THE RELATION BETWEEN INFANT ANTHROPOMETRY AND VISUAL INFORMATION PROCESSING

By

EBTESAM E.M. SENOSSI

Bachelor of Science in Public Health

Omar Almuktar University

Beida, Libya

1998

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 2011

THE RELATION BETWEEN INFANT

ANTHROPOMETRY AND VISUAL

INFORMATION PROCESSING

Thesis Approved:

Dr. Tay Kennedy

Thesis Adviser

Dr. Barbara Stoecker

Dr. David Thomas

Dr. Mark Payton

Dean of the Graduate College

ACKNOWLEDGMENTS

.

I would like to thank all the research team for the opportunity to work on this project, especially Nicki Aubuchon-Endsley, Stephanie Grant, and Tabitha Valtr. I also like to sincerely thank my committee members Dr. Thomas, and Dr. Stoecker, for their support and guidance. And last but not least I would like to thank Dr. Kennedy for her excellent support, guidance and patience that she provided to me throughout this entire process.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

Table Page

CHAPTER I

INTRODUCTION

Infant growth is a process that involves changes in both size and behavior; physical growth contributes to the developmental process of the mental and cognitive abilities of infants and children that is demonstrated in motor and intellectual performance (Johnson & Blasco, 1997; Vaughan, 1992). Anthropometric measurements are commonly used as indices to assess physical growth and development in infants and children. Growth is evaluated by comparing individual measurements to standard references represented by percentile curves on a growth chart. Anthropometric deficits could contribute later to delays in cognitive and intellectual performance in children (Mendez & Adair, 1999).

Inadequate nutrition during infancy and childhood contributes to faltering in linear growth and to impaired mental and intellectual performance. In addition, maternal factors such as nutritional status, socio-economic status, and dietary habits such as consumption of alcohol and caffeine, might affect the growth of infants (Fahmida et al., 2008; Nolan, Schell, Stark, & Gomez, 2001). Micronutrient or energy supplement has beneficial effects on growth and development if the infants or children are malnourished or have deficits in growth (Ashworth, Morris, Lira, & McGregor, 1998; Black, Sazawal, Black, Khosla, Kumar, & Menor, 2004; Hamadani, Fuchs, Osendarp, Khatun, Huda, & Grantham-McGregor 2001; Torbjan, Lonnerdal, Stenlund, Gamayanti,Isamil, Seswandhana, & Perrson, 2004).

Anthropometry:

Anthropometric measures have been widely used in research studies, especially those related to children and infants (Engebretsen, Tylleskar, Wamani, Karamagi, & Tumwine, 2008; Fok et al., 2009; Vaktskjold,Tri, Phi, & Sandanger, 2010). Anthropometry assesses the size, proportion, and composition of the human body (Mascarenhas, Zemel, & Stallings, 1998). The proper assessment and interpretation of physical status can help prevent future health problems and also help evaluate the effect of the nutrition and public health interventions (de Onis & Blossner, 2003). Anthropometric measurements can be divided into two types (World Health Organization [WHO], 1995):

- Body size measurements: which includes the height, length, weight, and head circumference; these indices are used to detect any changes in nutritional status and growth development.
- Body composition measurements: which includes the skin fold and mid upper arm circumferences (MUAC); these measurements are used to assess body fat and lean body mass.

The WHO (2006) focuses on use and interpretation of anthropometric measurements. The anthropometric indices which are commonly used as standards for evaluating the adequacy of nutrition and growth are derived by comparison to three standard reference curves: 1) length-for -age; 2) weight-for-age; 3) weight-for-length. Although a deficit in one or more of the anthropometric indices is often related to malnutrition, anthropometric measurements do not assess the cause of malnutrition. Thus the interpretation of growth deficits depends on the indices that are used, cause of deficit, and socioeconomic status. The socioeconomic status suggests how low-income and poverty lead to food insecurity and inadequate health care, and eventually results in poor growth which is represented in diminished physical health and cognitive abilities (Brooks-Gunn & Duncan, 1997).

The use of the Z-score for evaluating anthropometric data allows for the comparison of growth at different ages and between genders (Mei & Grummer-Strawn, 2007). New child growth standards were released in 2006 by WHO which replaced the US National Center for Health Statistic (NCHS) reference. The aims of releasing a new reference were to represent how children should grow rather than how they are growing by using a diverse sample from different geographic sites. Only infants who complied with the WHO breastfeeding recommendations were included and there were frequent measurements of growth in the early months of life. Thus the reference population reflected current health and feeding recommendations (de Onis, Onyango, Borghi, Garaza, & Yang, 2006).

Visual information processing (VIP):

Recent studies used procedures like visual information processing to assess specific cognitive processes and examine cognitive development. For example, the Fagan Test of Infant Intelligence is based on the preference that an infant shows for a novel stimulus, which is an active phenomenon that is found in early infancy (Fagan, 1984b; Rose & Feldman, 1997; Rose &Wallace, 1985). This approach of examining specific underlying cognitive processes differs from past approaches that used scales of general development to measure infant cognitive and mental development (Nellis & Gridly, 1994). General measures of development include the Bayley Scales of Infant Development (Bayley, 1993) which is comprised of three assessments: 1) a *mental scale* assessing tasks such as looking for a hidden object and naming pictures, 2) a *motor scale* which assesses skills including grasping ability and movement skills, and 3) a *behavior scale* assessing sociability and displays of fear.

VIP is used to assess the speed at which information can be encoded and the rapidity with which information is acquired (Rose, Feldman & Jankowsky, 2004). Results can also be used to derive novelty preference which measures the infant's tendency to direct visual attention toward a novel stimulus rather than the familiar one. Visual habituation is exhibited as a decrease of attention to a repeatedly presented stimulus. Colombo & Janowsky (1998) and Kavsek (2004) suggested that fast habituators are characterized by short looking times, whereas slow habituators demonstrate a relatively longer looking. In addition, rapid habituation indicates the ability to rapidly encode the visual stimulus into memory. On the other hand, visual dishabituation refers to attention given toward a novel stimulus following habituation.

A strong dishabituation (novelty preference) reaction illustrates an advanced capability of discriminatory recognition performance among infants (Kavsek, 2004). The strength of dishabituation can be measured by comparing the duration of looking toward the habituation stimulus at the end of the phase with the duration of looking toward the novel stimulus. The duration of the longest look during the habituation phase is considered to be one of the more sensitive variables with a longer look indicating the speed and the process of stimuli encoding (Colombo, 2001). Jacobson, Jacobson, Sokol, Martier, & Ager (1993) found that prenatal alcohol exposure negatively affects infant speed of processing and could contribute later to learning problems.

Also different levels of docosahexaaeonic acid (DHA) are related to development of attention in infants. Colombo, Shaddy, Richman, Maikran, and Blaga (2004) found that infants whose mothers had high levels of DHA at birth showed accelerated developmental stages in attention during their first year. Breastfeeding has been shown to provide DHA, which is an essential nutrient for neural and psychomotor development (Heird, 2001; Jensen, Voigt, & Prager, 2005).

Kennedy et al., (2008) examined growth and visual information processing in generally malnourished infants 6-8 months of age in Ethiopia and found that infants had a strong familiarity preference rather than the expected novelty preference. In addition, their results showed significant differences among the malnourished and the well-nourished infants in regard to the VIP. Rose (1994) also reported that anthropometric measurements that are used to assess malnutrition and growth are related to information processing in infants. Infants who exhibited deficits in weight, length, and head circumference performed poorly on tasks of visual recognition memory.

Research Question:

The gap that needs to be investigated further is identifying if normal growth patterns of breastfed infants in the United States could be related to cognitive development outcomes. The objective of this study is to examine how growth, as a general indicator of nutritional status in infants, is correlated to cognitive ability as measured by VIP; and to determine how socio-economic and maternal factors may affect the relation between physical growth and cognitive development of infants at the age 3 months.

Methods:

Subjects and Recruitment:

One hundred and thirty one pairs of 3 month-old infants (predominately breastfed) and their mothers are included in the study. The inclusion criteria for recruiting included full term single birth infants, and exclusion criteria involved infants who take more than 28 oz of formula/week, maternal blood transfusion or illness, and current infant illness.

Tests and Measurements:

At 3 months of age (13weeks ± 2) infants and their mothers were asked to visit the laboratory for the following procedures:

1) Visual Information Processing: The dependent variables that are derived from the VIP procedure are the length of the longest look, mean duration of looks, and number of glance shifts per unit time, which are suggested to represent the speed and efficiency by which the infant processes visual stimuli. The novelty preference, measured as percentages of total looking time that the infant fixates on the novel stimulus during the test is used to assess memory (Thompson, Fagan, & Fulker, 1991).

2) Anthropometric Assessment: Infants will be weighed using a digital infant scale and measured on an infant length board. Head circumference is assessed with a non-stretchable tape.

3) Demographics: At the three month visit, mothers will be given a demographic information questionnaire.

Data analysis plan:

Correlation analysis will be used to identify the relationship between the variables. Regression analysis will also be used with the significant variables of the correlation analysis. The demographic characteristics and infant anthropometry z-scores will be the independent variables and the VIP variables will be the dependent variables. The anthropometric measurements (height, weight, and head circumference) will be converted to z-scores using WHO Anthro software and the significance will take the value $p < 0.05$.

Limitations:

Recruiting only healthy breast fed infants and not including formula fed infants could be considered bias. In addition, it could be hard for some infants to tolerate the mental trial tests, which can lead in some cases to incomplete data. There is also the difficulty of recruiting mothers to participate in a long term study which demands continuing time and effort of the family especially for those who live at far distances.

CHAPTER II

LITERATURE REVIEW

Anthropometric measurements are used as indices to assess short-term and long-term growth and predict functional outcomes. Several studies have investigated factors that affect the growth of infants such as nutritional status, feeding patterns (Agostoni, Grandi, Gianni, Torcoletti, Giovannini, & Rita 1990; Donma & Donma, 1999), socio-economic status, and maternal dietary habits as in the consumption of alcohol and caffeine (Day et al., 1990; Fahmida et al., 2008; Haste, Brooke, Anderson, & Balnd, 1991; Nolan, Schell, Stark, & Gomez, 2001; Shu, Hatch, Mills, Clemens & Susser, 1995).

However; limited studies have looked at the relation between infant growth in terms of anthropometry measurements and cognitive development in terms of visual information processing (VIP) (Kennedy et al., 2008; Rose, 1994). Therefore, the purpose of this study is to investigate how physical growth of the infant, which is evaluated by using anthropometric indices, could be associated with VIP, which is an infant procedure that is used to predict later cognitive and intellectual development (Rose, & Feldman, 1997; Rose, Feldman, & Wallace, 1992).

This section will review previous studies that investigated the relation between anthropometric measurements in infancy and cognitive and intellectual outcome. In addition, several studies have illustrated the effect of maternal demographic factors such as education, employment, social-economic status, and ethnicity on infant physical growth and cognitive development. Finally, evidence showing the significant impact of breastfeeding in enhancing the neurological system in early infancy and its contribution toward better cognitive functional outcome will be summarized.

<u>Section 1- Anthropometry and Intelligence:</u>

Growth monitoring during infancy allows for early detection of chronic illness or nutritional deficiency. It is also important for evaluating the efficacy of medical and nutritional intervention (Ross & English, 2005). The most common anthropometry measurements during infancy include weight and length. Length is an excellent indicator of growth, since it is not subject to daily variations as is the case with weight. Measurement of head circumference is an indicator of brain growth, and while it is a less sensitive indicator of growth, it reflects brain development and possible neurological disorders (Gokhale & Kirschner, 2003). Three different systems are commonly used for evaluating body size anthropometric data. All three systems compare an individual child's growth to the growth of children in a reference population (WHO, 1995):

1) The Z-score or standard deviation system, this system expresses the anthropometric value as the number of standard deviations that are below or above the median value.
2) The percentile system, the percentile refers to the position of an individual on a given reference distribution.
3) The percent of median system: The anthropometric measurements are expressed as a percentage of the median value of the expected reference.

