Severity items (e.g. “How many times before the age of 16 did an adult caregiver slap you...?”) were scored on a scale of “never” to “more than 10 times.” As scales were highly skewed with most mothers reporting no experiences or witnessing of abuse, we recoded the scales to be dichotomous (i.e. “none” or “any”): witnessing verbal abuse (21%), witnessing physical abuse (9.6%), experiencing physical abuse (14.2%), and experiencing sexual abuse (9.8%).

| Current Caregiver and Household Risk Factors | **Other Caregiver Risk Factors.** Additional caregiver features were assessed using the Family Demographics module from the OCHS. Maternal age when first giving birth was recoded to make |
a teenage mother dummy variable (6.2% of mothers had their first child under 20 years of age). Mothers reported whether they were born outside of Canada (46.5% immigrant), if they entered Canada as a refugee (6.4% refugee), if they were not living with their partner at the time of the interview (6.4% living without a partner 2 months after giving birth), whether they had previously had a “spouse or live-in partner” (10.6%) and if they had worked in the last year (25.9%). A question asking the number of children in the family was recoded to indicate less than three children, versus 3 or more children living in the home (25.9%).

**Maternal Depression.** Maternal depression was evaluated using the Center for Epidemiological Studies Depression Scale (CES-D), a widely used self-report scale that assesses depression in nonclinical populations (Radloff, 1977). Mothers rated the frequency of 20 depressive symptoms over the past week using a 4-point scale, where higher scores represent higher depression levels. Internal consistency from the original study was $\alpha = .85$ for the general population and $\alpha = .90$ for a sample of patients suffering from depression. In the present sample (for mothers) it was $\alpha = .84$. Items were summed and the standard cutoff of 16 or higher was used to index persons who would likely meet criteria for clinical depression (16.6% of mothers were depressed).

**Marital Conflict.** Marital conflict was evaluated using the child
involvement subscale of the Conflicts and Problem Solving Scales (Kerig, 1996). This scale assesses the extent to which children are present or involved in marital conflict using frequency-based items such as “argue in front of the children”. The Child Involvement scale was based on 4 items rated on a 4-point scale from ‘Never’ (1) to ‘Often’ (4). For each scale, the mean of the items was calculated, with higher scores indicating more symptomatology. The internal consistency was α = .68. Items were averaged and a score of 1.76 or higher was used to index the presence of substantial marital conflict around children (24.4% of families were said to have high conflict in front of children).

<table>
<thead>
<tr>
<th>Socioeconomic Risks</th>
<th><strong>Income.</strong> To assess household finances, mothers were asked, “What is your total personal income from all sources?” Mothers responded based on 16 ordered categories ranging from 1 (no income) to 16 ($105,000 Canadian) or more. A cut-off of less than $20,000 Canadian was used to index low-income. In the current study, 9% of families were making less than $20,000 at the initial wave of measurement.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Parental Education.</strong> Maternal and paternal education was assessed by asking parents the number of years of formal education they have received excluding kindergarten. A natural cut-point was observed in the distribution and selected as a dichotomization target. Mothers and fathers who had less than 13</td>
</tr>
</tbody>
</table>
years of education (i.e. 0 to 12 years) were categorized as having “low education”. This cut-point is broadly reflective of the absence of post-secondary education, assuming 12 years of compulsory schooling (i.e. high-school diploma, or less). Based on this, 15.2% of fathers and 18.0% of did not have any post-secondary education.

**Other Socioeconomic Indicators.** To understand families’ assets and equity, mothers were asked “do you currently own your home/apartment/unit, even if still making payments on a mortgage”. Based on this question, 36.1% of families did not own their residence. Additionally, to further understand family cash flow, families were asked, “is rent for this dwelling subsidized by government?” Only 5.2% of families were receiving subsidies.

