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# INFANT COGNITIVE DEVELOPMENT: THE INFLUENCE OF MATERNAL SENSITIVITY AND PRIOR COGNITIVE CAPACITY

by

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University of Western Ontario, 2008

A Thesis

presented to Ryerson University

in partial fulfillment of the

requirements for the degree of

Master of Arts

in the Program of

Psychology

Toronto, Ontario, Canada, 2010

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Infant cognitive development: The influence of maternal sensitivity and prior cognitive capacity

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Master of Arts

Psychology

Ryerson University

2010

#### Abstract

Researchers have found that maternal sensitivity predicts cognitive development above and beyond prior cognitive capacity; however, cognition and sensitivity scores in previous studies were amalgamated. The principal aim of this thesis was to evaluate the changing influence of maternal sensitivity and prior capacity over several points in infancy. Maternal sensitivity was assessed in the home at 6 and 18 months, and infant cognitive development at 6, 12, 18 and 36 months. Through a series of multiple regressions and change score analyses, results indicated that maternal sensitivity is a better predictor of cognitive development than prior capacity of the infant in early infancy; however, as the infant ages, the relative influence of predictors changes. That is, at 18-36 months, prior capacity appears a better predictor. Thus, findings indicate maternal sensitivity is most influential in early infancy, whereas prior capacity of the infant is more influential in later infancy.

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To my family, for being my secure base.

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#### CHAPTER I

#### Introduction

#### Stability of Cognitive Development

Infant cognition refers to how an infant perceives, thinks, and gains understanding of the world (Bayley, 1993). Neurological development is rapid in the first two years of life, which is manifest as qualitative behavioural changes. For instance, an infant initially engages in simple reflexes (e.g., rooting, sucking) but moves to complex exploration and manipulation of objects as he/she matures. Bayley (1933) argued that tests of infant development before 2 years of age measure simple cognitive functioning, and only when the child becomes older does cognitive ability constitute "intelligence". Similarly, researchers argued that the transition from infancy to childhood involves a qualitative change from sensorimotor intelligence to symbolic intelligence (e.g., Belsky and Nezworski, 1988). Several investigators argued that infant measures should not be expected to predict later outcome on principle, since early and later stages of cognitive functioning are fundamentally different in nature (Bayley, 1970; Belsky & Nezworski, 1988; Colombo, 1993). Other researchers have echoed this perspective, suggesting that the first few years of life involve periods of cognitive instability due to reorganizations of cognitive function, which only settle into stable and mature forms of intelligence after this erratic period (McCall, 1979).

Piaget (1970) argued that a child's intellect develops through a series of stages, beginning with the sensorimotor stage in infancy (e.g., generalized action patterns to understand the world), moving all the way to the formal-operational stage in adulthood (e.g., scientific thinking, logical reasoning). The sensorimotor stage itself consists of 6 stages, which take place from birth to 24 months. For instance, the infant moves from engaging in basic reflexes, to primary and secondary

circular reactions (e.g., intentionally repeating actions, and doing so to trigger a response), coordination of reactions (e.g., clear intentional actions), tertiary circular reactions (e.g., trial-and-error experimentation), all the way to early representation of thought (e.g. development of symbols to represent objects or events). The infant develops rapidly through these stages, with each stage lasting for a few months. Given that infant stages of development are quite different, and movement from stage to stage occurs rapidly, stability of cognition in infancy is expected to be low.

Apparently consistent with this theorizing, several studies have demonstrated only modest cognitive stability within infancy. McCall (1979) reviewed 19 studies published between 1933 and 1975 in order to examine the stability of test scores across infancy. Tests used to assess cognitive capacity were the Gesell Developmental Schedules (Gesell, 1925), Bayley Scales of Infant Development (Bayley, 1969), Cattell Infant Intelligence Scale (Cattell, 1960), and Griffiths Mental Development Scales (Griffiths, 1984). Table 1 shows stability of cognitive capacity throughout infancy, as summarized by McCall (1979). Every cell includes a decimal number that represents a median correlation. Each median correlation was calculated from a set of correlations, originating from the studies he reviewed. Correlations along the diagonal, which represents the correlations with the shortest time spans between assessments, are the highest. Correlations decline farther away from the diagonal. This table suggests that longer time span is associated with lower correlations between test scores. I rank ordered the correlations in Table 1 and compared this rank order to time span separating assessments using Spearman's rho; rho = .89, p = .001. That is, the shorter the time-span between assessments, the larger the correlation. This finding is consistent with theorizing that qualitative changes in functioning attenuate stability of cognitive development scores.

Table 1

Median Correlations of Cognitive Capacity in Infancy, as reviewed in McCall (1979)

	1-3 months	4-6 months	7-12 months	13-18 months
4-6 months	.52			
7-12	.29	.40		
months 13-18	.08	.39	.46	
months 19-24	04	.32	.31	.47
months				

Note. Months refer to infant age at testing. Data was taken from Anderson (1939); Bayley (1933); Bayley (1954); Birns and Golden (1972); Cattell (1940); Cavanaugh, Cohen, Dunphy, Ringwell, and Goldberg (1957); Elardo et al. (1975); Escalona and Moriarty (1961); Fillmore (1936); Goffeney, Henderson, and Butler (1971); Hindley (1965); Honzik, Macfarlane, and Allen (1948); Ireton, Thwing, and Gravem, (1970); Kangas, Butler, and Goffeney (1966); Klackenberg-Larsson and Stensson (1968); McCall (1972); Moore (1967); Nelson and Richards (1939); Werner (1968), as reviewed by McCall, 1979.

Given that cognitive intercorrelations across the first 2 years of life are only modest, we would expect predictions of cognitive development from infancy to childhood to be modest at best. Indeed, several studies have strengthened the position of what has been termed "cognitive instability," showing that infant performance on cognitive tests, particularly within the fist year of life, is irrelevant to later intellectual functioning in childhood (see Table 2; McCall, 1979). Table 2 shows the median correlations, which were derived from several studies reviewed by McCall (1979), between infant cognitive functioning tests (up to 30 months) and IQ tests in childhood (3 to 18 years). McCall (1979) argued that tests given later in infancy are most predictive of IQ in childhood. He also noted another trend, although weak, suggesting that prediction is better when childhood IQ is assessed at a younger age. Indeed, McCall's (1979) argument is correct; to assess

his hypothesis, I rank ordered the correlations from Table 2 and compared them to time between assessments, rho = .87, p = .002. The shorter the time between assessments, the stronger the correlation between cognitive development scores.

Table 2

Median Correlations of Cognitive Capacity from infancy to Childhood, as reviewed in McCall

(1979)

	1-6 months	7-12 months	13-18 months
3-4 years	.21	.32	.50
5-7 years	.09	.20	.34
8-18 years	.06	.25	.32

Note. Months and years refer to infant age at testing. Data was taken from Anderson (1939); Bayley (1933); Bayley (1954); Birns and Golden (1972); Cattell (1940); Cavanaugh et al. (1957); Elardo et al. (1975); Escalona and Moriarty (1961); Fillmore (1936); Geoffeney et al. (1971); Hindley (1965); Honzik et al. (1948); Ireton et al. (1970); Kangas et al. (1966); Klackenberg-Larsson and Stensson (1968); McCall (1972); Moore (1967); Nelson and Richards (1939); Werner (1968), as reviewed by McCall, 1979.

While the literature on cognitive development in infancy is almost entirely consistent in showing modest stability, a recent study by Blaga et al. (2009) demonstrated strong stability of cognitive development through infancy. For instance, cognitive capacity scores from 12 to 18 months correlated at r = .91, and cognitive capacity scores from 18 to 24 months correlated at r = .94. Blaga et al. (2009) argued that because this study incorporated an extensive database (i.e. sample of 226 participants) and a more rigorous and comprehensive examination of intellectual development (i.e. assessments of the Bayley Scales of Infant Development, the MacArthur-Bates Communicative Development Inventory, amongst others), cognitive stability findings were

stronger than in previous research. Sample size, although it would contribute to reliability of findings, would not likely affect the magnitude of correlations. The inclusion of multiple cognitive assessments could have improved stability, given that the latent construct form may be better correlated with the "true" score of infant cognition than a single assessment; however, this does not appear reason enough for such a drastic improvement in predictive strength demonstrated in this study, especially since each individual test is highly reliable. These findings are greatly unusual in the infant literature and the stability figures exceed what has been found in childhood, and, in some instances, even adulthood (Matarazzo, Carmody, & Jacobs, 1980). In addition, these findings are not consistent with the theoretical basis of cognitive development in infancy that specifies a lack of early cognitive continuity due to rapid qualitative changes within the first few years of life (Colombo, 1993, Piaget 1970). Therefore, the Blaga et al. (2009) findings may be an overestimate of cognitive continuity in infancy. The overall consensus within the literature, although variable in some instances (i.e. Blaga et al. 2009), is that cognitive stability in infancy is modest. In addition, relatively stronger predictions occur later in infancy, and when predictions occur more closely in time (McCall, 1979).

Modest stability findings in infancy starkly contrast with strong stability findings in childhood. Two longitudinal studies are presented below: the Fels study (Sontag & Baker, 1958) is presented in Table 3, the Berkeley Growth study (Bayley, 1949) in Table 4. In each study, cognitive capacity was assessed using the Stanford-Binet IQ test between 9 and 12 years of age (McCall, 1979). In comparing these studies to the infant stability studies, infant tests given a few months apart between 1 and 2 years range from zero to .47, whereas correlations in childhood range from .81-.93. These findings in childhood have been replicated with other cognitive tests. For instance, Kaufman (1992) found strong stability of IQ in gifted children using the WISC-III,

with predictive correlations ranging from .87-.94. Thus, age-to-age predictions of cognitive development in infancy are markedly lower than predictions in later childhood. McCall (1979) argued that the lack of stability within infancy is not likely due to issues of measurement. McCall (1979) stated that the term development implies change, and since infant cognitive development involves rapid neurological change, predicting from one time point to another is justifiably modest.

Table 3

Cognitive Predictions in Childhood, from Sontag and Baker (1958)

	9 years	10 years	11 years
10 years	.90		
11 years	.82	.90	
12 years	.81	.88	.90

*Note.* Years refer to child age at testing.

Table 4

Cognitive Predictions in Childhood, from Bayley (1949)

	9 years	10 years	11 years
10 years	.88		
11 years	.90	.92	
12 years	.82	.90	.93

Note. Years refer to child age at testing.

#### The Information Processing Theory of Cognitive Development

The view of cognitive discontinuity was challenged in the 1980s and 1990s, with an information processing approach to predicting intellectual development. The information processing orientation to cognitive development has largely focused on measures of attention as indexes of mental ability in infancy (Bornstein & Sigman, 1986). For instance, 'decrement of attention' (i.e. how an infant removes focus from an aspect of the environment that is unchanging) and 'recovery of attention' (i.e. how an infant attends to part of the environment that is novel) promotes cognitive development. Information processing abilities are presumed to be fundamental in forming the basis for intellectual development. Several studies, as reviewed by Bornstein and Sigman (1986), revealed that information-processing abilities in the first 3 to 6 months of age moderately to strongly predict childhood intelligence (ages 2-8 years), with most correlations falling within the .40-.60 range. (i.e. Bornstein 1984; Lewis & Brooks-Gunn, 1981; Sigman, Cohen, Beckwith, & Parmelee, 1986; Slater, Cooper, Rose, & Perry, 1985).