It is important to repeat the measurements frequently to avoid errors in the interpretation of anthropometric indices (World Health Organization [WHO], 1995). Several studies have examined the effect of micronutrients and macronutrients on growth and development during infancy (defined as between birth and 12 months of age).

Torbjorn et al. (2004) conducted a study in Indonesian that tested the effect of zinc and iron on growth and psychomotor development in infants. They tested each nutrient as a single supplement and zinc and iron as a combined supplement. The results showed that giving the zinc and iron as two single supplements significantly improved growth and psychomotor development, but using them as one supplement did not affect growth or development, probably because of the antagonistic interactions between the two metals that may have affected their absorption. Another study showed that supplementation in pregnancy of under nourished mothers with multiple micronutrients which included 15 different vitamins and minerals (iodide, zinc, selenium, Cu, Vitamin A, $B_{1,}$ B_2, B_3, B_6, B_{12}, C, D, E) in addition to iron-folate supplements, had a significant benefit for infants in their motor development and activity levels compared to infants whose mothers received only an iron-folate supplement (Fahmida et al., 2008).

Infant feeding patterns can also affect the growth and development of infants. A study in India found that breast milk enhances nervous system development (Selvakumar & Vishnu Bhat, 2007). This development was quantified using the Trivandrum Development Screening Charts (TDSC). Anthropometric parameters were measured and analyzed with Z-score of weight, and weight-for-height using CDC 2000 anthropometric standards. The TDSC scores were significantly different between babies weaned before three months of age and ones that weaned around the ideal time of six months or more. A significantly lower development score was found in early weaned (< 3 months) infants compared to those exclusively breast fed for 6 months or more. Furthermore, significant difference in Z-scores of weight was observed. Infants exclusively breast fed beyond the ideal time (6 months) showed lower Z-score of weight compared to infants exclusively breast fed for 6 months or less. Infants who were exclusively breast fed for ≤3 months are more likely to have slower development, while infants weaned after 6 months are more likely to have lower weight than those weaned at 6 months.

Heinonn et al. (2008) conducted a study in Finland to investigate the relation between growth and cognitive abilities in infancy and early childhood. Anthropometric measures (weight, length, and head circumference) were measured at 5, 20, and 56 months of age, and there were four cognitive- ability tests administered to the children at 56 month of age: 1) general reasoning 2) visual-motor integration 3) verbal competence, and 4) language comprehension. The study revealed that children born at term with a relatively smaller body size at birth performed worse on cognitive performance tests later at 56 months of age. This suggests that different periods and measures of growth may be associated with different effects on later cognitive abilities. Low BMI and decreased head circumference might have negative effects on cognitive abilities that could extend from birth to the second year of age while a decrease in growth rate (weight and height) could have negative effect on cognitive abilities during the early months of age (birth to 5 months).

A study in France investigated the relation between growth status and the development of cognitive and intellectual abilities (Vaivre-Douret et al., 2009). Information such as gestational age in weeks, birth weight, head circumference, and stature was recorded from the child's medical file. A parent questionnaire was mailed to 1200 families covering different aspects of child and family history (pregnancy, neonatal period, psychomotor development, schooling and parental socio-economic status). Only 725 of the questionnaires were returned and the study distinguished three groups: preterm infants, full-term infants, and post-term infants.

The research showed that there was no significant difference between the preterm and full-term infants in regard to their motor abilities (sitting, crawling, walking), but the post-term were significantly earlier than the preterm and full-term infants in developing these abilities (Vaivre-Douret et al.,2009). Also the IQ was measured during primary or secondary schooling (mean age: 11.0± 4 years) by using the WISC-III. The IQ scores of children who were preterm at birth did not significantly differ from those who were full-term and post-term infants. This implies that children born preterm could catch up in growth when they are exposed to favorable prenatal environment (few pregnancy complications) and favorable postnatal socio-economic environment.

Broekman et al. (2008) examined the association between birth length (BL), birth weight (BW), head circumference (HC), gestational age at birth (GA) and childhood IQ in a large cohort study of healthy Singapore children of normal birth size. Children aged 7 to 9 years, were recruited from 3 schools in different parts of Singapore. The children's IQ was measured by completing the Raven's Standard Progressive Matrices (RPM). This test assesses visual alertness and spatial and abstract pattern-recognition abilities, and the parents completed a baseline questionnaire. The finding showed that the children who were born with normal ranges of BL, BW, and HCs had higher IQ scores later in childhood. This also suggests that BL may better reflect the phases of fetal growth related to later cognitive function, because fetal length increases primarily during the second trimester which suggests that developmental process during this period has a lasting effect on cognitive ability.

The Avon longitudinal study was conducted in the United Kingdom to investigate the effect of head growth prenatally, during infancy, and during later periods of development on cognitive function of 633 full-term infants (Gale, O'Callaghan, Bredow, & Martyn, 2006). The cohort was asked to attend clinics for a follow up examination at 4, 8, 12, 18, 25, 31, 37, 43, 49, 61, and 96 months of age. Head circumference was measured after birth and during each visit to the clinic. Furthermore, standing heights at the ages of 4 and 8 years were measured. Cognitive function was evaluated with the Wechsler Preschool and Primary Scale of Intelligence at the age of 4 years and with Wechsler Intelligence Scale at the age of 8 years. The results showed that head circumference at birth was a significant indicator of performance IQ scores at the age of 4 years. It was also an important predictor of IQ at the age of 8 years. However, the findings showed that brain growth during infancy is the most significant period of postnatal brain growth for predicting later intelligence.

An Avon longitudinal study of parents and children (ALSPAC) investigated the association between poor weight gain in infancy and subsequent intellectual deficit (Edmond, Blair, Emmett, & Drewett, 2007). A total of 1406 live births were included in the cohort study. Weight measurements were taken at birth, at 8 weeks (range1-3 months), and 9 months (range 6-12 months), Socioeconomic and health data were collected by using a series of postal questionnaires completed by the parents at 4 weeks, 6months, and 15 months after delivery. And at the age of 8 years, children were tested by using the Wechsler Intelligence Scale for Children. There was a positive linear relationship between infant growth from birth to 8 weeks and child IQ at 8 years of age. An improved weight gain in early infancy (first 8 weeks) was significantly associated with increase in child IQ scores. Also parental education and social class showed to be strong predictors of IQ scores, children whom performed well on the test were from better educated families. This suggests that the deficit in IQ is related to early rather than later growth faltering, and timely intervention is required to prevent any intellectual deficits that may occur.

The US Collaborative Prenatal Project (CPP) studied the impact of season of birth on various anthropometric and neurocognitive development variables from birth to 7 years of age (McGrath, Saha, Lieberman & Buka, 2006). Between 1960 and 1967, the CPP conducted a study, involving 50,000 women and their offspring from 12 different US sites. The main predictor variable of this study was season of birth, while the outcome variables included three anthropometric measurements (weight, length or height, and head circumference). Six measures of motor and cognitive developments were used during the study. Weight, length, and head circumference were examined at birth, 8 months, 4 and 7 years of age.

The main findings showed that winter and spring births were associated with changed physical and neurocognitive outcomes (McGrath, Saha, Lieberman & Buka, 2006). At birth, winter/spring babies were significantly taller, heavier, and had larger head circumference. However, season of birth was not significantly associated with any of the anthropometric measures at the age 8 months or 4 years, although there was a remarkable relation between winter/spring birth and improved performance of the Bayley Scale motor component at 8 months of age. However, the relation was not so obvious on the Bender Gestalt Test that measures the visuo-constructive ability. (This suggests that exposure to seasonal changes influences brain developments more in some domains (fine and gross motor coordination) than others (sensory discrimination ability).

The National Collaborative Prenatal Project in the US examined the relation between variation in birth weight and IQ (Matte, Bresnahan, Begg, & Susser, 2003). A sibship sample was constructed from children who met specific inclusion criteria. The full sibship sample included 3484 children from 1683 families. Children from the sibship sample were from families of higher than average socioeconomic status. Furthermore, two samples were drawn from the full sibship sample, the first sib sample included one sibling and was chosen randomly from each family (n= 1683, 871 girls and 812 boys). The second sample included all siblings pair from families contributing only two children and were chosen randomly from larger sibships (n= 3366, 1742 girls and 1624 boys)

The intelligence tests were administered at age 7 years, including four of five verbal and three of five performance tests from the Wechsler Intelligence Scale for Children (Matte, Bresnahan, Begg, & Susser, 2003). The results showed a significant association between IQ and birth weight in both sexes, and it was stronger in boys than girls, a 1000 g increase in birth weight relates to a 4.6 point increase in IQ among boys but only 2.8 among girls. Within siblings pairs of the same sex, IQ differences were related to differences in birth weight (heavier sibling have higher IQ), but this association was significant only in boys. However, children with low birth weight had a slightly lower mean IQ than their same sex, normal birth weight siblings. This implies that IQ at age 7 years is linearly associated to birth weight among children of normal birth weight.

Evidence showed that IQ tends to be higher in those with normal birth weight. Gale, O’Callaghan, Godfrey, Law, and Martyn, 2004 investigated the relationship between brain growth in different periods of pre- and postnatal life and cognitive function of 9 year-old children. The study included singleton children born to Caucasian women who attended antenatal clinic at < 17 weeks gestation. Anthropometric measurements were taken at three time periods: 18 weeks gestation (fetal ultrasound), birth, and 9 months of age. Information about the pregnancy and delivery, parental social class, and maternal education were collected. At the 9 month postnatal visit, women were asked regarding infant feeding. A total of 559 children were followed up to the age of 9 months, and a total of 221 children were tested for their cognitive function at age 9 years.

The cognitive function of the child and his/her mother was assessed using the Wechsler Abbreviated Intelligence Scale; this provides age-adjusted IQ scores for full scale, verbal and performance intelligence (Gale, O'Callaghan, Godfrey, Law, & Martyn, 2004). The results showed that boys achieved higher scores than girls for full-scale IQ (108.7 compared with 104.2) and for performance IQ (107.4 compared with 101.7), but there was no significant difference between the sexes in verbal IQ. There was no significant relation between birth weight and length at birth with IQ at age 9 years, also no significant relation was found between IQ and weight and length at 9 months or weight and height at 9 years. But there were strong significant associations between measures of postnatal head growth and IQ. These findings imply that, increased postnatal brain growth is more important than fetal growth to attain a peak cognitive performance later in childhood.

In summary, infant growth, which is assessed by anthropometric measurements (weight, length, head circumference), contributes to cognitive and intellectual abilities later in childhood in typical weight infants in Singapore (Broekman et al., 2008), Finland (Heinonn et al., 2008), and France (Vaivre-Douret et al., 2009). Micronutrient supplement and exclusive breast feeding have been shown to improve growth and development of infants (Torbjorn et al., 2004; Selvakumar & Vishnu Bhat, 2007). Also season of birth showed impact on anthropometric and neurocognitive development (McGrath, Saha, Lieberman & Buka, 2006). Deficits in anthropometric indices in early infancy (poor weight, length, head circumference) could affect cognitive development later in childhood (Edmon et al., 2007). However, these studies looked at effects of infant growth on later cognitive performance. Using VIP procedures, cognitive development can be assessed in infancy.

Section 2 - Visual Information Processing (VIP) and Intelligence:

Visual information processing assesses attention, memory formation, and ability to process information quickly and efficiently, which are fundamental aspects of cognitive functioning (Bornstein, 1985; Bornstein, Slater, Brown, Roberts, & Barrett, 1997). Measures of habituation refer to the decrease in visual attention that ultimately reflects memory formation of the familiar stimulus, and consequently the processing of information from the stimulus. Therefore measures of habituation have been noticed as potential predictors of intelligence (McCall, 1994). Several studies found evidence that measures of information processing in infancy are related to cognition and intelligence in later childhood (Dougherty & Haith, 1997; Rose, Feldman, Wallace, & McCarton, 1991; Thompson, Fagan & Fulker, 1991).