| Neighborhood Risks | Perceived Neighborhood Trust, Social Control and Victimization. Parental perceptions of neighborhood trust and control were derived from Sampson and colleagues’ study of collective efficacy (Sampson, 1997). The trust scale was comprised of five items such as “people around here are willing to help their neighbors”. Parents responded on a five-point scale ranging from strongly agree (1) to strongly disagree (5). The social control scale was comprised of five items such as “if some children were spray-painting graffiti on a local building, how likely is it that your neighbors would do something about it?” |
Parents indicated the likelihood that their neighbors would intervene in such situations based on a five-point scale that ranged from very unlikely (1) to very likely (5). These scales demonstrated reliability in the original Sampson study (.92 for the trust scale, and .87 for the social control scale). In the present study, reliability was $\alpha = .82$ and $\alpha = .74$ on the trust and social control scales, respectively. Trust, Social Control and Victimization were dichotomized at 3.00, 2.75 and 1.00 respectively. Based on these cut-points, 15.8%, 12.6% and 28.5% of families lived in neighborhoods characterized by lower trust, lower social control and higher victimization.

**Observed Neighborhood Quality.** Observed neighborhood quality was measured using a modified seven-item version of the Block Environment Inventory (McGuire, 1997). Five items examining the general condition of the residences and buildings on the street, the presence of safety precautions on building fronts, the volume of street traffic, the presence of litter or trash, and the number of teenagers / adults loitering in the street were rated by trained interviewers during home visits. Responses were coded on a four-point scale where higher ratings indicated poorer quality and more neighborhood disorder. Two items assessing how safe the neighborhood would feel to an individual during the daytime and at night time and were also rated by interviewers on a six-
point scale, with higher ratings being indicative of more fear for one’s personal safety. For nineteen percent of families (N = 128), two interviewers independently completed the seven neighborhood items. Rater agreement for individual items ranged from $\alpha = .91$ to 1.0 and rater agreement across the entire scale was $\alpha = .96$. The mean of all seven items was taken to generate the neighborhood quality score ($\alpha = .82$). The scale was dichotomized, whereby families who had scores of 2.30 or higher were viewed as living in low quality neighborhoods (18.8% of families lived in low quality neighborhoods).

**Census Neighborhood Characteristics.** Additional neighborhood characteristics were identified based on the Canadian national census. Families were matched to their census tract (i.e. geographic neighborhood) using their postal code. Several variables were available, all of which reflected a percentage of the entire census tract. Below, the variables are listed (with dichotomization points in parentheses). Families above the dichotomization point were assigned the risk factor: percent of families in census tract that were lone parents (28.2), were below the poverty line (32.60), and were receiving income supplements or government transfers (17.90), percent of adults that were unemployed (10.10) and the percent of individuals in the neighborhood over 25 years of age without a high school diploma.
Based on these cut-points, between 14.8% and 15.2% of families were characterized by these risk factors.

References for Appendix 1


Appendix 2: Measurement Appendix for Study 2

Measurement for Cumulative Risk Index

A trained interviewer conducted initial home visits when children were 2 months old. Information on risk factors was collected via maternal self-report, interviewer observation and by matching families to the national census. For the cumulative risk index measured risk factors were either naturally categorical, dichotomized based upon informative cut-points, or continuous. For continuous variables, a cut-point was identified as close as possible to the most extreme 15% of the distribution towards the risky or adverse pole. This would correspond to +1 standard deviation above or below the mean, based on the normal distribution (i.e. the greatest risk or adversity, based on the metric in question). Of course, the categorization is going to vary as a function of the distribution. Each risk factor is described below:

**Maternal History of Violence.** Maternal history of violence was assessed using an adapted adult-version of the Childhood Experience of Violence Questionnaire (Walsh, MacMillan, Trocmé, Jamieson, & Boyle, 2008). Mother’s rated direct experience of physical and sexual violence. Severity items (e.g. “How many times before the age of 16 did an adult caregiver slap you...”) were scored on a scale of “never” to “more than 10 times.” As scales were highly skewed with most mothers reporting no experiences, we recoded the scales to be dichotomous reflecting “none” or “any” exposure. These scales were collapsed, and 73 of the 385 participating mothers (19%) reported experiencing any violence.

**Teenage Parenthood.** Mother reported age of first pregnancy < 20 years old. Twenty (5%) of mothers had their first pregnancy as teenagers.
Single Parent Status. Mothers reported whether or not they had a partner at the time of initial assessment. Twenty-three (6%) of mothers were single.