In more recent years, Rose, Feldman, Jankowski, and Van Rossem (2005) proposed the *cognitive cascade model*. The cognitive cascade model predicts that basic abilities underpin more complex ones in infancy, which in turn influence general intelligence in preschool. Rose, Feldman, Jankowski, and Van Rossem (2008) assessed information processing of infants in the second half of the first year. In support of the cognitive cascade model, Rose et al. (2008) found that representational competence (ability to create mental image of unseen object and use it flexibly) at 7 months predicted representational competence at 12 months (r = .27), which then predicted intelligence at preschool (2 and 3 years of age, r = .36). In addition, recognition memory at 7 months and representational competence at 7 months each predicted intelligence in preschool, with correlations of r = .48 and r = .16, respectively. In partial confirmation of the

cognitive cascade, recognition memory (an early form of explicit memory) at 7 months predicted recognition memory at 12 months (r = .59), although recognition memory at 12 months did not predict intelligence at preschool (2 and 3 years of age). Thus, Rose et al. (2008) validated the cognitive cascade model. In conclusion, an information processing orientation to cognitive development is useful because basic processing abilities in infancy are predictive of later cognitive functioning. However, the issue remains that these predictions, although significant, do not explain all the variance. Therefore, it is necessary to assess other domains potentially related to infant cognitive development.

Maternal Sensitivity, Vygotskian Theory, and Cognitive Development

Bayley (1933) proposed that environmental factors influence early capacity since the brain is not yet fully developed and is malleable to environmental influences. Specifically, she proposed that parenting behavior might be highly influential to the cognitive development of a young child. Consistent with this argument, neural plasticity, or the impact of the environment on brain structure, is likely to occur in a younger infant since the brain is more flexible at this stage of development (Cicchetti & Curtis, 2006). Researchers in the cognitive developmental sphere have begun to explore alternative environmental predictors that are not cognition-specific, namely, maternal sensitivity.

Maternal sensitivity refers to maternal responsivity that is timely, contingent, warm, predictable and appropriate (Ainsworth, Blehar, Waters, & Wall, 1978). A sensitive mother responds quickly and appropriately to infant signals of distress or bids for attention (Ainsworth et al., 1978). Consistently sensitive parenting fosters a sense of security in the child, allowing the child to confidently explore the social and objective world (Warren & Brady, 2007). Maternal sensitivity is related to secure attachment between the mother and infant (De Wolff & van

IJzendoorn, 1997), as well as the child's positive socioemotional development (Crockenberg, Leekers, & Lekka, 2007). Secure attachment has been associated with more active exploration (Hazen & Durrett, 1982), better negotiation of environment (Cassidy, 1986), and greater persistence in difficult tasks (Frodi, Bridges, & Grolnick, 1985). Insecure attachment has been related to poorer mastery motivation and less goal oriented play (Frodi et al., 1985).

From a Vygotskian framework, researchers interested in the socioemotional context of cognitive development have referred to the "zone of proximal development" in describing adult-child interactions that facilitate a child's advancement in some area of learning (Moss, 1992). In the context of cognitive growth, it is presumed that children progress through collaborative experience with a more skilled partner. Vygotsky argued that a knowledgeable partner and child engage in interactions through which the partner's understanding of a task, concept, or way of thinking is conveyed to the child through appropriate instruction (Mulvaney, McCartney, Bub, & Marshall, 2006). More specifically, the more skilled partner teaches the child within a particular "zone" that is not too far beyond the child's "zone of actual development" that he/she does not understand, and not too close so that the child is uninterested.

In this vein, it is one thing for a skilled partner to simply convey their understanding to a less knowledgeable party, and it is another to convey knowledge in a manner that is contingent on the child's inclination for receiving that information. It may require special attunement on the part of the skilled partner to perceive the most appropriate moment and manner of communicating new information to the child. A sensitive parent may be aware of her infant's current level of development; she may recognize the appropriate moment to direct her child to an advanced task, and how to do this in a way that is meaningful for the child. A sensitive mother may be sufficient at engaging with her infant in co-exploration while following her infant's lead in a timely manner,

and appropriately directing her infant's learning in a way that is not intrusive or overwhelming.

Through sensitive scaffolding, the mother, will appropriately direct the child around novel stimuli to maximize learning, which will in turn foster cognitive development.

Studies originating from attachment research have supported the influence of security of attachment, which is thought to result from maternal sensitivity (Ainsworth et al., 1978), on the child's cognitive development (Crandell & Hobson, 1999; Moss & St-Laurent, 2001; Moss, St-Laurent, & Parent, 1999; van IJzendoorn, Dijkstra, & Bus, 1995). In their meta-analysis, van IJzendoorn et al. (1995) determined a significant, although small, relation between secure attachment and cognitive and language development. Moss and collegues (1999, 2001) also found that secure attachment at preschool and school age is related to cognitive functioning, specifically academic achievement and math performance. In addition, Crandell and Hobson (1999) found that children with secure mothers had higher Iqs than children of insecure mothers. Results indicate that the quality of maternal interaction may influence cognitive development of the child. Indeed, more recently, maternal sensitivity has been linked to infant and preschooler cognitive performance (Feldman & Eidelman, 2009; Lemelin, Tarabulsy, & Provost, 2006; Tarabulsy, Provost, Bordeleau, Trudel-Fitzerald, Moran, & Pederson, 2009; Taylor, Anthony, Aghara, Smith, & Landry, 2008).

A series of studies have examined the issue of maternal sensitivity and infant cognitive development directly (Feldman & Eidelman, 2009; Lemelin et al. 2006; Tarabulsy et al., 2009; Taylor et al., 2008). Tarabulsy et al. (2009) studied 40 high-risk adolescent mothers and their infants. They assessed maternal sensitivity with the short Maternal Behavior Q-sort (short MBQS; Tarabulsy et al., 2009) when infants were 10 months old. They assessed Infant cognitive capacity using the Bayley Mental Development Index (MDI; Bayley 1969) at 10 and 15 months.

They combined the 10 and 15-month MDI scores to form an aggregate score. Results indicated that maternal sensitivity was related to infant cognitive capacity (r = .48, p < .01).

Feldman and Eidelman (2009) conducted a longitudinal investigation of cognitive development. They measured cognitive development at 6, 12 and 24 months using the Bayley Scales of Infant Development (BSID; Bayley 1969) and the Wechsler Preschool and Primary Scale of Intelligence (WPPSI; Wechsler, 1967) at 5 years. They measured parent-child interactions at previous time points (i.e. 3, 6, 12 and 24 months) with the Coding Interactive Behavior scheme (CIB; Feldman, 1998). A portion of the CIB was used to code for maternal sensitivity with items such as vocal clarity, positive affect, gaze and consistency of style. Regression models indicated that maternal sensitivity at a previous time-point accounted for unique variance, above and beyond concurrent sensitivity, when predicting cognitive development at 6, 12, and 24 months, and 5 years (although the degree of variance accounted for by sensitivity was not reported in this study).

Other researchers examined whether sensitivity predicts infant cognitive function above and beyond prior infant cognitive functioning (Lemelin et al., 2006; Taylor et al., 2008). Taylor et al. (2008) performed a multiple regression to predict child IQ at age 4. They operationalized maternal sensitivity as the average of three scores at 6, 12, and 24 months. Taylor et al. (2008) controlled for prior capacity of the child (average of Bayley scores at 6, 12 and 24 months) as well as socioeconomic status, maternal age, and whether the child was in a biological risk group. The total model accounted for 38% of variance. Both maternal sensitivity and infant intelligence were significant predictors, but the authors did not indicate how much variance each predictor accounted for. While this remains a powerful demonstration of the influence of maternal sensitivity on infant cognitive capacity, the fact that cognitive performance and maternal

sensitivity were each averaged over three time points occludes comprehension of the age-specific relations between these two constructs and the developmental implications of those age-specific relations. Specifically, since prior capacity was an amalgamated score of cognitive assessments occurring from 6 to 24 months, earlier cognitive assessments may have reduced predictive power of later assessments as we know stability of cognitive development strengthens as the infant ages (McCall 1979). In addition, an amalgamated sensitivity score may be problematic because maternal sensitivity may have a differential effect on cognition depending on age of the infant. Thus, we cannot know which prior cognitive capacity score or which maternal sensitivity score is truly being controlled in this study.

Lemelin et al. (2006) used maternal sensitivity (at infant age 15 and 18 months) to predict cognitive capacity in preschool (36 months). In this study, the authors controlled for prior infant cognitive capacity. The infant capacity score was determined using the Bayley MDI at 6 and 10 months (aggregated to form one score). Maternal sensitivity was assessed using the MBQS at 15 and 18 months (aggregated to form one score). Consistent with the cognitive literature, infant capacity accounted for a small amount of the variance (11%) in preschool capacity. Maternal sensitivity accounted for approximately 8% of the variance, above and beyond prior capacity. This study was instrumental in providing evidence that maternal sensitivity influences intelligence in preschool, beyond capacity in infancy. Again, however, maternal sensitivity and cognitive development were amalgamated scores, leaving uncertainty with respect to relations between infant age and the relative contributions of prior cognitive development and maternal sensitivity. Overall, investigators have shown that maternal sensitivity predicts cognitive development above and beyond prior capacity (Lemelin et al., 2006; Taylor et al., 2008); however, because sensitivity

and prior capacity were amalgamated scores, the relative influence of each predictor is not well understood.

#### The Present Study

Few studies to date have considered maternal sensitivity and prior capacity jointly as predictors of cognitive development (Lemelin et al., 2006; Taylor et al., 2008). No studies have investigated both predictors using a true longitudinal design incorporating multiple time points to assess the chronological influence of each predictor. Lemelin et al. (2006) and Taylor et al. (2008) amalgamated cognitive scores and sensitivity ratings. The amalgamation of cognitive scores and sensitivity ratings in these studies precludes the possibility of assessing the *changing* association between prior cognitive development, maternal sensitivity, and subsequent cognitive development over time. In addition, the amalgamation of cognitive scores and sensitivity ratings precludes our ability to differentiate the potentially changing association between maternal sensitivity and cognitive development. This is so because the relative association between sensitivity and cognitive development is likely dependent on the changing association between prior cognitive development and subsequent cognitive development.

In this thesis, I employ an expanded longitudinal design to offer a clearer indication of the relative influence of each predictor at multiple points in time. The present thesis is comprised of two studies. In Study 1, I examine a sample of infants assessed for cognitive capacity (at 6, 12, 18, and 36 months), and their mothers, for maternal sensitivity when their infants were 18 months. In Study 2, I examine a subsample of these dyads for whom I have cognitive data at the aforementioned time points, as well as maternal sensitivity data at both 6 and 18 months. In both studies, I investigate the relative influence of prior cognitive capacity and maternal sensitivity on

subsequent capacity. In addition, I have employed the use of cognitive change scores to determine whether sensitivity accounts for change in cognitive capacity.