Kail (2000) described the developmental changes in speed of information processing, and the role of processing speed in the development of intelligence. He examined research that linked speed of information processing to intelligence and concluded that processing speed is an element of intelligence. That is, processing speed is not an independent factor that contributes to intelligence, but is thought to be linked to other elements of intelligence. More rapid processing enhances the memory, which in turn, enhances reasoning. Furthermore, processing speed can influence performance on intelligence tests directly and indirectly. The indirect effect is demonstrated by the impact of processing speed on memory and directly by, speeding retrieval of information from long-term memory, which eventually enhances performance on intelligence test.

Rose, Feldman, and Wallace (1992), examined infant information processing in relation to cognitive performance at 6 years of age. The cohort study consisted of 109 participants (63 preterms, 46 full terms infants) there were examined from 7 months to 6 years of age. At 7 months of age, visual recognition memory was assessed. At 1 year of age the infants first received seven paired comparison problems, three assessed visual recognition memory and four assessed cross-modal transfer (tactual-visual). Finally the Einstein Scale of object permanence was administered; this scale assesses the child's progress through a series of cognitive stages. At 6 years of age, the Wechsler Intelligence Scales for Children was used to assess verbal and performance IQ and other tests that involved measures of language, reading, and quantitative skills were also used. Several tests were used to assess perceptual organization and reasoning.

The results showed that in general the scores were higher for the full-terms infants than those born preterm (Rose, Feldman, & Wallace, 1992). The study found that at 7-months of age the visual recognition score was positively and significantly correlated with all aspects of IQ, at age 6 measures including language, achievement (reading and quantitative skills), and the perceptual organization. The 1-year cross-modal score was related to 6-year IQ. These findings imply that measures of information processing that were obtained during the first year of life are reliable in predicting intelligence and several specific cognitive abilities at 6 years.

Rose and Feldman (1997) examined the role of speed and memory in infant information processing to 11 years old children's IQ. The sample consisted of 90 children (50 preterm and 40 full terms).The participants had been followed from 7 months to 6 years of age, and then were contacted for an additional follow-up at 11 years of age. Two primary measures of information processing in infancy consisted of visual recognition memory and cross-modal transfer. At 11 years of age, children's memory and processing speed were assessed by the Cognitive Ability Test (CAT) and the Specific Cognitive Abilities test (SCA). The IQ was assessed using the Wechsler Intelligence Scale. The results of the study provided evidence that speed and memory are among the major contributors to infant information processing for prediction of later IQ in children. The relation between 7 month visual recognition memory and 11 year IQ declined when speed and/or memory were statistically controlled at 7 months and 1 year to 11 years of age. Furthermore, infants who had better information processing, showed better performance on the

(CAT, SCA) measures later in childhood.

A meta-analysis was conducted by McCall and Carriger (1993); it included studies that investigated infant habituation and recognition memory performance as predictors of later IQ. Some of the conclusions from this review suggested that prediction from habituation and recognition memory may be stronger when such assessments are made between 2 and 8 months of age rather than earlier or later. Infants, who perform tasks from paradigms (habituation and recognition memory) more rapidly which is representative of information processing, are more likely to have higher IQ. And the performance on these processes remains stable from infancy to childhood.

Sheppard and Vernon (2008) conducted a review that investigated the relationship between intelligence and speed of information processing during the past 50 years. Articles (n=172) that presented one or more correlations between mental speed measures and intelligence or effect sizes regarding age, sex, or racial differences for speeded task performance were included in this review. Measures of mental speed used in these studies were classified according to (reaction time, general speed of processing, speed of short-term memory processing, and speed of long-term memory retrieval). Measures of intelligence were classified as (general intelligence, fluid intelligence, and crystallized intelligence). Novel mental speed tasks were more correlated to fluid intelligence, while tasks that required subjects to retrieve learned information from long-term memory were highly correlated with crystallized intelligence. In regard to group differences in mental speed, results showed that mental speed is slower among elderly adults and young children. For the sex differences a number of studies have reported that females tend to have faster mental speed than males. And for racial differences, mental speed was significantly faster in whites than black.

Visual information processing is a aspect of the ability to convey information rapidly, through attention and memory formation to establish cognitive functioning (Bornstein, 1985)
Speed of information processing is an important factor that contributes to intelligence later in

childhood (Rose & Feldman, 1997; Rose, Feldman, & Wallace, 1992). Measures of visual habituation and recognition memory in infancy are potential elements of infant information processing for predicting later intelligence in children (McCall & Carriger, 1993). Also speed of information processing contributes to intelligence by enhancing memory and speeding retrieval of information from long-term memory, which in turn enhances the performance on intelligence tests (Kail, 2000).

Section 3- Anthropometry and Visual Information Processing:

Few studies have investigated the relation between anthropometry and visual information processing in infants (Kennedy et al., 2008; Rose, 1994). Both examined the relation between growth and visual information processing in generally malnourished infants. But no previous studies have investigated this relation in healthy breastfed infants.

Rose (1994) conducted a study in India that examined the relation between physical growth and visual information processing in infants. The sample consisted of 183 infants aged 5 to 12 months and whose weight was either adequate or low for their age. Anthropometric indices of weight-for-age, length-for-age, weight-for-length, and head circumference were used to index variation in physical growth. Also visual recognition memory and tactual-visual cross-modal transfer were measured in infants. The results showed that infants who are longer and heavier performed significantly better than infants who are underweight or have deficits in length growth. And head circumference, birth weight, and history of previous illness were positively associated with performance. Furthermore, maternal weight and height, and parental education were also associated with better infant performance.

Kennedy et al. (2008) examined growth and visual information processing in infants in Southern Ethiopia. Infants (n=100) aged 6 to 8 months were recruited; anthropometry measurements (weight, length, head circumference) and visual information processing (familiarization and test phases) trials were conducted. The final sample consisted of 69 infants, those who were able to complete at least three trials of VIP. The findings showed a correlation between total amount of familiarization and novelty quotient, infants who looked longer at the familiar stimuli had greater visual preference towards the novel one. Furthermore, three multiple regression analysis (longest look during familiarization, mean look duration, and novelty quotient), showed that none of the growth parameters (weight, length, and head circumference) related to novelty quotient, but weight for age Z score alone related significantly to longest look duration. Also head circumference showed a significant relation to the mean look duration. However, infants with lower weight-for-age Z-scores, and length-for-age Z-score had longest looks to stimuli, and slower mean shifts rates respectively during familiarization compared to better nourished infants. This suggests that malnourished infant physical growth is associated with visual information processing.

Infant physical growth is related to cognitive development, and impaired growth due to malnutrition or illness could consequently affect the cognitive process. Infants who are longer and heavier performed better on visual-recognition memory and cross-modal transfer (Rose, 1994). Also infants who are shorter and weigh less tend to look longer to stimuli and have less shift of looking between the familiar and novel stimuli (Kennedy et al., 2008). In general, infants who are adequately nourished have better information processing.

<u>Section 4- Demographic effects on Visual Information Processing / Anthropometry:</u>

Maternal smoking during pregnancy is associated with preterm delivery, low birth weight, and small head circumference (Kallen, 2000; Kyrklud-Blomberg & Cnattingins, 1998; Shah &Bracken, 2000). Also several studies reported that children born to mothers who smoke have deficits in IQ scores relative to those born to mothers who do not smoke (Fergusson & Lloyd, 1999; McGee & Stanton, 1994; Olds, Henderson, & Tatelbaum, 1994).

Kallen (2000) investigated the relation between maternal smoking during pregnancy and infant head circumference at birth. The study was based on all births of Swedish women in 1983-1996. During the first prenatal visit (10-12 week gestation) each women was interviewed for personal information; smoking habits were among the information that was recorded. Three outcomes were considered: head circumference < 32 cm, head circumference < 2 standard deviation (-2 SD) below the expected for gestational age, and the ratio between the actual head circumference and the expected head circumference according to gestational age. The findings of the study showed a statistically significant association between maternal smoking and small head circumference.

Olds, Henderson and Tatelbaum (1994) conducted a study in a semirural county in New York State between April 1978 and September 1980. They interviewed 400 women at the 34th week of gestation, and at 6, 10, 22, 34, and 46 months of the child's life. During the prenatal interview an assessment was made regarding smoking habits, diet, alcohol and drug use.

Women, who smocked ten or more cigarettes per day during pregnancy, were less educated, lived in lower social class, and had fewer prenatal care visits compared to those who did not smoke. Children born to women who smoked heavily during pregnancy had IQ scores at 1 and 2 years of age that were 7 points lower and at 3 and 4 years of age that were 9 points lower than children born to women who did not smoke during pregnancy. These suggest the risk of neuro-development impairment among children born to women who smoke during pregnancy.

A Scandinavian study investigated if smoking during pregnancy may have an adverse effect on child's mental and motor abilities (Trasti,Vik, Jacobsen, & Bakketeig, 1999). The sample consisted of 535 women (35% smokers, 64% non-smokers). Information about smoking habits and length of education was obtained from the women. And a total of 516 children were followed-up during the study, at age 13 months, children were assessed by using the Bayley Scales of infant development (BSID), and with the Wechsler Preschool and Primary Scales of Intelligence (WPPSI-R) at 5 years of age. There was no significant difference observed between children of smokers and non smokers on the BSID test, whereas the IQ scores obtained from WPPSI-R test were lower for children of smokers compared to those of the non smokers. There was a negative effect of smoking during pregnancy on cognitive function but it was not statistically significant.

Several studies have explored how poverty and low parental education are related to low levels of school achievement and IQ later in childhood (Alexander, Entwisle, & Danber, 1993; Duncan, Brooks-Gunn, 1997). Bradley & Corwyn (2002), found that socioeconomic status as an indicator of income, education, and occupation, was associated with better parenting and thus better cognitive outcome in children. Also maternal or parental education was found to be good predictors of later intellectual achievement (Davis-Kean, 2005).

Mayes and Bornstein (1995) conducted a study to investigate the relations between parental education and infant habituation and novelty recovery performance. The sample consisted of 94 term infants. Information on maternal education was classified as: 1) grade school, 2) high school graduate, 3) some college or college degree. Infants were seen at 3 months of age for habituation and novelty preference assessment. Infants who completed the habituation procedure (n= 76), showed no differences between boys and girls among the three maternal educational levels. According to the findings, early information processing is not correlated to maternal education. This suggests that other cognitive domains other than information processing, could still relate to parental education. Furthermore, genetic and behavioral factors may affect early measures of information processing.

Smoking during pregnancy can cause low birth weight and small head circumference (Kallen, 2000; Kyrklud-Blombeg & Cnattingins, 1998). Women who smoke during pregnancy tend to have less education, live in lower socioeconomic status. And children of smokers are more likely to have lower IQ Scores than children of non smokers (Olds, Hendrson, & Tatelbaum, 1994). Also smoking during pregnancy affected mental and motor abilities in infants and children (Trasti, Jacobsen, & Bakketeig, 1999). Although maternal education could contribute to cognitive function in infants and later in children, no significant association between maternal or parental education and information processing has been established (Mayes & Bornstein, 1995).

Section 5- Breast feeding and Intelligence and Growth:

Breast feeding during infancy has been associated with positive effect on later intelligence (Temboury, Otero, Polanco, & Arribas, 1994). Docosahexaenoic acid (DHA), which is a specific nutrient in human milk, was associated with significant improvement in mental, cognitive and motor development during infancy (Birch, Garfield, Hoffman, Uauy, & Birch, 2000). Furthermore, Slykerman et al. (2005) found breast feeding is particularly important for cognitive development of preschool children born small for gestational age. Children who were full term but small for gestational age and breastfed for longer than 12 months had higher IQ scores at 3.5 years of age than those who were not breastfed. Finally, a recent study based on a large randomized trial provided strong evidence that exclusive and prolonged breastfeeding improves children's cognitive development as measured by IQ at teachers' academic rating at age 6.5 years of age (Promotion of Breastfeeding Intervention Trial Study Group [PROBIT], 2008).