Maternal Depression. Maternal depression was evaluated using the Center for Epidemiological Studies Depression Scale (CES-D), a widely used self-report scale that assesses depression in nonclinical populations (Radloff, 1977). Mothers rated the frequency of 20 depressive symptoms over the past week using a 4-point scale, where higher scores represent higher depression levels. Internal consistency from the original study was $\alpha = .85$ for the general population and $\alpha = .90$ for a sample of patients suffering from depression. In the present sample (for mothers) it was $\alpha = .84$. Items were summed and a standardized cutoff of 16 or higher was used to index persons who would likely meet criteria for clinical depression. Fifty-four (14%) of mothers were depressed.

Marital Conflict. Marital conflict was evaluated using the child involvement subscale of the Conflicts and Problem Solving Scales (Kerig, 1996). This scale assesses the extent to which children are present or involved in marital conflict using frequency-based items such as “argue in front of the children”. The Child Involvement scale was based on 4 items rated on a 4-point scale from ‘Never’ (1) to ‘Often’ (4). For each scale, the mean of the items was calculated, with higher scores indicating more symptomatology. The internal consistency was $\alpha = .68$. Items were averaged and a score of 1.76 or higher was used to index the presence of substantial marital conflict around children (24.4% of families were said to have high conflict in front of children).

Income less than CAD$20,000. To assess household finances, mothers were asked, “What is your total personal income from all sources?” Mothers responded based on 16 ordered categories ranging from 1 (no income) to 16 ($105,000 Canadian) or more. A cut-off of less than
$20,000 Canadian was used to index low-income. In the current study, 31 (8%) of families were making less than $20,000 at the initial wave of measurement.

**No maternal post-secondary education.** Maternal education was assessed by asking the number of years of formal education they have received excluding kindergarten. A natural cut-point was observed in the distribution and selected as a dichotomization target. Mothers and fathers who had less than 13 years of education (i.e. 0 to 12 years) were categorized in the risk category, as this cut-point is reflective of the absence of post-secondary education, assuming 12 years of compulsory schooling (i.e. high-school diploma, or less). Based on this, 54 (14%) of mothers did not have any post-secondary education.

**Observed Neighborhood Quality.** Observed neighborhood quality was measured using a modified seven-item version of the Block Environment Inventory (McGuire, 1997). Five items examining the general condition of the residences and buildings on the street, the presence of safety precautions on building fronts, the volume of street traffic, the presence of litter or trash, and the number of teenagers / adults loitering in the street were rated by trained interviewers during home visits. Responses were coded on a four-point scale where higher ratings indicated poorer quality and more neighborhood disorder. Two items assessing how safe the neighborhood would feel to an individual during the daytime and at night time and were also rated by interviewers on a six-point scale, with higher ratings being indicative of more fear for one’s personal safety. For nineteen percent of families (N = 128), two interviewers independently completed the seven neighborhood items. Rater agreement for individual items ranged from $\alpha = .91$ to 1.0 and rater agreement across the entire scale was $\alpha = .96$. The mean of all seven items was taken to generate the neighborhood quality score ($\alpha = .82$). The scale was dichotomized,
whereby families who had scores of 2.30 or higher were viewed as living in low quality neighborhoods. Subsequently, 16% of families lived in lower quality neighborhoods.

**Census Neighborhood Characteristics.** Additional neighborhood characteristics were identified based on the Canadian national census. Families were matched to their census tract (i.e. geographic neighborhood) using their postal code. The following cut points (percentages) were identified, and families above the dichotomization point were assigned the risk factor: percent of families in census tract that were lone parents (28.2), percent below the poverty line (32.60). Based on these cut-points, 55 (14%) and 54 (14%) of participant families were said to be living in neighborhoods characterized by these risk factors, respectively.