#### **CHAPTER II**

#### Study 1

Predicting Cognitive Development with Maternal Sensitivity at 18 months

Study 1 is designed to examine prior capacity and maternal sensitivity jointly as predictors in a longitudinal investigation at multiple time points in infancy. An expanded longitudinal design will give a clear description of the relative influence of prior capacity and maternal sensitivity throughout infant development.

My hypotheses are as follows. First, maternal sensitivity is significantly related to cognitive development earlier in infancy. This is expected since researchers have shown sensitivity to predict cognitive development above and beyond prior capacity (e.g., Lemelin et al., 2006). Also, from the cognitive literature, earlier prior capacity is a weak predictor of subsequent capacity. It may also be the case that the influence wanes as the infant approaches 36 months of age. This is expected because predictions of cognitive capacity, using prior capacity, strengthen as the child approaches later infancy (i.e. after 2 years of age; see Table 1; McCall 1979). Second, maternal sensitivity will correlate with change between 6 and 36 month MDI. That is, the more sensitive a mother is to her infant, the greater the increase in cognitive capacity over time.

#### Method

#### **Participants**

Mothers were recruited from multiple hospitals in Montreal, Quebec, at 13-15 weeks gestation. Recruitment occurred between 2003-2007 and was part of a larger study called the Maternal Adversity, Vulnerability and Neurodevelopment (MAVAN) Project. The MAVAN Project was designed to study the impact of stress on infants prenatally and onwards.

The sample available at the time of writing consisted of the first 69 mother-infant dyads to complete the protocol. Of these, 45 mother-infant dyads had complete data at all time points. These dyads comprise the present sample. Dyads with complete data were compared to mothers with missing data in terms of cognitive capacity (at 6, 12, 18, and 36 months), maternal sensitivity, birth weight, and number of years the mother has been with her partner (i.e. husband or boyfriend). The sample with complete data did not differ from the sample with incomplete data in terms of 6, 12, and 18 month MDI, maternal sensitivity, birth weight, or number of years the mother and partner have been together. The samples did differ on 36 month MDI: the sample of 45 had a higher mean MDI score than the remaining 11 participants assessed (means = 97.18 and 85.45, respectively; t = 3.22, p = .002). The samples also differed on socioeconomic status (SES): the sample with complete data had a higher mean SES than the remaining 24 participants (means = 1.80 and 1.25, respectively; t = 2.47, p = .02). It appears that those with complete data are higher functioning than those with incomplete data. Therefore, the sample may not be fully representative of the population.

Of the 45 infants, 44% were male and 56% were female. Males and females from the sample did not differ on any variables, which included 6, 12, 18 and 36 month MDI, maternal sensitivity, SES, years mother and her partner have spent together, and birth weight.

Because MAVAN was designed to assess the effects of stress, pre- and postnatal, sampling over-represented infants who were born small for gestational age (SGA). Birth weight of infants ranged from 2460.0 g to 3890.0 g (M = 3204.2, SD = 380.6). At birth, 77.8% of the infants were typical in size (3000-3750 g), 20% were SGA (2200-2750 g), and 2.2% were heavier than normal.

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<sup>&</sup>lt;sup>1</sup> At the time of writing, I do not know the reasons for incomplete data.

Within the larger population, the prevalence rate of infants that are SGA is 6% (Statistics Canada, June 2010). The present study sample over-represents infants born SGA.

Socioeconomic status categorization was based on a number of factors, viz., maternal level of education, income (i.e. based on Low Income Thresholds, or LIT, from Statistics Canada), and neighborhood (e.g., postal codes that identify neighborhoods varying in terms of population density and crime rates)<sup>2</sup>. Of the 45 families, 86.7% were classified as high, 2.2% were classified as moderate, and 8.9% were classified as low in SES.

Mothers' ages ranged from 18.88 years to 43.98 years (M = 29.5, SD = 5.7) when infants were born. When the infants were 6 months, 95.6% of mothers had a partner (i.e. husband or boyfriend) whereas 4.5% were single. For those with a partner, the number of years spent together ranged from 2 to 14 years (M = 7.2, SD = 3.3).

#### Procedure

Prior to the commencement of each visit, an information letter was distributed outlining the procedure and purpose of the study. Assuming mothers agreed to participate, two trained research assistants visited each mother-infant dyad in their home and informed consent was obtained when the infant was 6 months old. The research assistants visited the home when the infant was 6, 12, 18 and 36 months of age to assess cognitive capacity using the Bayley Mental Development Index (MDI). Before leaving each home, the research assistants thanked the mother for her time and offered her \$25 compensation.

On a separate occasion, when the infant was 18 months of age, two female research assistants visited the home to assess maternal sensitivity. At the home-visit, the research assistants explained what would occur throughout the two-hour visit and subsequently observed interaction

<sup>&</sup>lt;sup>2</sup> At time of writing, I was unable to access a more specific description of how SES was derived.

between the mother and infant. Sensitivity coders were blind to infant cognitive development scores and the research assistants who assessed infant cognition were blind to sensitivity ratings. Before leaving each home the research assistants thanked the mother for her time and offered \$25 compensation.

#### Measures

Child Cognitive Development. Infant cognitive capacity was assessed at 6, 12, 18 and 36 months using the Mental Development Index (MDI), taken from the Bayley Scales of Infant Development II (BSID-II; Bayley 1993). The BSID has been normed for infants from 2 months of age to 2.5 years of age. It is a structured assessment of infant cognitive development that assesses an infant's ability to manipulate objects, sustain attention, imitate actions, comprehend, discriminate shapes, and problem solve, amongst other tasks (Bayley, 1993).

Reliability of the MDI is acceptable. All coefficient alphas are at appropriate levels: .92 at 6 months, .88 at 12 months, .92 at 18 months, and .89 at 36 months (Bayley, 1993). Bayley (1993) assessed test-retest reliability at 1, 12, 24, and 36 months, with intervals between assessments ranging from 1-16 days (median of 4 days). The 1- and 12-month age groups and 24- and 36-month age groups were combined to determine if reliability differed in relation to age. Test-retest reliability was adequate for ages 1 and 12 months (r = .83) and ages 24 and 36 months (r = .91). The MDI also has high concurrent validity when compared to other cognitive development measures for infants (Bayley, 1993; Plomin & DeFries, 1985). For the present study, trained research assistants administered the BSID-II to infants, from which the MDI score was derived.

*Maternal Sensitivity*. Maternal sensitivity was assessed at 18 months using the Maternal Behavior Q-Set (MBQS). The MBQS is a coding procedure that provides a detailed description of the quality of maternal interaction with the infant (Pederson & Moran, 1995). The MBQS

consists of 90 items and each item describes potential maternal behaviors. Items are sorted equally into nine piles on a rectangular distribution, in which pile 1 represents maternal behaviors that are least like the mother and pile 9 represents maternal behaviors that are most like the mother. Each item is assigned a score that corresponds to the pile it is sorted into; for instance, an item in pile 9 is scored as 9. A score for maternal sensitivity is based on a correlation between the participant's derived score and a prototypical sensitivity score, developed by experts in the field (Pederson & Moran, 1995). Therefore, scores range from -1.0 (extremely insensitive) to 1.0 (prototypically sensitive). MBQS scores strongly predict infant security scores (Moran, Pederson, Pettit, & Krupka, 1992; Pederson, Moran, Sitko & Campbell, 1990).

Two trained observers visited each dyad in their homes to observe mother-infant interactions over a span of two hours. During this time, mothers were asked to engage in interactions with their children during play with toys provided by the observers, play with no toys, and also to complete questionnaires while the infants were in the room unattended. After the visit, the observers each described the quality of mother-infant interactions using the MBQS and calculated a sensitivity score. Inter-rater reliability between the observers was adequate (*ICC* = .76). A final sensitivity score was determined by averaging the observers' scores.

#### Results

In the following analyses, I examine maternal sensitivity (at 18 months) and prior infant capacity as predictors of subsequent infant capacity.

Assumptions of Multiple Regression

The assumptions of normality, linearity, homoscedasticity, and independence of the error terms were all met. Refer to Appendix for a description of the procedures.

#### Regression Diagnostics

To determine if multivariate outliers existed, I conducted regression diagnostics. Discrepancy was evaluated by examining the studentized deleted residual values compared to t(42) = 2.02. Upon examining absolute values of minimum and maximum scores, the maximum score was higher than the critical t, indicating that there are scores with high discrepancy. Next, centered leverage values were inspected and scores greater than 3(2)/45 = .133 were flagged. The value of .133 was less than the maximum centered leverage values of the dependent variables in question; thus, at least one multivariate outlier was present in the dataset. Finally, influence was examined using minimum and maximum Cook's D values. The cut-off score of  $2 \sqrt{3/45} = .52$  was greater than the maximum Cook's D values of the dependent variables in question, therefore there were no scores in the dataset with substantial influence on the regression analysis. Based on the combined results of all regression diagnostics, multivariate outliers were not suspected within this dataset. Therefore, overall, the assumptions for multiple linear regression were met. *Assessment of Multicollinearity* 

With respect to correlations among predictor variables, infant cognitive ability at 6 months and maternal sensitivity had a very low correlation (r = .13, p = .20). The tolerance values for each step of the hierarchical regression were larger than 0.10. These results indicate that the model is stable and there is no concern for multicollinearity among these predictor variables.

Infant cognitive ability at 12 months and maternal sensitivity were significantly correlated (r = .36, p = .007). Infant cognitive ability at 18 months and maternal sensitivity were also significantly correlated (r = .29, p = .026). Although the predictor variables are correlated in each case, the tolerance values for each step of the hierarchical regressions were larger than 0.10. The

degree of overlap between predictors is acceptable; thus, each model is stable and there is no concern for multicollinearity among predictor variables.

#### Descriptive Statistics

The means and standard deviations of each variable are presented in Table 5. Correlations between study variables are reported in Table 6.

Table 5

Means and Standard Deviations of Study Variables (N = 45)

Variable	M	SD
MDI at 6 months	98.18	7.65
MDI at 12 months	96.76	9.92
MDI at 18 months	97.27	9.78
MDI at 36 months	97.18	11.28
MBQS	.41	.40
SES	1.80	.59
Birth weight	3204.18	380.56

*Note*. MDI = Mental Development Index, MBQS = Maternal Behavior Q-Sort, SES = Socioeconomic Status.

Table 6

Intercorrelations of Study Variables (N = 45)

	MDI 12	MDI 18	MDI36	MBQS	SES	Birth weight
MDI 6	08	.20	.18	.13	.08	.11
MDI 12	-	.23	.33*	.36*	11	03
MDI 18	-	-	.61***	.29*	.23	.13
MDI 36	-	-	-	.40*	.31*	.15
MBQS	-	-	-	-	.16	.14
SES	-	-	-	-	-	.02

*Note.* MDI = Mental Development Index, MBQS = Maternal Behavior Q-Sort, SES = Socioeconomic Status.

#### Hierarchical Multiple Regression

Predicting cognitive development from 6 to 12 months. As shown in Table 6, cognitive capacity at 6 months is not significantly correlated with cognitive capacity at 12 months, but maternal sensitivity and cognitive capacity at 12 months were significantly correlated.