Section 6- Summary:

Infant growth is assessed by anthropometric measures, and evaluated by comparing individual measures to standard references, most common anthropometric measures used in infancy include (weight, length, and head circumference) (WHO, 2006). Physical growth contributes to cognitive and mental development (Johnson & Blasco, 1997; Vaughan, 1992). Also inadequate dietary intake could lead to deficits in growth and cognitive abilities (Mendez & Adair). Micronutrient supplements such as zinc and iron have been shown to improve growth and psychomotor development in infants and children. Infants exclusively breast fed for 6 months or more, appear to grow and develop intellectually better than those weaned at 3 months of age (Selvakumar & Vishnu Bhat, 2007). Also improved weight gain and head growth during infancy is significantly associated with higher IQ scores later in childhood (Edmond, Blair, Emmett, & Drewett, 2007; Gale, O'Callaghan, Bredow, & Martyn, 2006; Heinonn et al., 2008).

Later intellectual and cognitive abilities may be related to infant information processing (Dougherty & Haith, 1997; Rose, Feldman, Wallace, & McCarton, 1991; Thompson, Fagan, & Fulker, 1991). Attention and habituation are major components in information processing, and habituation is a potential predictor of intelligence later in childhood (McCall, 1994). Infants who process information more rapidly are more likely to have higher IQ (Kail, 2000), and infants who are longer and heavier perform better on visual information processing variables (Rose, Feldman, & Wallace, 1992).

Maternal factors such as education, socioeconomic status, and smoking have been shown to influence cognitive outcomes later in childhood (Kyrklud-Blomberg & Cnattings, 1998; Shah & Bracken, 2000) Women who smoke during pregnancy are more likely to be less educated and thus have less income and low socioeconomic status which contributes to physical an cognitive deficits later in childhood ((Kallen, 2000; Olds, Henderson, & Tatelbaum, 1994; Trasti, Vik, Jacobsen, & Bakketeig, 1999). Also maternal or parental education and socioeconomic status have been found to be good predictors of intellectual achievement later in childhood (Davis-Kean, 2005), also low parental education levels have been shown to be related to low levels of school achievement later in childhood (Alexander, Entwisle,& Danber, 1993).

Finally, breast feeding has been shown to have a positive impact on later intellectual abilities (Temboury, Otero, Polanco, & Arribas, 1994). Children who continue breast feeding for prolonged time (> 12months), had better cognitive development and thus higher IQ scores (PROBIT, 2008).

CHAPTER III

METHODOLOGY

Section 1-Background and Design:

This study examines the relation between anthropometry, as an indicator of growth, and visual information processing, as an indicator of cognitive development of infants at 3 months of age. Furthermore, this study determines how maternal factors (smoking, education) may affect this relationship. The design of this research is cross-sectional and observational.

Section 2- Sample:

The sample consisted of 132 infants who were predominately breastfed and their mothers. One infant lacked anthropometric data and was excluded leaving a final total of 131. Subjects who participated in this study had to meet the inclusion criteria that included full term single birth infants and weigh at birth between 2.95 and 4.32 kg. Exclusion criteria involved infants who take more than 28oz of formula/week, also if maternal blood transfusion or illness, or current infant illness had occurred.

Procedures:

At the age of 3months (13 weeks ±2), infants and their mothers were scheduled to arrive at the laboratory. Upon the arrival of the infants the research assistant and experimenter interacted with the infant to make him/her feel comfortable and familiar with the place and persons. Visual information processing trials were conducted and physical measurements were performed on infants. Demographic information was obtained from the mothers at this visit and modified questions from the Pregnancy Risk Assessment Monitoring System (PRAMS) instrument were read to the mother and the responses were recorded by the research assistant.

Section 3-Visual Information Processing (VIP) Trial:

In this procedure the infants viewed a single stimulus on a 22-inch computer screen while sitting in darkened room in a car seat with the mother standing behind. During the process the stimulus the infant viewed was presented on the screen until a look away of one second was made. Once the initial one second look was made, the familiarization continued until two repetitive looks toward the stimulus were made which showed a 50% decline from the most recent longest look (Colombo, Shaddy, Richman, Maikranz, & Blaga, 2004). Following a two second blank interval, a familiar and novel stimulus appeared on the screen until the infant fixates on one or both of these stimuli for 10 seconds. The familiarization face was randomly selected for each infant and sufficient numbers were used to avoid any recurrence of these stimuli during the trials.

The presentation of the stimuli was controlled by one computer which calculated looking time and derives visual habituation rate. The experimenter observes the infant through a closed circuit television and during the trial the experimenter encodes the infant’s look toward and away from the stimuli by pressing and holding the left mouse key when the infant fixates on the stimulus. During the familiarization phase, the experimenter pressed and holds the left button when the infant fixates on the right stimulus. A digital camera was also used to record the looking behavior to ensure reliability (Colombo et al., 2004; Kennedy et al., 2008; Rose, 1994). The dependent variables that were derived from the VIP procedure are length of the longest look, total duration of looks, and average look duration and number of looks which are suggested to represent the speed and efficiency by which the infant process the visual stimuli. The novelty quotient, measured as percentages of total looking time that infant fixate the novel stimulus during the test phase was used to assess memory.

Section 4-Anthropometric Assessment:

The infant's weight was measured using a digital infant scale (Seca, Columbia, MD, accuracy to 0.002 kg). The infant was lying down on the scale with his/her light clothes and a diaper. The research assistant recorded the weight in grams. Infant's crown-heel length was measured by using an infant length board (Shorr Production, Olney MD, accuracy to 0.1cm). The length was taken twice and if these measures were more than 1cm apart, the length was taken again and the discrepant value was discarded before the results are averaged for analysis. Finally, infant's head circumference was measured by using a non-stretchable tape that is passed around the head, placing it on the most anterior protuberance of the forehead and the most posterior protuberance of the back head, and the measure was recorded in centimeters.

Section 5-Pregnancy Risk Assessment Monitoring System (PRAMS) Questionnaire:

PRAMS is a surveillance project of the Centers for Disease Control and Prevention (CDC) and state health departments (PRAMS, 2008). It assesses maternal attitudes and experience before, during, and shortly after pregnancy. It provides data that allows the CDC to monitor changes in maternal and child health indicators (unintended pregnancy, prenatal care, and breast-feeding, smoking, drinking, infant health). Questions were modified slightly for this study. The final questionnaire consisted of 44 questions; each question was asked by the research assistant and the response was recorded according to the mother's answers. In this research, 18 items from the questionnaire that has been used relate to maternal and infant health (7 items), smoking (7items), and alcohol consumption (4 items).

Section 6-Statistical Analysis:

Initially descriptive statistics were performed on all variables of interest. Correlation analysis was used to identify the relationship between the variables. Regression analysis was used with the variables identified by correlation analysis. The anthropometric measurements (height, weight, and head circumference) were converted to z-score using WHO Anthro software. The demographic characteristics of infant z-score are independent variables and the VIP variables are the dependent variables and the study's significance will take the value $p < 0.05$.

CHAPTER IV

RESULTS

The study examined the relation between the infant anthropometry and visual information processing. The relation between demographic characteristics of the mothers, particularly smoking and alcohol drinking, education and income level and infant anthropometric Z-scores, and the VIP dependent variables were examined.

<u>Section 1- Maternal Demographic Characteristics:</u>

The sample consisted of a total of 132 infants and their mothers. Table (1) presents the maternal demographic aspects of the sample. Women ranged in age from 19 to 42 with a mean age of 28.2 years (SD 4.5). Over half were unemployed (56%) and 26% were employed full time. The average number of children was 1.82 (SD± 1.0) and 48% of women had only one child, while 8% had four or five children. Also 90% of the mothers were married, and 78% of the mothers had C-section. Specific variables of interest such as (smoking, and alcohol drinking) were examined using the modified PRAMS questionnaire. Most mothers reported generally good health (97%). The most common complications of pregnancy were severe nausea, vomiting, or dehydration (14.6%), labor pains more than 3weeks before the baby was due (14.6%), and urinary tract infection (13.1%). Before pregnancy 13 % women reported smoking cigarette, however during pregnancy less than 5% of women smoked. Only 4% women reported smoking now during lactation. Similarly, before pregnancy 55.1% of women reported at least some alcohol consumption but this essentially stopped during pregnancy with 96.9%. Complete responses to PRAMS questions are presented in Appendix 1.

Table (1): Maternal Demographic Characteristics (*n*=131):

Variables	**Number**	**Percentages**
Race		
White	115	87.7%
Native American	9	6.9%
Hispanic	3	2.3%
Asian	3	2.3%
Black	1	0.8%
Education		
High School graduator less	8	6.1%
Some college	39	29.8%
College graduate	34	26.0%
Post graduate or above	5	38.2%
Income Level (n=128)^		
Under $15,000	15	11.5%
$15,000-25,000	21	16.0%
$25,000-40,000	30	23.3%
$40,000-60,00	29	22.7%
Over $60,000	33	25.2%

^ Data were not provided by some subjects

<u>Section 2- Infant's Anthropometric and Visual Information Processing Measures:</u>

Infant (79 female, 52 male) growth measures are presented in Table (2); **Z-scores** are defined as having a mean of 0 and **SD** of 1 and thus this sample is typically growing. Also Z-scores were calculated using gender specific criteria, thus the means include both boys and girls. The mean infant's birth weight was 3464.3 g, SD± 416.0 gm).

Table (2): Infant's Anthropometric Measures (*n*=131):

Variables	Mean	Standard Deviation
Length-for age **z-score**	-.07	1.07
Weight-for-age **z-score**	.03	.99
Weight –for-length **z-score**	.19	1.07
HC-for-age **z-score**^	.81	1.89
BMI-for-age **z-score**	.11	1.04

^ One infant refused head circumference

Table (3) presents VIP variables of interest. These are laboratory measures and have no standardized criteria to which they may be compared. The novelty quotient reflects memory and the other variables reflect processing speed. Five infants did not have the data for the procedure and an additional 13 did not complete the test phase and thus do not have novelty quotients.

Table (3): Infant's Visual Information Processing Variables (n=126):

Variables	Mean	Standard Deviation
Longest look ^	59.02	87.20
Total duration of looking	131.07	153.03
Length of average look	21.05	26.10
Number of looks	6.70	2.85
Novelty Quotient *	0.5013	.1745

^ *n* = 124, 2 subjects are missing data
* *n* = 113, 13 infants did not complete familiarization phase.

Section 3-:Bi variant Relations Between Anthropometry Measures & PRAMS Questions & VIP Variables:

Relations among the various anthropometric variables and among the individual VIP variables are presented in Appendix 2. Table (4) presents relations between anthropometric and VIP variables. As mentioned in the previous section, not all infants completed all parts of the procedures, so subject counts are given for each correlation.

Table (4): Anthropometric Variables and Visual Information Processing:

Variables	Longest look	Total duration of looking	Length of Average look	Number of looks	Novelty Quotient
Length-for-age z-score					
Pearson Correlation	-.074	-.049	-.079	.073	.049
Sig. (2-tailed)	.412	.585	.381	.416	.605
n	124	126	126	126	113
Weight-for-age z-score					
Pearson Correlation	.154	.148	.154	-.006	**.200***
Sig. (2-tailed)	.089	.099	.085	.947	.034
n	124	126	126	126	113
Head circumference-for-age z-score					
Pearson Correlation	-.033	-.043	-.030	-.036	**.287****
Sig. (2-tailed)	.716	.631	.736	.691	.002
n	123	125	125	125	112
BMI-for-age-score					
Pearson Correlation	**.252****	**.225***	**.255****	-.063	**.217***
Sig. (2-tailed)	.005	.011	.004	.484	.021
n	124	126	126	126	113
Weight-for-length z-score					
Pearson Correlation	**.262****	**.232****	**.265****	-.070	**.193***
Sig. (2-tailed)	.003	.009	.003	.438	.041
n	124	126	126	126	113
Birth Weight gm					
Pearson Correlation	.115	.123	.127	.000	.028
Sig. (2-tailed)	.204	.171	.157	.999	.766
n	124	126	126	126	113

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Table (5) presents maternal demographic factors. Only mother's education was shown to be significantly correlated with VIP variables, specifically those associated with encoding speed.