**Items for Cognitive Sensitivity Coding Scheme from Prime et al., (2014; 2015)**

The following items were rated on a 5 point Likert scale ranging from 1 (not at all true) to 5 (very true)

**Communicative clarity**

1. This person gives clear and specific verbal directions
2. This person gives positive nonverbal directions
3. This person reminds her partner about goals/rules of the task
4. This person is clear in her requests for help
5. If given a task, this person will try to complete it
6. If given a task, this person will try her best to follow the rules

**Mutuality building**

7. This person gives positive feedback to reinforce her partner
8. This person reminds her partner when it’s his/her turn
Mind-reading

9. This person is good at rephrasing what her partner does not understand

10. This person is sensitive to what her partner knows and/or understands

11. This person is responsive to her partner’s request for help, even those that are subtle and/or nonverbal

References for Appendix 2


Appendix 3: Statistical Appendix for Study 2

Social Relations Model Specification and Estimation Procedures

Section 1 presents the simplest version of the social relations model where we do not distinguish between mothers, older-siblings and younger-siblings. Section 2 extends this to the Models A and B applied in the paper where we do distinguish these roles. Section 3 details how we implement these models using the runmlwin command (Leckie and Charlton, 2013) to call the MLwiN multilevel modelling software (Rasbash et al., 2009) from within Stata.

Social relations model with indistinguishable members

Let \( y_{ijk} \) denote the sensitivity that individual \( i \) (\( i = 1, \ldots, n_k \)) shows individual \( j \) (\( j = 1, \ldots, n_i \)) in family \( k \) (\( k = 1, \ldots, K \)). The multilevel formulation of the social relations model for this response can be written as:

\[
y_{ijk} = \beta_0 + f_k + a_{ik} + p_{jk} + e_{ijk},
\]

where, for ease of exposition, the fixed-part of the model contains only an intercept \( \beta_0 \) measuring the population-average sensitivity shown from one individual to another. The random-part of the model consists of: \( f_k \) measuring the average sensitivity shown in family \( k \), over and above the population-average value; \( a_{ik} \) measuring the average sensitivity shown by individual \( i \) in that family, over and above the average shown by all family members; \( p_{jk} \) measuring the average sensitivity received by individual \( j \), over and above the average received by all family members; and \( e_{ijk} \) measuring residual sensitivity. The latter is typically interpreted as the unique relationship effect between individual \( i \) and \( j \), unexplained by the individuals’ family, actor and partner effects. We note that it will also capture any error in measuring sensitivity, but we shall
not discuss this further. The $f_k$, $a_{ik}$, $p_{jk}$ and $e_{ijk}$ are modelled as random effects with the following distributional assumptions:

$$f_k \sim N(0, \sigma_f^2),$$

$$\begin{pmatrix} a_{ik} \\ p_{lk} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_a^2 & \sigma_{ap} \\ \sigma_{pa} & \sigma_p^2 \end{pmatrix}\right),$$

$$\begin{pmatrix} e_{ijk} \\ e_{ijl} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_e^2 \\ \sigma_{ee} \end{pmatrix}\right),$$

where $\sigma_f^2$ denotes the between-family variance summarizing the degree to which families vary in their average sensitivity, $\sigma_a^2$ and $\sigma_p^2$ denote the within-family-between-individual actor and partner variances (with associated covariance $\sigma_{ap}$) summarizing the degree to which individuals in general vary within their families in the sensitivity they give and receive, and $\sigma_e^2$ denotes the relationship variance (with associated covariance $\sigma_{ee}$).

The actor-partner and relationship covariances are typically re-expressed as correlations $\rho_{ap}$ and $\rho_{ee}$ quantifying the degree of generalized and dyadic reciprocity respectively:

$$\rho_{ap} = \frac{\sigma_{ap}}{\sigma_a \sigma_p},$$

$$\rho_{ee} = \frac{\sigma_{ee}}{\sigma_e^2}.$$

The former measures the degree to which individuals who in general show high sensitivity to other family members in general receive high sensitivity back. The latter measures the degree to which sensitivity shown in specific dyadic relationships is reciprocated.
The variance components of the SRM are often re-expressed in relative terms (i.e., as variance partition coefficients) by dividing each component by the total, \( \sigma_f^2 + \sigma_a^2 + \sigma_b^2 + \sigma_e^2 \).