The overall model (MDI at 12 months regressed on sensitivity and MDI at 6 months) was significant: F(2, 42) = 3.63, MSE = 319.38, p = .035. In the first step of the hierarchical regression analysis, infant cognitive ability at 6 months was not a significant predictor of infant cognitive ability at 12 months; b = -0.11, SE = 0.20,  $\beta = -.08$ , t = -0.54, p = .60,  $R^2 = .00$ . In the second step, maternal sensitivity was added to the model. Maternal sensitivity was a significant predictor of infant cognitive ability at 12 months: b = 9.42, SE = 3.58,  $\beta = .38$ , t = 2.63, p = .01,  $\Delta R^2 = .14$ .

<sup>\*</sup>p < .05, \*\*p < .01, \*\*\*p < .001.

Predicting cognitive development from 6 to 18 months. As shown in Table 6, cognitive capacity at 6 months is not significantly correlated with cognitive capacity at 18 months, but maternal sensitivity and cognitive capacity at 18 months were significantly correlated.

The overall model was not significant, although it approached significance: F(2, 42) = 2.67, MSE = 237.38, p = .081. In the first step of the hierarchical regression analysis, infant cognitive ability at 6 months was not a significant predictor of infant cognitive ability at 18 months: b = 0.26, SE = 0.19,  $\beta = .20$ , t = 1.36, p = .18,  $R^2 = .04$ . In the second step, maternal sensitivity was also not a significant predictor of infant cognitive ability at 18 months, although it approached significance: b = 6.64, SE = 3.60,  $\beta = .27$ , t = 1.85, p = .07,  $\Delta R^2 = .07$ .

Predicting cognitive development from 6 to 36 months. Cognitive capacity at 6 months is not significantly correlated with cognitive capacity at 36 months. Maternal sensitivity and cognitive capacity at 36 months were significantly correlated (as shown in Table 6).

The overall model is significant: F(2, 42) = 4.41, MSE = 486.02, p = .018. In the first step, infant cognitive ability at 6 months was not a significant predictor of infant cognitive ability at 36 months: b = 0.26, SE = 0.22,  $\beta = .18$ , t = 1.19, p = .24,  $R^2 = .03$ . In the second step, maternal sensitivity was a significant predictor of infant cognitive ability at 36 months; b = 10.76, SE = 4.01,  $\beta = .38$ , t = 2.69, p = .01,  $\Delta R^2 = .14$ .

Predicting cognitive development from 12 to 18 months. Cognitive capacity at 12 months is not significantly correlated with cognitive capacity at 18 months. Maternal sensitivity and cognitive capacity at 18 months were significantly correlated (as shown in Table 6).

The overall model is not significant, although it approached significance: F(2, 42) = 2.43, MSE = 217.70, p = .10. In the first step, infant cognitive ability at twelve months was not a significant predictor of infant cognitive ability at 18 months: b = 0.23, SE = 0.15,  $\beta = .23$ ,

t = 1.57, p = .13,  $R^2 = .054$ . In the second step, maternal sensitivity was not a significant predictor of infant cognitive ability at 18 months: b = 5.87, SE = 3.85,  $\beta = .24$ , t = 1.53, p = .14,  $\Delta R^2 = .050$ .

Predicting cognitive development from 12 to 36 months. Cognitive capacity at 12 months is significantly correlated with cognitive capacity at 36 months. Maternal sensitivity and cognitive capacity at 36 months were significantly correlated (as shown in Table 6).

The overall model was significant: F(2, 42) = 5.19, MSE = 555.16, p = .01. In the first step, infant cognitive ability at 12 months was a significant predictor of infant cognitive ability at 36 months: b = 0.38, SE = 0.16,  $\beta = .33$ , t = 2.31, p = .026,  $R^2 = .11$ . In the second step, maternal sensitivity was a significant predictor of infant cognitive ability at 36 months: b = 8.99, SE = 4.20,  $\beta = .32$ , t = 2.14, p = .038,  $\Delta R^2 = .09$ . However, in the second step, 12-month capacity dropped out when sensitivity is added: b = 0.25, SE = 0.17,  $\beta = .22$ , t = 1.47, p = .15. Maternal sensitivity was a significant predictor, accounting for 9% of the variance in capacity at 36 months, above and beyond cognitive capacity at 12 months.

Predicting cognitive development from 18 to 36 months. Cognitive capacity at 18 months is significantly correlated with cognitive capacity at 36 months. Maternal sensitivity and cognitive capacity at 36 months were significantly correlated (as shown in Table 6).

The overall model was significant: F(2, 42) = 15.74, MSE = 1200.14, p = .0005. In the first step, infant cognitive ability at 18 months was a significant predictor of infant cognitive ability at 36 months: b = 0.71, SE = 0.14,  $\beta = .61$ , t = 5.10, p = .000,  $R^2 = .38$ . In the second step, maternal sensitivity was not a significant predictor of infant cognitive ability at 36 months, although it approached significance: b = 6.72, SE = 3.46,  $\beta = .24$ , t = 1.95, p = .058,  $\Delta R^2 = .05$ .

<sup>&</sup>lt;sup>3</sup> For all multiple regressions described in Study 1, no predictor variables significantly interacted. I explored interactions tentatively but not formally, given small sample size.

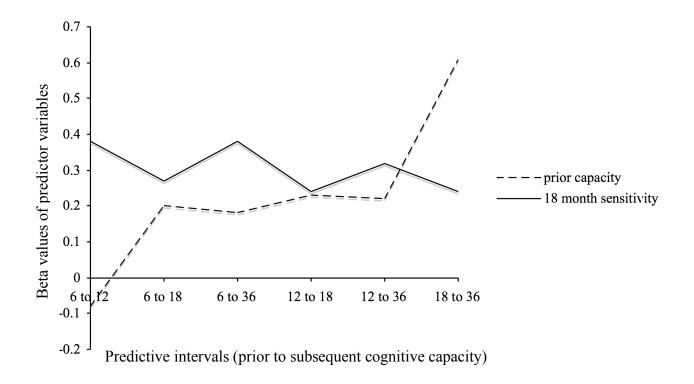
#### Change Analysis

A change score for cognitive capacity was determined by calculating the difference between 6 month MDI and 36 month MDI. This change score was not significantly correlated with maternal sensitivity at 18 months, although it approached significance: r = .28, p = .06. In addition, a change score between 12- and 18-month MDI was calculated and did not correlate with a 6- and 36-month MDI change score: r = .06, p = .70. I then compared the correlation between sensitivity and 6- to 36-month change, on the one hand, with the correlation between 12- to 18-month change and 6- to 36-month change, on the other (using Fisher  $z_r$  transformations). The correlations were not significantly different (Z = 1.05, p = .30).

#### Summary of Study 1

Findings from Study 1 indicate that maternal sensitivity at 18 months is a better predictor than early prior capacity in predicting cognitive development. When the child approaches preschool, however, prior capacity (at 18 months) appears a better predictor of subsequent capacity than maternal sensitivity. Although this is the trend, I could not test it formally by comparing regression slopes due to small sample size. Figure 1 shows the changing influence of predictor variables (in terms of Beta values from multiple regressions) on infant cognitive development.

Figure 1. The Changing Influence of Maternal Sensitivity and Prior Capacity (N = 45)



## **CHAPTER III**

## Study 2, Part I

Predicting Cognitive Development with Maternal Sensitivity at 6 months

Maternal sensitivity was assessed at 6 months of age for 26 of the 45 participants from Study 1. A series of hierarchical multiple regressions were conducted using 6-month sensitivity as a predictor instead of 18-month sensitivity. Although maternal sensitivity is relatively stable through time (Atkinson, Chisholm, Scott, Goldberg, Vaughn, Blackwell et al., 1999; Bahadur, 1999; Pederson & Moran, 1995), it is possible for environmental circumstances to influence change in sensitive parenting over time (e.g., parental stress; Degroat, 2003). In study 2, I use an earlier assessment of maternal sensitivity to predict cognitive capacity. Predicting cognitive development with 6-month maternal sensitivity permits replication and extension of results reported above. I hypothesize that there are similar trends as 18-month sensitivity regression models reported above. Specifically, I expect 6-month maternal sensitivity to predict subsequent cognitive capacity above and beyond early prior capacity. I also expect maternal sensitivity to account for change in cognitive capacity.

# Power Analyses

I conducted power analyses to determine appropriate power and sample size considerations using  $G^*$  Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007). To establish effect size, I calculated the median  $R^2$  from Study 1:  $R^2 = .16$ . In the first analysis, I specified an a priori *alpha* of .05 and power of .8. The power analysis indicated that a sample of 64 is requisite for power of .80. Therefore, I conducted a second power analysis, this time specifying *alpha* at .05, sample size of 26, and effect size of  $R^2 = .16$ . The analysis indicated that the model has .38 probability of rejecting the null hypothesis if, indeed, it is false. Therefore, I increased the *alpha* 

to .10 and conducted a third power analysis. With *alpha* set at .10 and the other parameters as above, the model has .52 power. I therefore use a .10 alpha level in the following analyses. I recognize that this course of action magnifies the probability of Type I error. Although the sample is small and statistical error is increased, this study is a starting point to understanding the influence of maternal sensitivity at an early point in development.

## Method

## **Participants**

The 26 participants were a subsample of the 45 subjects who participated in Study 1. I compared the 26 Study 2 participants with the 19 participants who did not provide complete data. The two groups did not differ on MDI scores at 6, 12, 18 or 36 months, maternal sensitivity (MBQS), birth weight, or SES. The two groups did differ on number of years the mother has spent with her partner, where the group of 19 had higher mean years (t = -2.14, p = .04). Of the 26 infants, 46% were male and 54% were female. Birth weight of infants ranged from 2530 g to 3890 g (M = 3220.88, SD = 390.27). At birth, 80.8% of infants were normal in size, 19.2% were small for gestational age (SGA), and no infants were heavier than normal. Again, infants who are SGA are over-represented in this sample.

Socioeconomic status (SES) was assessed as described above. Of the 26 families, 82.1% were classified as high, 5.1% were classified as moderate, and 12.8% were classified as low in SES. With respect to marital status at infant age 6 months, 92.3% of mothers had a partner (i.e. husband or boyfriend) whereas 7.7% were single. For those with a partner, the number of years spent together ranged from 2 to 13 years (M = 6.2, SD = 3.2).

#### Procedure

At the 6-month home-visit, after cognitive development was assessed, the research assistant videotaped mother-infant interaction, in which mothers were asked to play as they normally would with their infants for the duration of 10 minutes. Although this time frame is short, three meta-analyses have shown that the length of time of mother-infant interaction used to code sensitivity does not affect prediction, at least in the context of attachment security (Atkinson, Niccols, Paglia, Coolbear, Parker, Poulton, et al., 2000; De Wolff & van IJzendoorn, 1997; Goldsmith & Alansky, 1987). After the visit, two different research assistants, using the Ainsworth Scales, coded maternal sensitivity from the videotaped interaction. The research assistants coding maternal sensitivity were blind to Bayley MDI. For further description of the procedure used in this study please refer to the Methods section of Study 1.

#### Measures

*Child Cognitive Development.* For a description of the cognitive measures used in this study please refer to the Methods section of Study 1.