Table (5): Demographic and Visual information Processing Variables:

Variables	Longest look	Total duration of looking	Average look	Number of looks	Novelty Quotient
Infant gender	.				
Pearson Correlation	.129	.106	.138	-.007	-.118
Sig. (2-tailed	.153	.238	.123	.393	.215
n	124	126	126	126	113
Number of children					
Pearson Correlation	-.009	.012	-.003	.041	-.152
Sig. (2-tailed)	.920	.890	.973	.649	.109
n	124	126	126	126	113
Income level					
Pearson Correlation	.086	.057	.060	-.004	-.048
Sig. (2-tailed)	.350	.532	.511	.962	.619
n	121	123	123	123	111
Mom Education					
Pearson Correlation	**.193***	**.198***	**.187***	.042	-.017
Sig. (2-tailed)	.032	.026	.036	.638	.858
n	124	126	126	126	113

*Correlation is significant at the 0.05 level

Visual inspection of the responses to the PRAMS suggested that for most items there was limited variability making them inappropriate for use in correlation analysis (see Appendix1). The questions with some variability (item 1, regarding general health, item 6, asking about alcohol consumption before pregnancy, and item 38, regarding length of hospital stay post birth) were checked and found not to be normally distributed. Thus PRAMS questions were excluded from further analysis.

<u>Section 4- Regression Results Examining Maternal Education and Anthropometric Measures Relation to VIP Variables:</u>

Regression analysis has been used with the variables that showed significant correlation with the VIP variables. These variables included maternal education, BMI-for-age, head circumference (HC), weight-for-age, and length-for-age. Birth weight was also included because of its significance in the literature (Edmond, Blair, Emmett, & Drewett, 2007; Matte, Bresnahan, Begg, & Susser, 2003). As weight and length are used to calculate BMI; the first set of analyses used only the BMI for age variable.

The relation between maternal education, and BW, explained approximately 5% of the variance in the longest look [F (2,122) = 2.950, *p*=0.056]. The maternal education was significant (*p*= .042) but BW was not (*p*= .290). HC-for-age, BMI-for-age, maternal education, and BW explained 10 % of the variance in the longest look [F (4,122) = 3.404, *p*=.011]. In Table (6), the BMI is shown to explain more of the variance than mother's education.

Table (6): Regression examining Maternal Education, BW, HC, and BMI and the Longest look:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	2.352	.863		2.726	.007
Mom Education	.187	.095	.173	1.977	**.050***
BW gm	.000	.000	.047	.506	.614
BMI-for-age	.239	.090	.244	2.655	**.009***
HC-for-age	-.049	.049	-.090	-.999	.320

a. Dependent Variable: **Longest Look**
*Contains the cells that had significance between the two variables with α= .05.

The relation between the maternal education, and BW explained 5% of the Total duration of looking variance [F (2,124) = 3.233, *p*= .043]. The mother's education was significantly related with total duration of looking (*p*= .035), but not BW (*p*=.245). In Table (7), HC-for-age, BMI-for-age, maternal education, BW, explained approximately 10% of the variance in duration of look, [F (4,124) = 3.183, *p*= .016]. Again BMI showed more influence than maternal education.

Table (7): Regression examining Maternal Education, BW, HC, and BMI and the Duration of looking:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	3.265	.767		4.256	.000
Mom Education	.172	.084	.179	2.055	**.042***
BW gm	.000	.000	.063	.687	.493
BMI-for-age	.188	.081	.214	2.335	**.021***
HC-for-age	-.048	.044	-.098	-1.094	.276

a. Dependent Variable: **Total Duration of looking**
*Contains the cells that had significance between the two variables with α= .05.

The relation between maternal education, and BW explained approximately 5% of the variance in the Length of Average look [F (2,124) =2.984, *p*=.054]. This relation was just barely significant. HC-for-age, BMI-for-age, maternal education, and BW explained 10% of the variance in average look [F (4,124) = 3.486, *p*= .010]. Only BMI was a significant predictor.

Table (8): Regression examining Maternal Education, BW, HC, and BMI and the Average look:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	1.549	.744		2.083	.039
Mom Education	.155	.081	.165	1.901	.060
BW gm	.000	.000	.058	.633	.528
BMI-for-age	.211	.078	.246	2.701	**.008***
HC-for-age	-.043	.042	-.090	-1.010	.315

a. Dependent Variable: **Length of Average look.**
*Contains the cells that had significance between the two variables with α= .05.

The relation between maternal education, BW, and Number of looks was not significant. [F (2,124) = 0.125, *p*= .882]. Also the relation between maternal education, HC, BMI, BW and number of looks in table (9), was not significant [F (4,124) = 0.230, *p*= .921].

Table (9): Regression examining Maternal Education, BW, HC, and BMI and the Number of looks:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	1.710	.309		5.535	.000
Mom Education	.018	.034	.048	.523	.602
BW gm	1.730	.000	.020	.206	.837
BMI-for-age	-.023	.032	-.069	-.719	.474
HC-for-age	-.005	.018	-.027	-.291	.771

a. Dependent Variable: **Number of looks**
*Contains the cells that had significance between the two variables with α= .05.

The relation between maternal education, BW, and Novelty quotient was not significant [F (2, 111) = .133, *p*= .876]. However, the relation between maternal education, BW, HC, and BMI explained approximately 13% of the variance in Novelty quotient [F (4,111) = 3.924, *p*= .005]. In Table (10), HC was the most influential among the variables.

Table (10): Regression examining Maternal Education, BW, HC, and BMI and the Novelty Quotient:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	.638	.149		4.282	.000
Mom Education	-.006	.016	-.036	-.392	.696
BW gm	-3.771	.000	-.090	-.934	.352
BMI-for-age	.036	.016	.222	2.309	**.023***
HC-for-age	.023	.008	.265	2.856	**.005***

a. Dependent Variable: **Novelty Quotient.**
*Contains the cells that had significance between the two variables with α= .05.

Section 5- Regression Results Examining Weight and Length Measures Relation to VIP Variables:

To further examine the relations we looked at the variables that are components of BMI: Weight-for age and length-for-age. The relation between maternal education, Weight, Length, and HC explained 12% of the Novelty quotient variance [F (4,111) = 3.718, *p*= .007]. In Table (11), the weight showed some significant relation to novelty quotient, but the HC was more significantly correlated.

Table (11): Regression examining Maternal Education, Weight, Length, HC, and the Novelty Quotient:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	.514	.065		7.876	.000
Mom Education	-.008	.016	-.044	-.480	.632
HC-for-age	.021	.008	.250	2.705	**.008***
Weight-for-age	.044	.020	.255	2.149	**.034***
Length-for-age	-.023	.019	-.140	-1.199	.233

a. Dependent Variable: **Novelty Quotient.**

*Contains the cells that had significance between the two variables with α= .05.

The relation between maternal education, weight, length, HC explained 33% of the longest look variance [F (4,122) = 3.617, *p*=.008]. In Table (12), weight-for-age and length was significantly related to the longest look.

Table (12): Regression examining Maternal Education, Weight, Length, HC, and the longest look:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	2.717	.385		7.061	.000
Mom Education	.196	.094	.182	2.086	**.039***
HC-for-age	-.040	.048	.-.074	-.832	.407
Weight-for-age	.345	.119	.329	2.896	**.005***
Length-for-age	-.277	.109	-.283	-2.535	**.013***

a. Dependent Variable: **Longest look**
*Contains the cells that had significance between the two variables with α= .05.

The relation between maternal education, weight, length, and HC explained 31% of the duration of look variance [F (4,124) = 3.203, *p*= .015]. In Table (13), length was significant but negatively correlated with duration of looking; weight and maternal education were positively associated to look duration.

Table (13): Regression examining Maternal Education, Weight, Length, HC, and the Duration of look:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	3.722	.344		10.829	.000
Mom Education	.180	.084	.187	2.151	**.033***
HC-for-age	-.040	.043	-.083	-.929	.355
Weight-for-age	.279	.107	.298	2.621	**.010***
Length-for-age	-.208	.098	-.236	-2.121	**.036***

a. Dependent Variable: **Duration of Look**
*Contains the cells that had significance between the two variables with α= .05.

The relation between maternal education, weight, length, and HC explained 33% of the average look variance [F (4,124) = 3.714, *p*= .007]. In Table (14), the length was significant but negatively correlated with the Average look, and weight, maternal education were positively associated.

Table (14): Regression examining Maternal Education, Weight, Length, HC, and the Average look:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	1.948	.332		5.865	.000
Mom Education	.163	.081	.174	2.016	.046
HC-for-age	-.034	.042	-.072	-.817	.416
Weight-for-age	.309	.103	.339	3.003	**.003***
Length-for-age	-.251	.095	-.292	-2.644	**.009***

a. Dependent Variable: **Average look**
*Contains the cells that had significance between the two variables with α= .05.

The relation between maternal education, weight, length, and HC explained 11.5% of the variance in number of looks [$F(4,124) = .404$, $p = .805$]. In Table (15), there was no significant correlation observed between length, weight and the number of looks.

Table (15): Regression examining Maternal Education, Weight, Length, HC, and the Number of looks:

Coefficients

Model	**Unstandarized coefficients**		**Standardized coefficient**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
1 (constant)	1.775	.138		12.857	.000
Mom Education	.017	.034	.046	.502	.617
HC-for-age	-.006	.017	-.033	-.350	.727
Weight-for-age	-.030	.043	-.084	-.711	.479
Length-for-age	.043	.039	.128	1.100	.274

a. Dependent Variable: **Number of looks**
*Contains the cells that had significance between the two variables with α= .05

CHAPTER V

CONCLUSIONS AND DISCUSSION

<u>Section 1- Conclusions:</u>

The study examined the relation between anthropometric measures and visual information processing in infants at 3 months of age. The design of the study was cross-sectional and observational, and was conducted in a rural community setting in Oklahoma. Infant anthropometric measures (weight, length, head circumference, and BMI z-scores) showed significant relations to VIP variables; however, only maternal education from the demographic factors was shown to be significantly related to VIP.

Demographic characteristic:

Mothers were predominantly white, married, and highly educated. Also the research staff recorded that most mothers were post graduate students at the university. Although 56% of the mothers were unemployed, the average income level for 25% of them was over $ 60,000 and 23% ranged between $25,000-40,000 annually. Most mothers had a C-section (78%), and 48% of them had only one child while 8% had four or five children. Also only 13 women reported smoking during the first trimester of their pregnancy, and in the third trimester only 6 women reported alcohol consumption during this period. Because of this limited variability these factors were not considered further in this study.

The study included 131 infants (79 male, 52 female). Infant's birth weights rangedbetween 2.95-4.32 kg. They appeared to be growing normally, and were all predominately breastfed (less than 4 oz of formula daily) at 3 months of age.

Anthropometric Measures and Maternal Education relation to VIP variables:

The anthropometric measures included weight-for-age z-scores, length-for-age z-scores, head circumference-for-age z-score, BMI-for-age z-score, and birth weight. Scores for weight, length, head circumference, and BMI, and maternal education showed significant correlation with VIP variables. Although birth weight did not show any significant relation to VIP variables, it was included among the independent regression variables because it was strongly supported in the literature (Edmond, Blair, Emmett, & Drewett, 2007; Matte, Bresenahan, Begg, & Susser, 2003). Table (16) presents a summary of the regression results that examined anthropometry measures and maternal education in relation to VIP variables.