Social relations model with roles

The models presented in the paper extend that described above to distinguish family members by the different roles they play, in our case mothers \((i = 1)\), older siblings \((i = 2)\), and younger siblings \((i = 3)\). Model 1 can be written as:

\[
y_{ijk} = \beta_1 x_{1ijk} + \beta_2 x_{2ijk} + \beta_3 x_{3ijk} + \beta_4 x_{4ijk} + \beta_5 x_{5ijk} + \beta_6 x_{6ijk} + f_k + x_7 a_{1k} + x_8 a_{2k} + x_9 a_{3k} + x_{10} p_1 k + x_{11} p_2 k + x_{12} p_3 k \\
x_{1ijk} e_{1,2k} + x_{2ijk} e_{1,3k} + x_{3ijk} e_{2,1k} + x_{4ijk} e_{2,3k} + x_{5ijk} e_{3,1k} + x_{6ijk} e_{3,2k},
\]

where the covariates are defined as follows:

- \( x_{1ijk} \): dummy variable for mother-older relationship
- \( x_{2ijk} \): dummy variable for mother-younger relationship
- \( x_{3ijk} \): dummy variable for older-mother relationship
- \( x_{4ijk} \): dummy variable for older-younger relationship
- \( x_{5ijk} \): dummy variable for younger-mother relationship
- \( x_{6ijk} \): dummy variable for younger-older relationship
- \( x_{7lk} \): dummy variable for actor being mother
- \( x_{8lk} \): dummy variable for actor being older sibling
- \( x_{9lk} \): dummy variable for actor being younger sibling
- \( x_{10jk} \): dummy variable for partner being mother
• $x_{11ijk}$: dummy variable for partner being older sibling
• $x_{12ijk}$: dummy variable for partner being younger sibling

The model now has six intercepts $\beta_1, \beta_2, \ldots, \beta_6$ measuring the population-average sensitivity shown for each relationship type. The family random effect $f_k$ is defined and interpreted as before. The actor random effects $a_{1k}, a_{2k}, a_{3k}$ and partner random effects $p_{1k}, p_{2k}, p_{3k}$ are now distinguished by role, while the relationship random effects are distinguished by relationship $e_{1,2k}, \ldots, e_{3,2k}$. The resulting expanded set of distributional assumptions can be written as:

$$f_k \sim N\left(0, \sigma_f^2\right),$$

$$\begin{pmatrix} a_{1k} \\ a_{2k} \\ a_{3k} \\ p_{1k} \\ p_{2k} \\ p_{3k} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{a1}^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & \sigma_{a2}^2 & 0 & 0 & 0 & 0 \\ 0 & 0 & \sigma_{a3}^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma_{p1}^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & \sigma_{p2}^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & \sigma_{p3}^2 \end{pmatrix}\right),$$

$$\begin{pmatrix} e_{1,2k} \\ e_{1,3k} \\ e_{2,1k} \\ e_{2,3k} \\ e_{3,1k} \\ e_{3,2k} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{e12}^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & \sigma_{e13}^2 & 0 & 0 & 0 & 0 \\ 0 & 0 & \sigma_{e21}^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma_{e23}^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & \sigma_{e31}^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & \sigma_{e32}^2 \end{pmatrix}\right),$$

where, as before, $\sigma_f^2$ denotes the between-family variance, but we now have role-specific actor and partner variances $\sigma_{a1}^2, \sigma_{a2}^2, \sigma_{a3}^2$ and $\sigma_{p1}^2, \sigma_{p2}^2, \sigma_{p3}^2$ together with associated covariances.
\( \sigma_{a1p1}, \sigma_{a2p2}, \sigma_{a3p3} \), similarly we now have relationship-specific variances \( \sigma^2_{e12}, \ldots, \sigma^2_{e32} \) with their associated covariances \( \sigma_{e12e21}, \sigma_{e13e31}, \sigma_{e23e32} \).

As before, the actor-partner and relationship covariances can be re-expressed as correlations in the usual way to quantify the degree of generalized reciprocity and dyadic reciprocity, respectively, but these correlations are now calculated by role and relationship type, respectively.