Maternal Sensitivity. Maternal sensitivity was assessed at 6 months using the Ainsworth Sensitivity Scales (Ainsworth, Bell, & Stayton, 1971). The four scales are: maternal sensitivity (mother responds promptly and appropriately to child signals), acceptance (mother values child's autonomy), cooperation (mother's interventions are not intrusive), and accessibility (mother is available, both psychologically and physically). Each scale is scored from 1 (not sensitive) to 9 (very sensitive) based on extensive descriptions provided by Ainsworth et al. (1971). The concurrent ratings of these variables correlated highly (.76 to .87, median = .85) in the present sample, suggesting they do not measure distinct constructs. This finding is typical in the literature

(Atkinson et al., 1999). I therefore averaged the scores to form a single sensitivity composite. Inter-rater reliability was strong (ICC = .96).

#### Results

In the following analyses, I examined 6-month maternal sensitivity and prior infant capacity as predictors of subsequent infant capacity.

Assumptions of Multiple Regression

The assumptions of normality, linearity, homoscedasticity, and independence of the error terms were all met. Refer to Appendix for a description of the procedures.

Regression Diagnostics

To determine if multivariate outliers existed, I conducted regression diagnostics. Discrepancy was evaluated by examining the studentized deleted residual values compared to t(23) = 2.07. Upon examining absolute values of minimum and maximum scores, the maximum score was higher than the critical t for 12 month MDI, indicating that there are scores with high discrepancy. The absolute values of the minimum and maximum scores for 18 month and 36 month MDI were lower than the critical t. Next, centered leverage values were inspected and scores greater than 3(2)/26 = .23 were flagged. The value of .23 was less than the maximum centered leverage value for 36 month MDI; thus, at least one multivariate outlier was present in the dataset. For 12 month and 18 month MDI, the centered leverage values were acceptable. Finally, influence was examined using minimum and maximum Cook's D values. The cut-off score of 2 sqrt[3/26] = .68 was greater than the maximum Cook's D values for each dependent variable, therefore there were no scores in the dataset with substantial influence on the regression analyses. Based on the combined results of all regression diagnostics, multivariate outliers were

not suspected within this dataset. Therefore, overall, the assumptions for multiple linear regression were met.

Assessment of Multicollinearity

With respect to correlation among predictor variables, infant cognitive ability at 6 months and maternal sensitivity had very low correlation (r = .015, p = .47). Also, infant cognitive ability at 12 months and maternal sensitivity were not significantly correlated (r = .005, p = .49). The tolerance values for each step of the hierarchical regression were larger than 0.10 in each case. These results indicate that the model is stable and there is no concern for multicollinearity among these predictor variables.

Infant cognitive ability at 18 months and maternal sensitivity were significantly correlated (r = .40, p = .022). Although the predictors are correlated in this case, the tolerance values for each step of the hierarchical regressions were larger than 0.10. The degree of overlap between predictors is acceptable; thus, the model is stable and there is no concern for multicollinearity among predictor variables.

Of course, despite meeting multiple regression assumptions, the sample size is small and I adopted an *alpha* of .10. For these reasons, all results must be interpreted with caution.

# Descriptive Statistics

The means and standard deviations of each variable are presented in Table 7. Correlations between study variables are reported in Table 8.

Table 7

Means and Standard Deviations of Study Variables (N = 26)

Variable	M	SD
MDI at 6 months	98.35	7.59
MDI at 12 months	95.15	10.35
MDI at 18 months	97.38	9.78
MDI at 36 months	96.58	10.96
Ainsworth Scale	5.38	1.38
MBQS	.37	.38
SES	1.72	0.68
Birth weight	3220.88	390.27

*Note*. MDI = Mental Development Index, MBQS = Maternal Behavior Q-Sort, SES = Socioeconomic Status.

Table 8

Intercorrelations of Study Variables (N = 26)

	MDI 12	MDI 18	MDI 36	Ainsworth Scale	MBQS	SES	Birth weight
MDI 6	31	.10	.03	.02	.02	041	.20
MDI 12	-	.24	.30	.005	.49***	23	02
MDI 18	-	-	.73****	.40**	.23	.19	00
MDI 36	-	-	-	.33*	.25	.18	.05
Ainsworth Scale	-	-	-	-	.15	.29	50***
MBQS	-	-	-	-	-	.11	13
SES	-	-	-	-	-	-	.04

*Note*. MDI = Mental Development Index, MBQS = Maternal Behavior Q-Sort, SES = Socioeconomic Status.

\*
$$p < .10$$
, \*\*  $p < .05$ , \*\*\*  $p < .01$ , \*\*\*\*  $p < .001$ .

# Hierarchical Multiple Regression

Predicting cognitive development from 6 to 12 months. Cognitive capacity at 6 months is not significantly correlated with cognitive capacity at 12 months. Maternal sensitivity (Ainsworth Scale) and cognitive capacity at 12 months were not significantly correlated (as shown in Table 8).

The overall multiple regression model was not significant: F(2, 23) = 1.23, MSE = 138.56, p = .31. In the first step, infant cognitive ability at 6 months was not a significant predictor of infant cognitive ability at 12 months; b = -0.44, SE = 0.27,  $\beta = -.31$ , t = -1.60, p = .12,  $R^2 = .10$ . In the second step, maternal sensitivity was not a significant predictor of infant cognitive ability at 12 months: b = 0.07, SE = 1.54,  $\beta = .01$ , t = 0.05, p = .96,  $\Delta R^2 = .00$ .

Predicting cognitive development from 6 to 18 months. Cognitive capacity at 6 months is not significantly correlated with cognitive capacity at 18 months. Maternal sensitivity and cognitive capacity at 18 months were significantly correlated (as shown in Table 8).

The overall model was not significant: F(2, 23) = 2.33, MSE = 225.38, p = .12. In the first step, infant cognitive ability at 6 months was not a significant predictor of infant cognitive ability at 18 months: b = 0.14, SE = 0.28,  $\beta = .10$ , t = 0.50, p = .62,  $R^2 = .01$ . In the second step, maternal sensitivity was a significant predictor of infant cognitive ability at 18 months: b = 2.98, SE = 1.42,  $\beta = .40$ , t = 2.09, p = .048,  $\Delta R^2 = .16$ . Nevertheless, the certainty of this finding is undermined by the fact that the model as a whole is not significant. The model's nonsignficance may be due to the fact that 6-month and 18-month MDIs are not correlated (i.e., r = .10; see Table 1) and the model itself has low power to detect real differences.

Predicting cognitive development from 6 to 36 months. Cognitive capacity at 6 months is not significantly correlated with cognitive capacity at 36 months. Maternal sensitivity and cognitive capacity at 36 months were significantly correlated (as shown in Table 8).

The overall model is not significant: F(2, 23) = 1.38, MSE = 160.57, p = .27. In the first step, infant cognitive ability at 6 months was not a significant predictor of infant cognitive ability at 36 months: b = 0.05, SE = 0.30,  $\beta = .03$ , t = 0.17, t = 0.

Predicting cognitive development from 12 to 18 months. Cognitive capacity at 12 months is not significantly correlated with cognitive capacity at 18 months. Maternal sensitivity and cognitive capacity at 18 months were significantly correlated (as shown in Table 8).

The overall model is significant: F(2, 23) = 3.16, MSE = 288.86, p = .061. In the first step, infant cognitive ability at 12 months was not a significant predictor of infant cognitive ability at 18 months: b = 0.23, SE = 0.19,  $\beta = .24$ , t = 1.21, p = .24,  $R^2 = .057$ . In the second step, maternal sensitivity was a significant predictor of infant cognitive ability at 18 months: b = 2.98, SE = 1.38,  $\beta = .40$ , t = 2.15, p = .042,  $\Delta R^2 = .16$ .

Predicting cognitive development from 12 to 36 months. Cognitive capacity at 12 months was not significantly correlated with cognitive capacity at 36 months. Maternal sensitivity and cognitive capacity at 36 months were significantly correlated (as shown in Table 8).

The overall model was significant: F(2, 23) = 2.75, MSE = 289.24, p = .085. In the first step, infant cognitive ability at 12 months was not a significant predictor of infant cognitive ability at 36 months: b = 0.30, SE = 0.20,  $\beta = .30$ , t = 1.52, p = .14,  $R^2 = .09$ . In the second step, maternal sensitivity was a significant predictor of infant cognitive ability at 36 months: b = 2.57, SE = 1.49,  $\beta = .33$ , t = 1.73, p = .097,  $\Delta R^2 = .11$ . This result indicates that infant cognitive ability at 12 months accounts for little variability in infant cognitive ability at 36 months, and maternal sensitivity accounts for 11% of the variability above and beyond 12 month MDI.

Predicting cognitive development from 18 to 36 months. Cognitive capacity at 18 months is significantly correlated with cognitive capacity at 36 months. Maternal sensitivity and cognitive capacity at 36 months were also significantly correlated (as shown in Table 8).

The overall model was significant: F(2, 23) = 13.13, MSE = 800.18, p = .0005. In the first step, infant cognitive ability at 18 months was a significant predictor of infant cognitive

ability at 36 months: b = 0.77, SE = 0.15,  $\beta = .73$ , t = 5.22, p = .000,  $R^2 = .53$ . In the second step, maternal sensitivity was not a significant predictor of infant cognitive ability at 36 months; that is, maternal sensitivity did not predict unique variance in 36 month capacity above and beyond 18 month capacity: b = 0.33, SE = 1.23,  $\beta = .04$ , t = 0.28, p = .79,  $\Delta R^2 = .00$ .

## Change Analysis

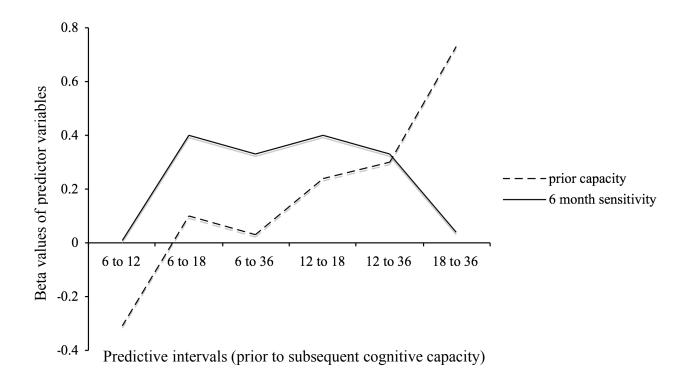
Change analysis was conducted in parallel to multiple regressions in order to assess the relation of 6-month maternal sensitivity and change in capacity. The change score for cognitive capacity (difference between 6 month MDI and 36 month MDI) was not significantly correlated with maternal sensitivity at 6 months: r = .26, p = .19. The change score between cognitive capacity at 6 and 36 months did not correlate with the change score between cognitive capacity at 12 and 18 months: r = .09, p = .68. This indicates that change in MDI at one time interval is not related to change in MDI at another time interval. The correlations were not significantly different (Z = .33, p = .74).

## Summary of Study 2, Part I

Findings from Study 2, part I, are similar to those of Study 1. Results indicate that maternal sensitivity at 6 months better predicts cognitive development than early prior capacity. However, at the 18 to 36 month mark, prior capacity appears a better predictor of subsequent capacity than maternal sensitivity. Again, although this is the trend, I did not test it formally. Figure 2 shows the changing influence of predictor variables (in terms of Beta values) on infant cognitive development.