Table (16): Summary of the anthropometry measures and maternal education in relation to VIP variables:

Variables	Model		Maternal education	BW	HC	BMI
	p	R^2				
Length of longest look	.011	.103	✓	**NS**	**NS**	✓
Total duration of look	.016	.096	✓	**NS**	**NS**	✓
Length of the Average look	.010	.104	*	**NS**	**NS**	✓
Number of looks	.921	.008	**NS**	**NS**	**NS**	**NS**
Novelty Quotient	.005	.128	**NS**	**NS**	✓	✓

✓ contains the cells that had $p \leq .05$
* contains the cells that had $p = .05\text{-}.10$

All significant associations are positive, maternal education is associated with three processing variables, and BMI is associated with all processing variables. Therefore, as the BMI and maternal education increases so does the lengths of look increase. As shorter looks are thought to be better because they reflect the speed of processing the information, infants who are thinner would have the best performance. This is consistent with other studies (Broekman et al., 2008; Gale, O'Callaghan, Godfrey, Law, and Martyn, 2004).

Table (17) presents regression results that examined maternal education, and the BMI components (weight and length for age z- scores) in relation to VIP variables.

Table (17): Summary of the maternal education, weight, and length in relation to VIP variables:

Variables	**Model**		**Maternal education**	**Weight**	**Length**	**HC**
	p	**R^2**				
Length of longest look	.008	.109	✓ +	✓ +	✓ □	**NS**
Total duration of look	.051	.096	✓ +	✓ +	✓ □	**NS**
Length of the Average look	.007	.110	✓ +	✓ +	✓ □	**NS**
Number of looks	.805	.013	**NS**	**NS**	**NS**	**NS**
Novelty Quotient	.007	.122	**NS**	✓ +	**NS**	✓ +

✓ contains the cells that had $p \leq .05$
* contains the cells that had $p = .05\text{-}.10$

The (+/ □) indicates direction of association, maternal education, weight, and HC are positively associated with processing variables, and length is negatively associated. Infants who are heavier and with larger heads have better memory as indicated by higher novelty quotients, but heavier infants have also longer looks, whereas infant who are taller have shorter looks.

In summary, maternal education showed to be the only demographic factor related to VIP. Other factors such as the income level were not correlated and smoking and alcohol consumption were not fully tested because of the limited variability. Anthropometric measures also showed significant relations with the VIP variables. The BMI and maternal education showed to be significant with VIP variables, whereas birth weight showed no significance. Infants who are from better educated mothers and have higher BMI tend to have longer looks. It would have been expected maternal education to be negatively associated with processing because as mother education increases the infant duration of look will decrease, which reflect better information processing. Also weight, length, and head circumference were significantly related to VIP variables, whereas length was negatively correlated. Heavier infants with larger head circumference had better memory, and taller infants had shorter look which suggests that infant's growth is related to cognitive development.

<u>Section 2- Relationship of Findings to the Literature Review:</u>

Demographic Factors:

The demographic factors that were examined in this study were maternal education, income level, smoking, and alcohol consumption. This study found maternal education to be correlated to VIP measures (longest look, duration of look, and average look), but not with novelty quotient. This was not consistent with another study that investigated the relation between parental education and the habituation and novelty performance in infants at 3 months of age, and found no significant relation between these variables (Mayes & Bornstein, 1995).

However, smoking during pregnancy could lead to deficits in anthropometric measures and cognitive abilities. Several studies found that women who smoked during pregnancy are more likely to have babies with low birth weight, smaller head circumference, and lower cognitive outcome later in childhood (Kallen, 2000; Kyrklud-Blomberg & Cnattingins, 1998; Trasti, Vik, Jacobsen & Bakketeig, 1999). Also alcohol consumption prenatally and during pregnancy was associated with longer fixation duration time, which indicates less efficient information processing (Jacobson,S., Jacobson, L., Sokol , Martier , & Ager, 1993). However, since there was a limited variability in these two demographic factors, further examination on the relation of these two variables (smoking and alcohol consumption) to VIP measures was not carried out in the study. Although some studies found that income level, as an indicator of socioeconomic status and education, was associated with better parenting, and thus better cognitive outcome later in child hood (Bradley & Corwyn, 2002), income level in this study did not show any significant relation with VIP measures.

Infant Growth and Intelligence:

Infant anthropometric measures showed significant relation to VIP variables, which are considered an indicator of intelligence later in childhood. Several studies examined the relation between weight, length, and head circumference. A study found a significant correlation between postnatal head growth and cognitive performance (Gale, O'Callaghan, Godfrey, Law, & Martyn, 2004). This supports our finding of the significant correlation between head circumference and novelty quotient. Another study found that children born with normal ranges of birth length, birth weight, and head circumference had higher IQ scores later in childhood (Broekman et al., 2008). This was also demonstrated in our study from the significant correlation that showed between the infant weight, length and VIP variables.

Also improved weight gain during early infancy was significantly correlated with later IQ scores in children (Vaivre-Douret et al., 2009). Slower gain in weight and BMI, and head circumference could have negative effects on cognitive abilities that could extend from birth to the second year of age (Heinon et al., 2008). This contradicts our study results that found a significant positive correlation between weight, BMI and VIP variables.

In this study, infant's birth weight did not show any correlation to VIP variables. However, Heinonn et al. (2008) found that children who were born with smaller body size at birth performed worse on cognitive performance test later in childhood. Another study found a significant relationship between birth weight and IQ scores in children, whereas the increase in childhood IQ continues with birth weight in normal range (Matte, Brenahan, Begg, & Susser, 2003).

Anthropometry and Visual information Processing Measures:

Few examined the relation between anthropometry measures and VIP in infants. Rose (1994) found that infants (5-12 months old) who are longer and heavier have better memory and shorter looks than those who were shorter and under weight. Also maternal education was significantly correlated with anthropometric and VIP variables.

Kennedy et al. (2008) found that weight, length and head circumference were significantly correlated to duration of look; infants who are shorter, weighed less, and with smaller heads had longer looks, whereas none of the anthropometric measures were related to novelty quotient. Some of the findings of these two previous studies were not consistent with some of our results. First, in our study novelty quotient was significantly correlated with head circumference and weight, but it was not significant in Rose or Kennedy et al. Secondly, Rose and Kennedy et al. found that weight, length was significantly related to longer looks, whereas Kennedy et al. showed that length was negatively correlated which was similar to our finding . Finally, the Rose study maternal education was significantly correlated with anthropometric and VIP measures, which is similar to our findings. However, in both Kennedy et al. and Rose's study, infants were malnourished, while our study included only healthy infants. This could contribute to some of the differences in the findings between the studies.

In conclusion, weight and BMI showed to be positively correlated with processing measures (duration of look, average look, longest look) and novelty quotient. This suggests that heavier infants tend to have longer looks; this was unexpected in our findings because according to the literature, infants of average weight and BMI have better cognitive outcome (Broekman et al., 2008; Vaivre-Douret et al., 2009). However, length was negatively correlated with VIP variables, which suggest that infants who are longer tend to have shorter duration look which was consistent with some of the literature (Kennedy et al. 2008) Head circumference was positively correlated with novelty quotient. This suggests that infants of bigger head circumference have better memory, that was consistent with other literature (Gale, O'Callaghan, Bredow, & Martyn, 2006; McGrath, Saha, Lieberman & Buka, 2006). Maternal education was the only demographic factor that was positively correlated to processing variables (duration of look, average look, longest look) but not novelty quotient. This suggested that infants whom mothers are educated have longer looks; this was not consistent with some of the literature that found no significant relation between mother education and information processing ((Mayes & Bornstein, 1995).

Section 3- Research Question:

The gap that was needed to be investigated further was indentifying if normal growth patterns of breastfed infants in the United States could be related to cognitive development outcomes. The objective of this study was to examine:

1) How growth, as a general indicator of nutritional status in infants is correlated to cognitive development as measured by VIP.
2) How socioeconomic and maternal factors may affect the relation between physical growth and cognitive development of infants at 3 months of age.

The findings of the study showed that anthropometric measures of growth (weight, length, and head circumference were related to measures of visual information processing.

The head circumference was related to novelty quotient, which is considered a measure of memory, whereas weight, length, and BMI were related to longest look, duration of look, and average look, which are considered measures of speed of processing information. Income level which is an indicator of the socioeconomic status was not related to any anthropometric or VIP variables. However, maternal education showed a significant relation to speed processing variables (longest look, average look, and duration of looks), but not with novelty quotient.

Section 4- Limitation and Further Research:

One limitation of this study is that the sample of the study could be considered biased because it included only breastfed, healthy normal babies and not formula fed babies. Also more than half of mothers were highly educated. This means limited variability among the sample. During the research process some infants found it hard to tolerate VIP trials tests, which consequently lead in some cases to incomplete data. Furthermore, the age at which the infants were tested for VIP trials in this study was 3 months; infant's cognitive abilities are still rapidly developing so relations may change over time as they progress in age.

Further research is needed to examine the relation between growth and VIP in infants at older ages, and using a more random reprehensive sample should be considered. Including formula fed infants in the sample could help examine possible difference in VIP between the breastfed and formula fed infants. Also maternal smoking and alcohol consumption should be further examined in future research to identify any possible relation to VIP; this was not possible in our study because of the limited variability. Finally, in our study birth weight did not have effect on any of the VIP variables; perhaps further research could allow investigating it more.

Section 5- Summary:

The study examined the relation between anthropometry and visual information processing in breastfed infants at 3 months of age. The anthropometric measures that were examined were weight, length, and head circumference Z-scores. All three measures showed significant relation to VIP measures. Also maternal education showed to be the only demographic factor related to VIP measures. Weight, length, and maternal education were significantly related to information processing measures (longest look, duration of look, average look), whereas head circumference, and weight showed to be significantly related to novelty quotient (memory). Length was negatively correlated to VIP measures, and birth weight did not affect any VIP variables.

REFERENCES

Agostoni, C., Grandi, M.L., Gianni, M., Torcoletti, M., Giovannini, M., & Riva, E. (1990). Growth patterns of breast fed and formula fed infants in the first 12 months of life: an Italian study. *Archive Disease of Children*, 81; 395-399

Alexander, K.L., Entwisle, D.R., & Danber, S.L. (1993). First –grade behavior: its short-and long- term consequences for school performance. *Child Development*, 64; 801-14.

Ashworth, A., Morris, S.S., Lira, PI.C., & McGregor, S.M. (1998). Zinc supplementation, mental development and behavior in low birth weight term infants in north Brazil. *European Journal of Clinical Nutrition*, 52; 223-227.

Bayley, N. (1993). *Bayley scales of infant development: Birth to two years- Second edition*. San Antonio, TX: The Psychological Corporation.

Birch, E.E., Garfield, S., Hoffman, D.R., Uauy, R., & Birch, D.G. (2000). A randomized controlled trial of early dietary supply of long-chain polyunsaturated fatty acids and rental development in term infants. *Developmental Medicine & Child Neurology*, 42; 174-181.

Black, M.M., Sazawal, S., Black, E.R., Khosla, S., Kumar, J., & Menon, V. (2004). Cognitive and motor development among small-for-gestational-age infants: impact of zinc supplementation, birth weight, and care giving practices. *Journal of* the *American Academy of Pediatrics*, 113; 1297-13.

Bornstein, M.H. (1985). Habituation of attention as a measure of visual information processing in human infants: summary, systematization, and synthesis. In: G., Gottleib, N.A., Krasnegor.(Eds.), *Measurement of audition and vision in the first year of postnatal life: a methodological overview* (pp. 235-300). Norwood, MA: Albex.

Bornstein, M.H., Salter, A., Brown, E., Roberts, E., & Barrett, J. (1997). Stability of mental development from infancy to early childhood: three 'waves' of research. In: J.G., Bremner, A., Slater,& G., Butterworth (Eds.), *Infant development: recent Advances* (pp. 191-215). Hove, UK: Psychology Press.

Bradley, R.H, Corwyn, R.F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, 53; 371-399.

Broekman, BF.P, Chan, Y., Quek, S., Fung, D., Low, Y., Ooi, Y., … & Saw, S. (2008). The influence of birth size on intelligence in healthy children. *Journal of the American Academy of Pediatrics*, 123; 1011-1016.