The variance components can again be expressed in relative terms (variance partition coefficients), but now this is done by role and relationship type and so requires averaging the variance components at every other level of analysis which are associated with that role. For example, the relative importance of mothers as actors in determining the sensitivity they show their children would be calculated as:

\[
\frac{\sigma^2_{a1}}{\sigma_f^2 + \sigma^2_{a1} + \frac{1}{2}(\sigma^2_{p2} + \sigma^2_{p3}) + \frac{1}{2}(\sigma^2_{e12} + \sigma^2_{e13})}
\]

Importantly, the model as it is currently stated is not identified (SRMs with roles are only identified when \( n_k \geq 4 \), or four or more persons in a family). Kenny, Kashy and Cook, (2006, p.245) describe different sets of parameter constraints which can be applied to the current model so that all remaining parameters are identified. In Model 1 we choose to constrain the partner variances (and therefore their associated actor-partner covariances) as follows:

\[
\sigma^2_{p1} = \sigma^2_{p2} = \sigma^2_{p3} = \sigma_{a1p1} = \sigma_{a2p2} = \sigma_{a3p3} = 0.
\]

Model B simply augments the fixed part of the above model with six interaction terms between the set of relationship dummy variables and the family-level cumulative risk variable.
Further covariates measured at the family-, individual-, dyadic-, or unique relationship-levels can be added to the model and interpreted in the usual way.

**Software implementation**

We fit both models using the MLwiN software (Rasbash et al., 2009). We call MLwiN from within Stata using the runmlwin command (Leckie and Charlton, 2013). Full documentation can be found within the runmlwin article, website (http://www.bristol.ac.uk/cmm/software/runmlwin/) and help file and so we only focus on those details salient to Model A and Model B below.

For both models, we must first use the `matrix` command to define a $6 \times 6$ binary indicator matrix $A$ corresponding to whether the elements of the relationship covariance matrix presented in Section 2 are freely estimated (1) or constrained to zero (0).

```
. matrix A = (1,0,1,1,0,0,1,0,0,1,0,1,0,0,1,0,0,0,1,0,1,0)
```

Next we fit Model 1 using the `runmlwin` command:

```
. runmlwin y x1 x2 x3 x4 x5 x6, ///
   level4(family: cons) ///
   level3(family: x7 x8 x9, diagonal) ///
   level2(family: x1 x2 x3 x4 x5 x6, elements(A)) ///
   level1(relationship:) ///
   nopause
```

where we have used Stata’s line continuation symbol `///` to spread the command over six lines. Line 1 specifies the response $y$ and the covariates appearing in the fixed part of the model,
namely the six relationship dummy variables $x_1 - x_6$. Lines 2-5 specify the random part of the model: the random effects and any constraints on their respective covariance matrices. All random effects are entered at the family level. Line 2 specifies the family random effect, line 3 specifies the three actor random effects and that only the diagonal elements of their covariance matrix should be estimated, while line 4 specifies the relationship effects and their patterned covariance matrix, as previously specified in matrix $A$. Line 5 included no random effects but is required to trick MLwiN into working; the lowest level in the model must be the observations themselves, here the relationships in each family. Finally, the `nopause` option in line 6 ensures the MLwiN output is passed seamlessly back to Stata, as opposed to the default of MLwiN pausing once when the model has been specified, and a second time once it has been fitted.

To fit Model B, we simply augment line 1 with six interaction terms between the set of relationship dummy variables and the family-level cumulative risk variable.

**References for Appendix 3**


Appendix 4: Statistical Appendix for Study 3

Supplementary Model Description

Multilevel path analysis will be employed in order to estimate the hypothesized model linking socioeconomic status, birth weight and maternal sensitivity across hierarchical level of family organization. Data take a two-level structure, whereby siblings (Level 1) are nested in families (Level 2). First, a null model will be estimated, fitting only Level 1 and 2 intercepts for birth weight and maternal sensitivity for the purposes of variance partitioning. From this model, variance partitioning coefficients will be computed that reflects the proportion of between-family variance, $\sigma^2_{\mu_i}$, to total variance (between-family variance plus within-family variance, $\sigma^2_{\mu_i} + \sigma^2_{e_0}$). Stated differently, this conveys the amount of family clustering in outcome variables. Next, a multilevel structural path model is estimated in order to identify the hypothesized associations amongst response variables. A series of linear equations were simultaneously fit to estimate the hypothesized associations.