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Figure 2. The Changing Influence of Maternal Sensitivity and Prior Capacity (N = 26)



Study 2, Part II

Predicting Cognitive Development with Maternal Sensitivity at 6 months and 18 months Six-month maternal sensitivity (Ainsworth Scale) and 18-month maternal sensitivity (MBQS) are investigated as predictors to compare the changing influence of sensitivity and prior cognition on cognitive development. Prior cognitive capacity alone was added in step 1 of hierarchical multiple regression. Then, sensitivity at 6 and 18 months were added as predictors simultaneously in step 2. Again, I used alpha of .10 for the following analyses. In addition, I conducted change analyses. I expect sensitivity (at 6 and 18 months) to predict capacity above and beyond prior capacity in early infancy.

## Results

# Hierarchical Multiple Regression

Predicting cognitive development from 6 to 12 months. The overall model was significant: F(3, 22) = 3.57, MSE = 313.47, p = .031. In the first step of the hierarchical regression analysis, infant cognitive ability at 6 months was not a significant predictor of infant cognitive ability at 12 months ( $\beta = -.31$ , p = .12). In the second step, sensitivity at 18 months was a significant predictor of infant cognitive ability at 12 months: b = 13.80, SE = 5.02,  $\beta = .49$ , t = 2.75, p = .01,  $\Delta R^2 = .23$ , but sensitivity at 6 months was not a significant predictor ( $\beta = -.06$ , p = .73). This result indicates that maternal sensitivity at 18 months accounts for 23% of variability in infant cognitive ability at 12 months, whereas sensitivity at 6 months does not account for a significant amount of variability.

Predicting cognitive development from 6 to 18 months. The overall model was not significant: F(3, 22) = 1.84, MSE = 179.06, p = .17. In the first step, infant cognitive ability at 6 months was not a significant predictor of infant cognitive ability at 18 months ( $\beta = .10$ , p = .62). In the second step, sensitivity at 6 months was a significant predictor of infant cognitive ability at 18 months ( $\beta = .37$ , p = .068), but sensitivity at 18 months was not ( $\beta = .18$ , p = .36).

Predicting cognitive development from 6 to 36 months. The overall model was not significant: F(3, 22) = 1.30, MSE = 150.74, p = .30. In the first step, infant cognitive ability at 6 months was not a significant predictor of infant cognitive ability at 36 months ( $\beta = .03$ , p = .87). In the second step, sensitivity at 6 months was not a significant predictor of infant cognitive ability at 18 months ( $\beta = .29$ , p = .15), and neither was sensitivity at 18 months ( $\beta = .21$ , p = .30).

Predicting cognitive development from 12 to 18 months. The overall model is not significant: F(3, 22) = 2.07, MSE = 196.72, p = .13. In the first step, infant cognitive ability at 12 months was not a significant predictor of infant cognitive ability at 18 months ( $\beta = .24$ , p = .24). In the second step, sensitivity at 6 months was a significant predictor of infant cognitive ability at 18 months ( $\beta = .39$ , p = .055), but sensitivity at 18 months was not ( $\beta = .08$ , p = .72).

Predicting cognitive development from 12 to 36 months. The overall model was not significant: F(3, 22) = 1.81, MSE = 198.09, p = .18. In the first step, infant cognitive ability at 12 months was not a significant predictor of infant cognitive ability at 36 months ( $\beta = .30$ , p = .14). In the second step, sensitivity at 6 months was not a significant predictor of infant cognitive ability at 18 months ( $\beta = .31$ , p = .12), and neither was sensitivity at 18 months ( $\beta = .08$ , p = .71).

Predicting cognitive development from 18 to 36 months. The overall model was significant: F(3, 22) = 8.61, MSE = 540.50, p = .001. In the first step of the hierarchical regression analysis, infant cognitive ability at 18 months was a significant predictor of infant cognitive ability at 36 months ( $\beta = .73$ , p = .0005). In the second step, sensitivity at 6 months was not a significant predictor of infant cognitive ability at 18 months ( $\beta = .04$ , p = .82), and neither was sensitivity at 18 months ( $\beta = .09$ , p = .57). This result indicates that infant cognitive ability at 18 months accounts for 53% of the variability in infant cognitive ability at 36 months, and sensitivity at both 6 and 18 months does not account for a significant amount of variability.

# Change Analysis

The change score for maternal sensitivity (difference between 6 month and 18 month sensitivity)<sup>4</sup> did not significantly correlate with change score for cognitive capacity (difference between 6 and 18 month MDI), r = -.09, p = .68, or another change score for cognitive capacity (difference between 6 and 36 month MDI), r = -.03, p = .90.

Summary of Study 2, Part II

Findings from Study 2, part II, indicate that sensitivity at either 6 or 18 months was a better predictor of cognitive development than early prior capacity. When predicting from 18 to 36 months, however, 18-month capacity was a better predictor and sensitivity at neither time point was significant (see Table 9). This is in accordance with findings from Study 1 and Study 2 part I, indicating the changing influence between maternal sensitivity and prior capacity over the course of infant development.

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<sup>&</sup>lt;sup>4</sup> Sensitivity scores at 6 and 18 months were first standardized, and then I calculated the change score.

Table 9

Summary of Findings with respect to MDI as Regressed against Prior MDI, 6-month Sensitivity, and 18-month Sensitivity

	Prior MDI	6-month Ainsworth	18-month MBQS
6 to 12			***
6 to 18		**	
6 to 36			
12 to 18		**	
12 to 36		*	
18 to 36	****		

Note. MDI = Mental Development Index, MBQS = Maternal Behavior Q-Sort.

p<.12\*, p<.10 \*\*, p<.05 \*\*\*, p<.01\*\*\*\*.

#### CHAPTER IV

#### Discussion

Previously, researchers found cognitive development to be unstable in infancy (McCall, 1979). Predictive correlations ranged from weak in early infancy to moderate in later infancy (correlations from zero to .40, with the time span between assessments being a few months; McCall, 1979). This was contrasted by the strong predictive correlations of childhood intelligence (correlations from .80 to .90, with the time span between assessments ranging from 1 to 3 years, McCall, 1979). The present findings are theoretically expectable because stages of infant cognitive development are qualitatively distinct and development through stages occurs rapidly, whereas childhood intelligence is more stable, with slower progression through stages of development (Piaget, 1970). Given correlations between cognitive assessments in infancy were relatively low, researchers looked to alternate predictors of infant cognitive development.

Some investigators found that maternal sensitivity was moderately related to infant cognition (Feldman & Eidelman, 2009; Tarabulsy et al., 2009). Furthermore, researchers found sensitivity to predict cognitive development above and beyond the infant's prior capacity (Lemelin et al., 2006; Taylor et al., 2008). However, cognition and sensitivity scores were amalgamated in these studies. It is paradoxical that researchers amalgamated scores when the research interest was to investigate *change* over time. Investigators conducted studies controlling for prior capacity because cognitive development is unstable; however, they combined estimates of cognitive capacity across time. This leads to potentially distorted findings, precluding developmental assessments of prior capacity and sensitivity as they relate to cognitive development in infancy. Due to amalgamated scores, left unknown was the relative influence of maternal sensitivity and prior capacity at multiple time points throughout infancy. Given that

early experience influences a young infant's brain development (Bayley, 1933; Cicchetti & Curtis, 2006), and given that cognitive stability improves as the infant ages (Colombo, 1993; McCall, 1979), it was expected that the relative influence of maternal sensitivity and prior cognition change over time.

The aim of this thesis was to investigate the influence of each predictor on infant cognitive development. This was pursued with two studies, one assessing cognitive capacity and 18-month sensitivity, and the second expanding the assessment of maternal sensitivity to 6 months. It was expected that maternal sensitivity influences cognitive development above and beyond early cognitive capacity scores. As the infant ages, however, the influence of sensitivity would wane and prior cognitive capacity would become influential on subsequent capacity, consistent with previous cognitive stability findings (McCall, 1979). In addition, it was expected that maternal sensitivity be related to change in cognitive capacity.

Consistent with expectations, maternal sensitivity (at 6 and 18 months) was a significant predictor of cognitive development, predicting capacity above and beyond early prior capacity. In these instances, early prior capacity was not a significant predictor of cognitive development. As the child approached the 18 to 36 month interval, however, prior capacity predicted cognitive development, and maternal sensitivity was not a significant predictor. Also, although maternal sensitivity was not significantly related to change in capacity, it approached significance. These findings, overall, signify the importance of maternal sensitivity in early infant development on the child's subsequent cognitive growth. Results are further discussed below.

The Stability of Cognitive Development Improves with Time

Consistently throughout the literature, cognitive development was found to be unstable in infancy (see Tables 1 and 2; McCall, 1979). Low to moderate correlations between cognitive

assessments in infancy contrasted with strong correlations between assessments in childhood, as reviewed above (see Tables 3 and 4). Early infant cognitive development is a period involving rapid neurological development (Colombo, 1993; McCall 1979). Due to rapid changes, earlier assessments of capacity are fundamentally different from later stages of cognitive development, resulting in modest correlations between assessments (Bayley, 1970).

The current study has replicated past findings of cognitive instability in infancy: overall, intercorrelations between MDI scores were low and nonsignificant (ranging from -.08 to .61, with a median of .22). In later infancy, however, stability increased; that is, correlations were significant in two instances (at 12 to 36 and 18 to 36 months). The correlations between 12- and 36-month MDI (r = .33), and 18- and 36-month MDI (r = .61) were moderate. Overall stability findings from this study are contrary to a recent article by Blaga et al. (2009), which found strong stability of cognition in infancy, ranging from .91 to .94. Findings from this study are consistent with the broader literature (McCall, 1979). That is, cognitive development appears unstable in early infancy; however, correlations are larger later in infancy, as the child begins to settle into a more stable form of intelligence (Bayley, 1933; McCall, 1979).

The Changing Influence of Maternal Sensitivity and Prior Capacity

The lack of cognitive stability in early infancy led researchers to an investigation of factors outside the cognition-specific domain. The relation between *maternal sensitivity* and cognitive development was investigated in few instances in the literature (Feldman & Eidleman, 2009; Lemelin et al., 2006; Tarabulsy et al., 2009; Taylor et al 2008). In past research, maternal sensitivity was found to correlate with cognitive functioning. For instance, Tarabulsy et al. (2009) found that sensitivity at 10 months correlated strongly with infant MDI at 10 and 15

months. Consistent with past findings, maternal sensitivity correlated moderately to strongly with cognitive capacity at 12, 18, and 36 months, in the current study.

The next step was to determine whether maternal sensitivity was uniquely predictive of cognition, above and beyond prior capacity of the infant. Taylor et al. (2008) determined that maternal sensitivity (averaged over 6, 12, and 24 months) predicted child IQ at 4 years of age, above and beyond prior capacity (averaged over 6, 12, and 24 months). However, since cognitive scores were amalgamated, we cannot decipher the true impact of prior capacity on subsequent capacity. For example, 24-month capacity may be a strong predictor of IQ at 4 years of age (McCall, 1979); however, since 24-month capacity was amalgamated with 6 and 12-month capacity, its predictive strength may have been reduced, while the predictive capacity of 6- and 12-month cognitive development may be overrepresented in this cognitive amalgamation.