Brooks-Gunn, J. & Duncan, G.J. (1997). The effect of poverty on children. *The Future of Children*, 7 (2); 55-7.

Centers for Disease Control and Prevention (CDC). (2008). The Pregnancy Risk Assessment Monitoring System [PRAMS]. Retrieved May 20, 2011, from http://www.cdc.gov/prams/index.htm.

Colombo, J. (2001). The development of visual attention in infancy. *Annual Review of Psychology*, 52; 337-367

Colombo, J., & Janowsky, J.S. (1998). Cognitive neuroscience of attention. In J. E. Richards (Ed.), *A cognitive approach to individual differences in infant cognition* (chap.12). New Jersey: Lawerence Erlbaum Association, Inc.

Colombo, J., Shaddy, D.J., Richman, W.A., Maikran, J.M., & Blaga, O.M. (2004). The development course of habituation in infancy and preschool outcome. *Infancy*, 5; 1-38.

Davis-Kean, P.E. (2005). The influence of parent education and family income or child Achievement: The indirect role of parental expectation and the home environment. *Journal of Family Psychology*, 19 (2); 294-304.

Day, N.L, Richardson, G., Robles, N., Sambamoorthi, U., Taylor, P., Scher, M., … & Cornelius, M. (1990). Effect of prenatal alcohol exposure on growth and morphology of offspring at 8 months of age. *The American Academy of Peadiatrics*, 85; 748.

de Onis, M., & Blossner, M. (2003). The World Health Organization global database on child growth and malnutrition: methodology and applications. *International Journal of Epidemiology*, 32; 518-526.

de Onis, M., Onyango, A.W., Boghi, E., Garza, C., & Yang, H. (2006). Comparison of the World Health Organization (WHO) child growth standards and the National Center for Health Statistic/ WHO international growth reference: implications for child health programmes. *Public Health Nutrition*, 9 (7); 942-947.

Donma, M.M., & Donma, O. (1999). Infant feeding and growth: a study on Turkish infants from birth to 6 months. *Pediatrics International*, 41; 542-548.

Dougherty, T.M., & Haith, M.M. (1997). Infant expectation and reaction time ass prediction of childhood speed of processing and IQ. *Developmental Psychology*, 33 (1); 146-155.

Duncan, G.J., & Brooks-Gunn, J. (1997). The effect of poverty on children. *The Future of Children and Poverty*, 7 (2).

Emond, A.M., Blair, P.S., Emmett, P.M., & Drewett, R.F. (2007). Weight faltering in infancy and IQ levels at 8 years in Avon Longitudinal study of parents and children. *Journal of The American Academy of Pediatrics*, 120; 1051-1058.

Engebretsen, IM.S., Tylleskar, T., Wamani, H., Karamagi, C., & Tumwine, J.K. (2008). Determinants of infant growth in eastern Uganda: a community-based cross-sectional study. *Biomedical Central of Public Health*, 8; 418.

Fagan, J.F. (1984b). The intelligent infant: Theoretical Implications. *Intelligence*, 8; 1-9.

Fagan, J.F., & Detterman, D.K. (1992). The Fagan test of infant intelligence: A technical summary. *Journal of Applied Developmental Psychology.* 13; 173-193.

Fahmida, T., Perrson, L.A., El-Arifeen, S., Hamadani, J.D., Mehrin, F., Ridont, D., … & Granthan-McGregor, S.M. (2008). Effects of prenatal food and micronutrient supplementation on infant development. A randomized trial from the maternal and infant nutrition interventions, Matalb (MINIMAT) study. *The American Journal of Clinical Nutrition*, 87; 704-11.

Fergusson, D.M., &LIoyd, M. (1991). Smoking during pregnancy and its effect on child cognitive ability from the ages of 8 to 12 years. *Pediatric Prenatal Epidemiology*, 5;189-200.

Fok, TF., Hon, KL., Ng, PC., Wong, E., So, HK., Lau, J., … & the Hong Kong Neonatal Measurements Group. (2009). Use of anthropometric indices to reveal nutritional status: normative data from 10,226 Chinese neonates. *Neonatology*, 95; 23-32.

Gale, R.G., O’Callaghan, F.J., Bredow, M., & Martyn, C.N. (2006). The influence of head growth in fetal life, infancy, and childhood at the ages of 4 and 8 years. *Pediatrics,* 118; 1486-1492.

Gale, C.R., O’Callaghan, F.J., Godfrey, K.M., Law, C.M., & Martyn, C.N. (2004). Critical periods of brain growth and cognitive function in children. *Brain*, 127(2); 321-329.

Gokhale, R., & Kirschner, B.S. (2003). Assessment of growth and nutrition. *Best Practice & Research Clinical Gastroenterology*, 17(2); 153-162.

Hamadani, D.J., Fuchs, J.G., Osendarp, J.M.S., Khatun, F., Huda, N.S., & Grantham-McGregor, M.S. (2001). Randomized controlled trial of the effect of zinc supplementation on the development of Bangladeshi infants. *American Journal of Clinical Nutrition*, 74; 381-6.

Haste, F.M., Brooke, O.G., Anderson, H.R., & Bland, J.M. (1991). The effect of nutritional intake on outcome of pregnancy in smokers and non-smokers. *British Journal of Nutrition*, 65; 347-354.

Heinonen, K., Raikkonen, K., Pesonen, AK., Kajantie, E., Anderson, S., Eriksson, G.J., … & Lano, A. (2008). Prenatal and postnatal growth and cognitive abilities at 56 months of age: A longitudinal study of infants born at term. *Journal of the American Academy of Pediatrics*, 121; 1325-1333.

Heird, W.C. (2001). The role of polyunsaturated fatty acids in term and preterm infants and breastfeeding mothers. *Pediatric Clinics of North America*, 48 (1); 173-181.

Jacobson, S.W., Jacobson, J.L., Sokol, R.J., Martier, S.S., & Ager, J.W. (1993). Prenatal alcohol exposure and infant information processing ability. *Child Development*. 64; 1706-1721.

Jensen, C.L., Voigt, R.G., & Prager, T.C. (2005). Effect of maternal docosahexaenoic acid intake on visual function and neurodevelopment in breastfed term infants. *American Journal of Clinical Nutrition*, 82(1); 125-132.

Johnson, C.P., & Blasco, P.A. (1997). Infant growth and development. *Pediatrics in Review*. 18(7), 224-242.

Kail, R. (2000). Speed of information processing: Developmental change and links to intelligence. *Journal of School Psychology*. 3(1); 51-61.

Kallen, K. (2000). Maternal smoking during pregnancy and infant head circumference at birth. *Early Human Development*, 58; 197-204.

Kavsek, M. (2004). Predicting later IQ from infant visual habituation and dishabituation: A meta-analysis. *Journal of Applied Developmental Psychology*, 25; 369-393.

Kennedy, T., Sykova, V., Stoecker, B., Thomas, D.G., Hubbs-Tait, L., Woltamo, T.,…, & Hambidge, K.M. (2008). Growth and visual information processing in infants in southern Ethiopia. *Journal of Applied Developmental Psychology*, 29; 129-140.

Kyrklund-Blomberg, N.B., & Cnattingus, S. (1998). Preterm birth and maternal smocking: risk related to gestational age and onset of delivery. *American Journal of Obstetrics and Gynecology*, 179; 1051-5.

Matte, T.D., Bresnahan, M., Begg, M.D., & Susser, E. (2003). Influence of variation in birth weight within sibship on IQ at age 7 years: cohort study. *British Medical Journal*, 323; 310-4.

Mayes, L.C., & Bornstein, M.H. (1995). Infant information processing performance and maternal education. *Early Development and Parenting*, 4 (2); 91-96.

McCall, R.B. (1994). What process mediates predictions of childhood IQ from infant habituation and recognition memory? Speculation on the roles of inhibition and rate information processing. *Intelligence*, 18; 107-25.

McCall, R.B., & Carriger, M.S. (1993). A meta-analysis of infant habituation and recognition memory performance as predictors of later IQ. *Child Development*, 64, 57-79.

McGee, R., & Stanton, W.R. (1994). Smoking in pregnancy and child development to age 9 years. *Journal of Pediatric and Child Health*, 30; 263-268.

McGrath, J.J., Saha, S., Lieberman, D.E., & Buka, S. (2006). Season of birth is associated with anthropometric and neurocognitive outcomes during infancy and childhood in a general population birth cohort. *Schizophrenia Research,* 81; 91-100.

Mei, Z., & Grummer-Strawn, L.M. (2007). Standard deviation of anthropometric z-scores as a data quality assessment tool using the 2006 WHO growth standards: a cross country analysis. *Bulletin of the World Health Organization*, 85; 441-448.

Mendez, M.A., & Adair, L.S. (1999). Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood. *The Journal of Nutrition*, 129; 1555-1562.

Mascarenhas, M.S., Zemel, B., & Stallings, V.A. (1998). Nutritional assessment in pediatrics. *Nutrition*, 14(1).

Nellis, L., & Gridly, B.E. (1994). Review of the Bayley Scales of Infant Development- second edition. *Journal of School Psychology,* 32 (2); 201-209.

Nolan, K., Schell, M.L., Stark, D.A., & Gomez, M. (2001). Longitudinal study of energy and nutrient intakes for infants from low-income, urban families. *Public Health Nutrition*, 5(3); 405-412.

Olds, D.L., Henderson, C.R., & Tatelbaum, R. (1994). Intellectual impairment in children of women who smoke cigarettes during pregnancy. *Journal of the American Academy Pediatrics*, 93; 221-227.

Promotion of Breastfeeding Intervention Trial Study Group [PROBIT]. (2008). Breastfeeding and child cognitive development. *Archives of General Psychiatry, 65* (5).

Rose, S.A. (1994). Relation between physical growth and information processing in infants born in India. *Child Development,* 65; 889-902.

Rose, S.A., & Feldman, J.F. (1997). Memory and speed. Their role in the relation of infant information processing to later IQ. *Child Development*, 68, 630-641.

Rose, S.A., Feldman, J.F., & Jankowski, J.J. (2004). Infant recognition memory. *Developmental Review*, 24; 74-100.

Rose, .S.A., Feldman, J.F., & Wallace, I.F. (1992). Infant information processing in relation To six- year cognition outcomes. *Child Development,* 63; 1126-1141.

Rose, S.A., Feldman, J.F., Wallace, I.F., & McCarton, C. (1991). Information processing at 1year: relation to birth status and development outcome during the first 5 years. *Developmental Psychology*, 127 (5), 723-737.

Rose, S.A., & Wallace, I.F. (1985). Visual recognition memory. A predictor of later cognitive functioning in preterms. *Child Development*, 56; 843-852.

Ross, A., & English, M. (2005). Early infant growth monitoring-time well spent. *Tropical Medicine and International Health*, 10(5); 404.

Selvakumar, B., &Vishnu Bhat, B. (2007). Infant feeding practice and its effect on the growth and development of babies. *Current Pediatric Research*, 11(1, 2); 13-16.

Shah, N.R., & Bracken, M.B. (2000). A systemic review and meta-analysis of prospective studies on association between maternal cigarette smoking and pretem delivery. *American Journal of Obstetrics and Gynecology*, 182; 465-72.

Sheppard, L.D., & Veron, P.A. (2008). Intelligence and speed of information processing: a review of 50 years of research. *Personality and Individual Differences*, 44; 535-551.

Shu, X.O., Hatch, M.C., Mills, J., Clemens, J., & Susser, M. (1995). Maternal smoking, alcohol drinking, caffeine consumption, and fetal growth: result from prospective study. *Epidemiology*, 6(2); 115-120.

Slykerman, R.F., Thompson, J.M.D, Becroft, D.M.O., Robinson, E., Pryor, J.E., Clark, P.M., … & Mitchell, E.A. (2005). Breastfeeding and intelligence of preschool children. *Acta Paediatrica*, 94; 832-837.