At Level 2, birth weight is estimated as:

$$\overline{BW_j} = \beta_0 + \beta_1(SES_j) + \mu_{0j}$$

Here, family average birth weight, $\overline{BW_j}$, is taken as the grand mean birth weight, $\beta_0$, plus the effect of family SES on family average birth weight, $\beta_1$, plus a family residual, $u_{0j}$, that is zero centered, normally distributed and takes on the variance, $\sigma^2_{0\mu}$. Accordingly, variability in family birth weight (estimated in standard deviation units for interpretability) is taken as follows:

$$\sqrt{\sigma^2_{0\mu_{ij}}} = \sigma_{0\mu_{ij}} = \beta_3 + \beta_4(SES_j) + \mu_{3j}$$
The family standard deviation in birth weight, $\sigma_{0\mu_j}$, is taken as the grand mean standard deviation in family birth weight, $\beta_3$, plus the effect of family SES on the family standard deviation in birth weight, $\beta_4$, plus a family residual which is zero centered, normally distributed, with constant variance. The parameter $\beta_4$ is of particular interest, where the hypothesized negative value would indicate that families of lower SES have siblings with greater variability in birth weight.

Maternal sensitivity is also estimated at Level 2. In this prediction, birth weight is now treated as an independent variable. Maternal sensitivity is estimated as:

$$
\overline{MS}_j = \beta_5 + \beta_6(SES_j) + \beta_7(\overline{BW}_j) + \beta_8(\sigma_{0\mu_j}) + \mu_{5j}
$$

Here, family average maternal sensitivity, $\overline{MS}_j$, is taken as the grand mean maternal sensitivity, $\beta_5$, plus the effect of family SES on family average maternal sensitivity, $\beta_6$, plus the effect of family average birth weight on family average maternal sensitivity, $\beta_7$, plus the effect of the family standard deviation in birth weight, $\beta_8$, plus a family residual, $u_{5j}$, that is zero centered, normally distributed and takes on the variance, $\sigma^2_{5\mu}$. Accordingly, variability in maternal sensitivity (also estimated in standard deviation units) is taken as follows:

$$
\sigma_{5\mu_j} = \beta_9 + \beta_{10}(SES_j) + \beta_{11}(\overline{BW}_j) + \beta_{12}(\sigma_{0\mu_j}) + \mu_{9j}
$$

The family standard deviation in maternal sensitivity, $\sigma_{5\mu_j}$, is equal to the grand mean standard deviation in maternal sensitivity, $\beta_9$, plus the effect of family SES, $\beta_{10}$, plus the effect of family average birth weight, $\beta_{11}$, plus the effect of the family standard deviation in birth weight, $\beta_{12}$, plus a family residual $\mu_{9j}$, which is zero centered, normally distributed, with constant variance. Of note, the parameter $\beta_{10}$ is of particular interest, as the hypothesized positive value
would indicate that greater variability in child birth weight is associated with greater variability in parenting at the between-family level. All of the implied indirect pathways at Level 2 will be tested for statistical significance using the Delta method. For example, the indirect effect of SES on family average maternal sensitivity via family average birth weight, where $\beta_1$ from above is the $\alpha$ path and $\beta_7$ from above is the $\beta$ path, is taken as:

$$Z = \frac{\alpha \beta}{\sqrt{\beta^2 \cdot s_{\beta}^2 + \alpha^2 \cdot s_{\alpha}^2}}$$

The resultant statistic is compared to a standard normal ($Z$) distribution for the purpose of testing the null hypothesis that $\alpha \beta$ is equal to zero.

At Level 1, a sibling fixed effects model (or within-family sibling comparison model) was employed in order to examine the association between sibling-specific birth weight and sibling-specific maternal sensitivity. This model is a more robust test of this association, as it is free of possible between-family confounders such as shared maternal or contextual factors. Such models have been effectively employed to examine the child-specific effects of non-shared environmental exposures and in the study of child-specific birth weight on parental investment. Child specific maternal sensitivity is estimated as:

$$MS_{ij} - \overline{MS}_j = \beta_{11}(BW_{ij} - \overline{BW}_j) + \gamma_1X_{ij} + e_{ij}$$

Here, the child-specific deviation from the family-average maternal sensitivity, $MS_{ij} - \overline{MS}_j$, is a function of the effect of child-specific deviation from the family-average birth weight, $\beta_{11}$, controlling for a vector of child-specific covariates, $\gamma_1$, which include gender, birth order, and preterm status, and a child specific error term, $e_{ij}$, that is zero centered and normally distributed with constant variance.