Lemelin et al. (2006) also found maternal sensitivity (at 15 and 18 months) to predict cognition at 36 months, above and beyond prior capacity (6 and 10 month aggregate). Again, amalgamated estimates of both cognitive development and maternal sensitivity restrict our understanding for the developmental relations between prior cognitive development, maternal sensitivity, and subsequent cognitive development. The study by Lemelin et al. (2006) was a starting point to assessing longitudinally the relative influence of prior capacity and sensitivity. What was lacking is a truly longitudinal design, in which cognitive capacity at multiple time points is compared to sensitivity, also assessed across time, to predict cognitive development.

## Study 1

In Study 1, I aimed to assess the changing influence of cognitive capacity and sensitivity on cognitive development. I have extended previous findings (i.e. Lemelin et al., 2006) by not

combining cognitive scores. This way, I have been able to clearly tease out the relative influence of prior capacity and maternal sensitivity on subsequent capacity at multiple time points.

Maternal sensitivity at 18 months is a better predictor of cognitive development, predicting capacity above and beyond prior capacity at points throughout early infant development. Specifically, maternal sensitivity is a better predictor than prior capacity when predicting from 6 to 12, 6 to 36, and 12 to 36 months. When predicting from 6 to 18 months, sensitivity approached significance (p = .07). When predicting from 12 to 18 months, neither prior capacity nor sensitivity significantly predicted cognitive development. However, as indicated in a subsequent power analysis, in order to have power of .80 a sample size of 64 was required. Study 1 had a sample of 45; thus, the study was underpowered, such that these instances may represent Type II error.

The prediction from 6 to 12 months was informative since maternal sensitivity has never been assessed as a predictor at this stage in development previous to this study. Researchers have had difficulty determining relevant predictors of cognitive development in the second half of the first year (Rose et al., 2005; Rose et al., 2008). Specifically, in the information processing field, investigators often examined whether early capacity (from 3-6 months) predicted later intelligence in childhood, whereas predicting cognitive development within the first year was not evaluated (Bornstein & Sigman, 1986). In instances where cognitive predictions in the first year occurred, cognitive stability was low (McCall, 1979). No researchers had looked at *sensitivity* as a predictor of cognitive capacity at 12 months, while controlling for capacity at 6 months. Thus, it is clear from the current study that sensitivity at 18 months is an important predictor of cognitive development in the second half of the first year.

Maternal sensitivity predicted above and beyond prior capacity when predicting from 12 to 36 months. Moreover, prior capacity was significant when entered in the regression equation on its own, but was no longer a significant predictor once sensitivity was added. That is, sensitivity was the most important predictor at this point in development. Again, this indicates that sensitive parenting is crucial in these early stages and still influences capacity at 36 months.

Cognitive capacity at 18 months was a significant predictor of capacity at 36 months, whereas maternal sensitivity was not a significant predictor. This finding is consistent with previous cognitive stability findings that have shown stronger stability at later stages in development (i.e. Table 2; McCall). It is possible, then, that although maternal sensitivity is more influential than *early* assessments of prior capacity, cognitive capacity at a *later* stage in development is stronger than sensitivity when predicting capacity in preschool. These results are consistent with the latter expectation of my first hypothesis for Study 1 (i.e. maternal sensitivity wanes as a predictor later in development), although Fisherian statistics do not permit assessment of the null hypothesis. Comparison of the regression slopes would be helpful in this regard, but the sample size is simply too small to support this test.

Previously, investigators amalgamated early and later assessments of capacity to form one prior capacity score, which was then compared to maternal sensitivity in multiple regression (i.e. Lemelin et al., 2006; Taylor et al., 2008). In particular, Lemelin et al. (2006) did not control for a later assessment of cognitive development, and only controlled for an amalgamated prior capacity score of 6 and 10 month MDI. Taylor et al. (2008) did assess a later cognitive capacity score (24 months), but amalgamated it with earlier assessments of capacity (6 and 12 months), which reduced 24-month predictive power. This study exemplified the importance of separating prior capacity scores.

# Study 2

In Study 1, prior capacity and maternal sensitivity were examined as predictors of cognitive development. Maternal sensitivity at 18 months was a better predictor of cognitive development than early prior capacity when predicting from 6 to 12, 6 to 18 (approached significance), 6 to 36, and 12 to 36 months; however, prior capacity at 18 months better predicted capacity at 36 months. Study 1 has shown that the degree of association between prior capacity and later capacity may change with time. It is expected that the association of capacity and sensitivity change with time as the infant ages; however, the design of study 1 precluded assessment of this change since I had only one assessment of sensitivity. Furthermore, it precluded assessment of change of sensitivity relative to prior and later capacity over time. Study 2 was introduced to overcome this shortcoming with sensitivity assessments at two time points (at 6 and 18 months). Thus, the aim of Study 2 was to gain a preliminary understanding of the changing influence of both prior capacity and maternal sensitivity on cognitive development.

Comparing results to multiple regressions in Study 1, the trend has been replicated in that maternal sensitivity at 6 months appears a better predictor than prior capacity. Maternal sensitivity at 6 months is a better predictor of cognitive development than prior capacity when predicting from 6 to 18 months, 12 to 18 months, and 12 to 36 months, and approaches significance when predicting from 6 to 36 months.

Similar to results in Study 1, when predicting from 18 to 36 months, maternal sensitivity at 6 months was no longer a significant predictor and prior capacity became a strong predictor (accounting for 53% of the variance). Conceivably, 18-month capacity has already absorbed the influence of sensitivity. At preschool age, the cognitive trajectory of the child is now perhaps more strongly based on the child's prior capacity (Bayley, 1993). This may be the point at which

intelligence becomes more stable (McCall 1979). Perhaps the mother has set her infant up on a trajectory through sensitive parenting, but at this point in development it is now the child's own cognitive trajectory.

In study 2 part II, I investigated whether sensitivity assessed at one point in development is more influential than sensitivity assessed at another point. Prior to this study, researchers amalgamated sensitivity scores as opposed to exploring these differences over time (Lemelin et al., 2006; Taylor et al., 2008). Again, maternal sensitivity predicted above and beyond prior capacity at certain periods in infancy. In particular, predicting from 6 to 12 months, sensitivity at 18 months was a better predictor than both 6-month sensitivity and 6 month MDI. Predicting from 6 to 18 months, maternal sensitivity at 6 months was a better predictor than 18-month sensitivity and 6 month MDI. Also, predicting from 12 to 18 months, maternal sensitivity at 6 months was a better predictor than 18-month sensitivity and 12 month MDI. Finally, when predicting from 18 to 36 months, the same finding occurred as in study 1: 18-month MDI was a strong predictor of 36-month MDI, whereas sensitivity at both time points did not predict capacity.

In Study 2, to combat Type II error, alpha was increased to .10; however, with an alpha of .10 the risk of Type I error was increased. In addition, even though I increased the alpha to .10, power was still low. Therefore, it is not clear whether null results are in fact true, or a result of Type II error. Taking this into account, the results from Study 2 are considered with caution and an understanding that more research is required before any firm conclusions are drawn.

## Maternal Sensitivity and Cognitive Development

A possible interpretation of these findings is that maternal sensitivity *influences* early cognitive development. This explanation is consistent with Vygotsky's theory of the "zone of proximal development", which refers to the difference between what a child can accomplish

independently versus what he/she can accomplish with guidance from a more skilled partner (Vygotsky, 1991). Presumably, instruction from a parent within this zone leads to cognitive growth in a child, and maternal sensitivity may be critical in this process. A mother who is sensitively attuned to her child may better direct her child's learning to certain aspects of a challenging task in order for her child to learn. By consistently scaffolding her child's learning in a way that is contingent on her child's perspicacity for that instruction, she may be influencing her child's cognitive growth.

Neuropsychologists have determined that experience can modify brain structure (see Cicchetti & Curtis, 2006). Younger infants may be more influenced by their environment than older infants because of their malleable stage of neurodevelopment. Neuroplasticity refers to the ability of the brain to change as a result of experience. Although neuroplasticity can take place throughout the lifespan, these modifications are more likely to occur in early infant development (Cicchetti & Curtis, 2006). Specifically, the influence of maternal sensitivity on cognitive development may result from *experience-expectant neural plasticity*. Experience-expectant neural plasticity refers to changes in the brain that occur because the brain is primed to receive certain information from the environment at a particular period of time. In accordance with this process, the optimal time for an infant to experience maternal sensitivity may be in early infancy (Cicchetti & Curtis, 2006). Thus, sensitivity early on may influence cognitive functioning of the child in part because of the brain's susceptibility to environmental influence at this stage in development.

One might argue, however, that it is the other way around; that a more cognitively developed child effectively elicits more sensitive parenting from his/her mother. This directional hypothesis is not likely. Interventions aimed at improving mother-child interactions have a positive impact on cognitive development (Tarabulsy, Baudry, & Atkinson, 2010); therefore, a

mother's improvement in responding promptly and appropriately to her infant's signals directly impacts her infant's cognitive development. These findings suggest it is unlikely that an infant's level of cognitive capacity influences sensitive parenting; rather, it is the reverse that occurs.

## Sensitivity linked to Change in Cognition

No researchers to date have related *change* in cognitive capacity to sensitivity. In Study 1, I calculated a change score for cognitive capacity (from 6 to 36 months), and correlated it with maternal sensitivity (r = .27, p = .06). I also calculated another capacity change score (12 to 18 months) as a metric by which to assess the influence of sensitivity on change. The correlation between these change scores (r = .06) was not significant (p = .70). Nor was the difference in correlations between sensitivity and change, on the one hand, and change from 12 to 18 months and change from 6 to 36 months, on the other. These data show that maternal sensitivity may account for change in cognitive capacity and, at the same time, they are consistent with earlier research showing the lack of cognitive stability during infancy.

The change analysis for Study 2 revealed the same trend as in Study 1. The MDI change score was not significantly correlated with sensitivity at 6 months; however, the correlation was  $.28 \ (p = .19)$ , and may have not been significant due to lack of power. The 6 to 36 month MDI change score essentially did not correlate with the 12 to 18 month MDI change score. The lack of significance and low power preclude firm conclusions with respect to this aspect of the study. Overall, however, results are consistent with the hypothesis that maternal sensitivity is associated with change in infant cognitive development over time.

#### Potential Mediators

Maternal sensitivity may influence cognitive development because sensitive instruction from a parent may be crucial to an infant's learning and cognitive advancement (Vygotsky, 1991).

An ensuing step is to determine potential factors that underlie the relation between maternal sensitivity and infant cognitive development. Some potential mediators may be the infant's willingness to explore (Hazen & Durrett, 1982), mastery motivation, goal oriented play (Frodi et al., 1985), and negotiation of the environment (Cassidy, 1986). These constructs are related to security of attachment, and presumably result from sensitive parenting. It is possible that these variables underlie the relation between sensitive parenting and infant cognitive development.

Another important variable to consider is *infant attention*, a type of information processing which is an important predictor of cognitive development (Bornstein & Sigman, 1986). More specifically, attention in infancy refers to how an infant shifts focus to part of the environment that is novel (recovery), and shifts focus away from an aspect of the environment that is unchanging (decrement; Bornstein & Sigman, 1986). Infants who demonstrate recovery and decrement of attention tend to prefer complexity (Greenberg, O'Donnell, & Crawford, 1973), tend to explore the environment rapidly (Messer, Kagan, & McCall, 1970), and problem solve quickly (Lewis, Goldberg, & Campell, 1969).