Temboury, M.C., Otero, A., Polanco, I., & Arribas, E. (1994). Influence of breast-feeding on the infant's intellectual development. *Journal Pediatric Gastroenterology and Nutrition*, 18; 32-6.

Thompson, L.A., Fagan, J.F., & Fulker, D.W. (1991). Longitudinal predictor of specific cognition abilities from infant novelty preference. *Child Development*, 62; 530-538.

Torbjorn, L., Lonnerdal, B., Stenlund, H., Gamayanti, L.I., Isamil, D., Seswandhana, R., & Perrson, LA. (2004). A community-based randomized controlled trial of iron and zinc supplementation in Indonesian infants: effects on growth and development. *American Journal of Clinical Nutrition*, 80; 729-3.

Trasti, N., Vik, T., Jacobsen, G., & Bakketeig, L.S. (1999). Smoking in pregnancy and children's mental and motor development at age 1 and 5 years. *Early Human Development*, 55; 137-147.

Vaivre-Douret, L., Lalanne, C., Charlemaine, C., Cabrol, D., Keita, G., Sebbane, O., … & Falisard, B. (2009). Relationship between growth status at birth and motor and cognitive development in a French sample of gifted children. *European Review of Applied Psychology*, 60; 1-9.

Vaktskjold, A., Tri, D.V., Phi, D.T., & Sandanger, T. (2010). Infant growth disparity in the Khauh Hoa province in Vietnam: A follow-up study. *Biomedical Central Pediatrics*, 10 (26); 1471-2431.

Van delope, E., Hosseinpoor, A.R., Speybroeck, N., & Vega, L. (2008). Socioeconomic inequality in malnutrition in developing countries. *Bulletin of World Health Organization,* 86(4); 282-219.

Vaughan, V.C. (1992). Assessment of growth and development during infancy and early childhood, *Pediatrics in Review*, 13(3); 88-96..

World Health Organization (WHO) Working Group on Infant Growth. (1995). Physical status: the use and interpretation of anthropometry in infants. *Bulletin of the World Health Organization*, 73(2); 165-174.

WHO Multicentre Growth Reference Study Group. (2006). *WHO child growth standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body Mass index-for-age: methods and development*. Geneva, Switzerland: World Health Organization.

APPPENDIX (1)

PREGNANCY RISK ASSESSMENT MONITORING SYSTEM
MODIFIED QUESTIONNAIRE
(PRAMS)

Table (18) PRAMS Questionnaire (n =130):

Questions	*n*	%
1.Would you say that , in general, your health has been		
Excellent	52	39 %
Very good	58	44.3 %
Good	18	13.7 %
Fair	2	1.5 %
5. In the 3 months before you got pregnant, how many cigarettes did you smoke?		
21-40	1	0.8 %
11-20	5	3.8 %
6-10	5	3.8 %
1-5	6	4.6 %
< 1	1	0.8 %
None	122	85.5 %
***6. During the 3 months before you got pregnant, how many alcoholic drinks did you have in an average week?**		
7-13 drinks a week	3	2.3 %
4-6	6	4.7 %
1-3	25	19.4 %
< 1	37	28.7 %
I didn't drink then	58	45.0 %
11. Did you have any of these problems during your most recent pregnancy? (Yes response is presented)		
a. High blood sugar (diabetes) that started before this pregnancy	0	0.00 %
b. High blood sugar (diabetes) that started during this pregnancy	7	5.4 %
c. Vaginal bleeding	14	10.8 %
d. Kidney or bladder (urinary tract) infection	17	13.1 %
e. Severe nausea, vomiting , or dehydration	19	14.6 %
f. Cervix had to be sewn shut (incompetent cervix)	1	0.8 %
g. High blood pressure, hypertension (including pregnancy-induced hypertension (PIH), pre-eclipse, or toxemia).	12	9.2 %
h. Problems with placenta (such as abruption placentae or placenta previa).	4	3.1 %
i. Labor pains more than 3 weeks before my baby was due (preterm or early labor).	19	14.6 %
j. Water broke more than 3 weeks before my baby was due (premature rupture of membrane (PROM).	3	2.3 %
k. I had to have a blood transfusion.	0	0.00 %
l. I was hurt in a car accident.	1	0.8 %
12. During your most recent pregnancy, did you take medicine on a regular basis to control seizures or epilepsy?	1	0.8 %

18.Have you smoked at least 100 cigarettes in the past 2 years? (A pack has 20 cigarettes). **(Yes response is presented)**	20	15.4 %
19. Have you had any alcoholic drinks in the past 2 years? (A drink is one glass of wine, wine cooler, can or bottle of beer, shot of liquor, or mixed drink).**(Yes response is presented)**	100	76.9 %
20. In the first 3 months of your pregnancy (first trimester), how many cigarettes did you smoke on an average day? 21 to 40 11 to 20 6 to 10 1 to 5 < 1 None	 1 1 2 4 5 117	 0.8 % 0.8 % 1.5 % 3.1 % 3.8 % 90.0%
***23. In the second 3 months of your pregnancy (second trimester), how many cigarettes did you smoke on an average day?** 21 to 40 6 to 10 < 1 None	 1 1 3 124	 0.8 % 0.8 % 2.3 % 96.1 %
26. In the last 3 months of your pregnancy (third trimester), how many cigarettes did you smoke on an average day? 1 to 5 < 1 None	 1 2 127	 0.8 % 1.5 % 96.9 %
***28. During the last 3 months of your pregnancy, how many alcoholic drinks did you have in an average week?** < 1 drink a week I didn't drink then	 4 125	 3.1 % 96.9 %
***29. During the last 3 months of your pregnancy, how many times did You drink alcoholic drinks or more in one sitting?** I didn't have > 5 I didn't drink then	 6 123	 4.6 % 95.3 %
33. How many cigarettes do you smoke on average day now? 6 to 10 cigarettes 1 to 5 < 1	 1 4 125	 0.8 % 3.1 % 95.4 %
***34. Does your husband or partner smoke inside your house? (Yes response is presented)**	1	0.8 %
37. After your baby was born, was he or she put in an intensive care unit? (Yes response is presented)	3	2.3 %

38. After your baby was born, how long did he or she stay in the hospital? Never < 24 hr 24-48 hr 3 days 4 days 5 days >6days	 3 5 94 20 4 1 2	 2.3% 3.8% 72.9% 15.5% 3.1% 0.8% 1.6%
39. Was your baby jaundiced (yellowing of the skin or whites of the eyes)? (Yes response is presented).	37	28.5%
41. Since your baby was born, have you has any medical problem That caused you to go to the hospital and stay overnight? (Yes response is presented)	1	0.8%

*numbers of subjects were 129 in those questions.

APPPENDIX (2)

THE RELATION BETWEEN ANTHROPOMTERIC VARIABLES AND (VIP) VARIABLES

Table (19): Anthropometric Variables:

Variables	Weight-for-age z-score	BMI-for-age z-score	Length-for-age z- score	HC-for-age z-score	Weight-for-length z-score	BW gm
Weight-for-age z-score						
Pearson Correlation	.	.789**	.640**	.138	.608**	.509**
Sig. (2-tailed)	-	.000	.000	.117	.000	.000
n		131	131	130	131	131
Weight-for-length z-score						
Pearson Correlation		.965**	-.217*	.161		.173*
Sig. (2-tailed)	-	.000	.013	.066	-	.048
n		131	131	130		131
HC-for -age z-score						
Pearson Correlation		.197*	.236**			.226**
Sig. (2-tailed)	-	.025	.007	-	-	.010
n		130	130			130
Birth Weight (BW) gm						
Pearson Correlation	.509**	.294**	.460**			
Sig. (2-tailed)	.000	.001	.000	-	-	-
n	131	131	131			
BMI-for-age z-score						
Pearson Correlation			.034			
Sig. (2-tailed)	-	-	.696	-	-	-
n			131			

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Table (20): Visual Habituation Variables:

Variables	Longest look	Total duration of looking	Average look	Number of looks
Total duration of looking				
Pearson Correlation	.919**		.924**	
Sig. (2-tailed)	.000	-	.000	-
n	124		126	
Average look				
Pearson Correlation	.975**			
Sig. (2-tailed)	.000	-	-	-
n	124			
Number of looks				
Pearson Correlation	-.098	.257**	-.132	
Sig. (2-tailed)	.281	.004	.142	-
n	124	125	126	
Novelty Quotient				
Pearson Correlation	.097	-.003	.078	-.208*
Sig. (2-tailed)	.313	.976	.413	.027
n	111	113	113	113

**Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level

Nutritional
Sciences
COLLEGE OF HUMAN
ENVIRONMENTAL SCIENCES

301 Human Environmental Sciences
Stillwater, Oklahoma 74078-6141

P 405 744 5040
F 405 744 1357
E nutsci@okstate.edu

http://ches.okstate.edu/nsci

July 20, 2011

Ebtesam Senossi utilized data from the larger Maternal Dietary Nutrients and Neurotoxins in Infant Cogitative Development (IRB number AS0783) in her thesis project "The relation between infant anthropometry and visual information processing."

Tay Kennedy PhD RD

Associate Professor Nutritional Sciences

312 Human Sciences

Phone: 405-744-5965

E-mail: tay.kennedy@okstate.edu

Oklahoma State University Institutional Review Board

Date:	Tuesday, December 11, 2007
IRB Application No	AS0783
Proposal Title:	Maternal Dietary Nutrients and Neurotoxins in Infant Cognitive Development
Reviewed and Processed as:	Expedited (Spec Pop)

Status Recommended by Reviewer(s): Approved Protocol Expires: 12/10/2008

Principal Investigator(s)

David Thomas	Tay Seacord Kennedy
215 N. Murray	312 HES
Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C. Jacobs, Chair
Institutional Review Board

VITA

Ebtesam E.M Senossi

Candidate for the Degree of

Master of Science

Thesis: THE RELATION BETWEEN INFANT ANTHROPOMETRY AND VISUAL INFORMATION PROCESSING

Major Field: Nutritional Science

Education:

Completed the requirements for the Master of Science in Nutritional Science at Oklahoma State University, Stillwater, Oklahoma in December, July, 2011.

Completed the requirements for the Bachelor of Science in Public Health at Omar Elmuktar University, Beida, Libya in July 1998.

Experience:

Graduate Research Assistant: Nutrition and Development Project: Maternal Dietary Nutrients and Neurotoxins in Infant Cognitive Development (Oklahoma State University)

Name: Ebtesam E.M Senossi Date of Degree: July, 2011

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: THE REALTION BETWEEN INFANT ANTHROPOMTERY AND VISUAL INFORMATION PROCESSING

Pages in Study: 59 Candidate for the Degree of Master of Science

Major Field: Nutritional Sciences

Abstract

Background: Anthropometric measurements are commonly used indices to assess physical growth and development in infants and children. However, few studies have examined the relation between infant growth in terms of anthropometry measurements and cognitive development in terms of visual information processing.
Objective: To examine how growth, as a general indicator of nutritional status in infants, is correlated to cognitive ability as measured by visual information processing. Also how socioeconomic status and maternal factors may affect the relation between physical growth and cognitive development of infants at 3 months of age.
Methods: The study is cross-sectional and observational, and consisted of 132 infants who were predominately breastfed and their mothers. At 3 months of age, the infants' growth measures, including weight, length and head circumference, were obtained and visual information processing trials were conducted. Also demographic information and information regarding pregnancy risk was obtained from the mothers.
Results: Weight, length, BMI and head circumference Z-scores were significantly related to VIP measures, whereas head circumference, and weight were significantly related to novelty quotient. Length was negatively correlated to VIP measures, and birth weight was not correlated to any of the VIP measures. Maternal education was significantly related to information processing measures.
Conclusion: infant of average weight, length, and head circumference processes information faster than those who are shorter and heavier.

ADVISER'S APPROVAL: Dr. Tay Kennedy

ADVISER'S APPROVAL: Dr. Tay Kennedy