Attention has also been linked to sensitivity and attachment (Atkinson, Scott, Chisholm, Blackwell, Dickens, Tam, et al. 1995). In order for a mother to respond sensitively, she must be proficient in monitoring her infant by balancing attention with respect to environmental/contextual demands and infant signals. Secure infants, who are exposed to consistently sensitive mothers, are able to flexibly shift attention from the caregiver to exploration, and back again when necessary (Main, 1995). Conversely, resistant and avoidant infants experience mothers who are inconsistent or insensitive, respectively. Thus, resistant and avoidant infants tend to rigidly maintain a certain attentional state, either on the caregiver or on exploration (Main, 1995). An infant who is able to fluidly shift attention and focus on novel

stimuli is likely to explore new tasks and perform well during cognitive testing later in childhood (Bornstein & Sigman, 1986; Rose et al., 2008). Future research should investigate whether infant attention mediates the relationship between maternal sensitivity and infant cognitive development.

# *Instability of Sensitivity*

Within the literature, the stability of maternal sensitivity ranges from low (Bornstein & Tamis-LeModa, 1990; Beckwith, Cohen, & Hamilton, 1999), to moderate (Isabella, 1993; Vizziello Ferrero, & Musicco, 2000). Overall, the stability of maternal sensitivity is inconsistent throughout the literature (Kemppinen, Kumpulainen, Raita-Hasu, Moilanen, & Ebeling, 2006).

In the current study, 6-month sensitivity did not significantly correlate with 18-month sensitivity (r = .15). This correlation is perhaps lower than previous stability findings (e.g. 6 to 24 months r = .29, p < .05; Pianta, Sroufe, & Egeland, 1989); however, it is not surprising given stability of sensitivity has been inconsistent throughout the literature. Previously, researchers had amalgamated sensitivity scores (Lemelin et al., 2006; Tarabulsy et al., 2009; Taylor et al., 2008), which may be problematic considering low stability of sensitivity. This finding (r = .15) confirms needed caution in combining sensitivity results.

Low stability may have occurred in this study for the following reasons. Firstly, it is possible for sensitivity to change over time, especially due to changes in environmental circumstances (e.g., parental stress; Degroat, 2003). The second possibility is artifactual in nature and depends on methodology. Different instruments were used to assess sensitivity at the different time points (Ainsworth Scale at 6 months and MBQS at 18 months). The MBQS has shown to be a stronger predictor of attachment security than the Ainsworth Scale (Atkinson, Paglia, Coolbear, Niccols, Poulton, Leung, et al., 2000). Since the MBQS is considered a richer assessment of maternal sensitivity, it is possible the Ainsworth Scale is missing valuable information and in turn

correlating weakly with the MBQS. Essentially, this explanation attributes the lack of stability in maternal sensitivity between 6 and 18 months to measurement error.

Finally, sensitivity at 6 months may not be as strong a measure of sensitivity as would an assessment at 18 months (Ainsworth et al., 1978). According to attachment theory, sensitive parenting is based on maternal behavior, or maternal responsiveness, that is contingent on the infant's bids for attention (Ainsworth et al., 1978). Based on how the infant reacts to the mother's behavior, the coder can know how effective the mother's strategies were. Since a 6-month old is not particularly socially reactive at this stage in development, it may be more difficult to code maternal sensitivity. Conversely, an older infant will be more responsive and reactive to his/her mother's behaviour, giving the coder a clearer indication of the quality of interaction and in turn a better indication of how sensitive the mother is.

#### Limitations and Future Direction

A limitation of the present study is small sample size and lack of power. To combat lack of power in study 2, alpha levels were increased to .10. This, in turn, increased the probability of Type I and Type II error. A larger sample size is required for future studies. Another limitation is that Study 2 is not independent of Study 1. Study 2 is a subsample of Study 1; thus, comparing results across these studies should be done cautiously.

Considering multiple regressions were conducted with two or three predictors and a small sample, these results must be interpreted with caution. Overall, I ran a series of very conservative equations. Each predictor introduced cost a degree of freedom from the error term without diminishing error variance. Since early prior capacity is not a strong predictor of subsequent cognitive development (McCall 1979), including it as a predictor has possibly undermined the power of sensitivity to predict cognitive outcome because the error term is relatively large. For

instance, in Study 2, 6-month maternal sensitivity and 36-month MDI are significantly correlated, yet 6-month sensitivity is not a significant predictor of 36 month MDI, likely because of increased error. It is possible that with a larger sample, sensitivity at both 6 and 18 months would have been significant predictors at intervals where they approached significance.

When compared to the Canadian population, infants born SGA were overrepresented in the current sample (Statistics Canada, June 2010). Although this was the case, the overall sample had high variability with regards to birth weight, and represents a full range of possible birth weights. Also, the present sample disproportionately included families with high socioeconomic status (SES). Future research should include families from a more expansive range of SES. Moreover, participants with complete data had higher SES and higher MDI scores at 36 months than those with incomplete data. Therefore, the sample may be higher functioning than the general population. This may restrict range of cognitive function and variability of participant characteristics. To this extent, the sample may not be fully representative of the population. Restrictions may have affected results of this study, rendering them more conservative than might have otherwise been the case.

An additional limitation of the current research is that I have not taken into account prenatal development. Important brain development occurs prenatally; for instance, most cortical neurons in the human cerebrum are generated prenatally (Cicchetti & Curtis, 2006). Furthermore, it is possible that the mothers who were most sensitive postnatally were the least stressed prenatally. Prenatal stress of the mother may compromise brain development of the infant; for example, prenatal stress in rat mothers has been found to cause dendritic atrophy of hypocampal neurons in rat offspring (Jia, Yang, Sun, Cai, Li, Cheng, et al., 2010). Since prenatal stress of the mother may be detrimental to brain development of the unborn fetus, infants of prenatally stressed

mothers may not develop optimally in terms of cognitive functioning. In future research, prenatal development should be considered as a covariate of cognitive development since it may be related to both maternal sensitivity and infant cognitive functioning.

Another limitation is that maternal intelligence was not controlled for in this study.

Although maternal sensitivity and maternal intelligence are not strongly related constructs
(Borduin, Henggeler, Sanders-Walls, & Harbin, 1986), maternal intelligence may be a relevant
moderator since there would be some genetic overlap between mother and infant (Plomin &
Petrill, 1997). In addition, there may be environmental overlap; for instance, a more intelligent
mother may structure the infant's environment differently, which might impact cognitive
development of the child. In future research, maternal intelligence should be explored since it is a
possible confounding variable.

With regards to the current dataset, maternal education was collected and will be available for analysis in the near future. Maternal education can act as a proxy for maternal intelligence and can be controlled for in all regression analyses. In terms of sample size, this dataset is currently growing. With a larger sample, Type II error will less likely be an issue. In addition, with a larger sample, more predictor variables can be included in multiple regression analyses (e.g., maternal education, maternal sensitivity at multiple time points), without increasing risk of statistical error.

Although maternal sensitivity seems to drop out as a significant predictor as the child approaches preschool, sensitive parenting may still be an important predictor. Perhaps if maternal sensitivity is measured in the context of *attention*, it will account for cognitive development in preschool and early childhood. Joint attention refers to a mother and child's mutual focus on an object or event with a goal to share the object or event. Maternal sensitivity is

an active component of joint attention. For the purposes of predicting cognitive development, maternal sensitivity might be best assessed in the context of joint attention because it is an interactive process between mother and child that incorporates the construct of *attention*. Research has shown that joint attention is related to language ability and theory of mind (Charman, Baron-Cohen, Swettenham, Baird, Cox, & Drew, 2000); however, no studies to date have evaluated whether joint attention predicts cognitive development in childhood. For future research, investigators should examine the link between joint attention and cognitive development in childhood.

### Conclusions

Incorporating predictors at several time points has allowed for a richer examination of cognitive development and maternal sensitivity. I have extended the literature by showing longitudinally at which points during infancy sensitivity and prior capacity are significant predictors of cognitive development. The present research has shown that maternal sensitivity, at both earlier (6 months) and later (18 months) points in infancy, is an important predictor of cognitive development, as it has predicted above and beyond early prior capacity. Once the child reaches late infancy, however, prior capacity appears a better predictor of cognitive development than maternal sensitivity, although I was unable to test this formally. Consistent with these findings, trends suggest that maternal sensitivity is associated with change in cognitive capacity, with more sensitive mothers having infants who show the greatest cognitive development between 6 and 36 months. A promising avenue for future research is an investigation of infant attention and mother-infant "joint attention" as predictors of child cognitive development.

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# Appendix

# Study 1 and 2 Assumptions

To determine normality of all variables, skewness and kurtosis values were examined. Skewness values were found to be smaller than |2| and kurtosis values smaller than |7|, indicating that data transformations were not necessary (West, Finch, & Curran, 1995). Skewness and kurtosis values are displayed in Table 9 for Study 1 and Table 10 for Study 2. Frequency histograms were created for the MBQS, and Bayley MDI at 6, 12, 18 and 36 months. Using the eye-balling technique, it was determined that all variables normally distributed. To detect univariate outliers in the data, minimum and maximum Z scores were obtained for all variables. As displayed in Table 9, all absolute Z score values were less than 3.29 indicating that no extreme scores were present (Tabacknick & Fidell, 1996).

Multiple regression assumptions of linearity and homoscedasticity were checked by plotting the standardized residuals against the standardized predicted values. The resulting scatter plots appeared random and, therefore, the assumptions of linearity and homoscedasticity were met. The normal distribution of the histogram of the residuals and the normal P-P plot indicated that there was a normal distribution of the residuals. Given that the dataset also has independence of the error terms, all assumptions of multiple linear regression were met.

Table 10 Skewness, Kurtosis, and Z scores for all variables from Study 1 (N = 45)

	Skewness (SE)	Kurtosis (SE)	Min Z Score	Max Z Score
MDI 6	-0.33(0.35)	-0.33(0.70)	-2.12	1.68
MDI 12	-0.20(0.35)	0.03(0.70)	-2.70	1.84
MDI 18	0.15(0.35)	-0.54(0.70)	-2.07	2.02
MDI 36	-0.44(0.35)	-0.31(0.70)	-2.32	1.67
MBQS	-0.78(0.35)	-0.45(0.70)	-2.42	1.17

Note. MDI = Mental Development Index, MBQS = Maternal Behavior Q-Sort.

Table 11 Skewness and Kurtosis scores for all variables from Study 2 (N = 26)

	Skewness (SE)	Kurtosis (SE)	-
MDI 6	-0.41(0.46)	0.14(0.89)	_
MDI 12	-0.18(0.46)	-0.22(0.89)	
MDI 18	-0.24(0.46)	-0.57(0.89)	
MDI 36	-0.38(0.46)	-0.35(0.89)	
Ainsworth	0.15(0.46)	-0.13(0.89)	
Scale			
MBQS	-0.52(0.46)	-0.83(0.89)	

Note. MDI = Mental Development Index, MBQS = Maternal Behavior Q-Sort.