

## Feeding Patterns Influence Brain Development in Infancy

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**Abstract.** Breastfeeding has been shown to promote more optimal neurodevelopmental outcomes (Jing, Gilchrist, Badger, & Pivik, 2010). The present study examined feeding patterns and infant brain development, using electroencephalograph (EEG) coherence (a measure of the relationship of two different electrode sites across regions). 113 mothers and their 1- and 3-month old infants participated. At each age, EEG was obtained from frontal (F3, F4), central (C3, C4), parietal (P3, P4) and occipital (O1, O2) sites. A series of repeated-measures multivariate analysis of variance (MANOVA) yielded significant effects, with greater coherence from the frontal region to parietal regions and central to occipital region for breastfed compared to bottle-fed infants. Multiple regression analyses showed that feeding type (longer duration of breastfeeding) and quality of feeding type (exclusively breastfeeding) uniquely predict more optimal brain patterns in the left hemisphere (and greater coherence from anterior to posterior regions). Findings from the study indicate that infants who are breastfed show more mature patterns of brain development.

### Introduction

An abundance of research has emphasized the benefits of breastfeeding on infant health. The nutritional advantages of breastfeeding have been associated with increased health in a host of developmental areas including physiological, psychological, and cognitive development (Leung, & Sauve, 2005). As of 2011, the World Health Organization (WHO) recommends that for optimum health and development, mothers should exclusively breastfeed their infants for the first six months of the infant's life and continue with partial breastfeeding up until the infant is two years of age or later. The WHO defines exclusive breastfeeding as, "the infant has received only breast milk from his/her mother or a wet nurse, or expressed milk and no other liquids or solids, with the exception of drops of syrups consisting of vitamins, mineral supplements, or medicines." The purpose of the present study is to examine the effects of different feeding patterns on infant's brain development.

#### *Human Milk vs. Formula Milk*

The composition of breast milk versus formula milk, and the feeding method, breast versus bottle, has been shown to influence the development of the central nervous system as well as behavioral devel-

opment (Jing, Gilchrist, Badger, & Pivik, 2010). Studies have demonstrated that breastfed infants show enhanced activation patterns across a number of brain regions and across hemispheric connections.

Human milk is, biologically, what infants are intended to consume. According to the WHO, breast milk provides all of the necessary energy and nutrients an infant needs in his or her first few months of life. In a meta-analysis performed on 11 studies relating breastfeeding to development, Anderson, Johnstone and Remley (1999) found that exclusive breastfeeding led to more rapid brain development and overall enhanced brain function. Another study found that breastfeeding enhances all of the following areas of development: cognition, visual function, motor function, emotional adaptation, behavioral adaptation, and better performance academically (Petryk, Harris, & Jongbloed, 2007).

There have been many efforts to imitate the composition of breast milk in formula milk, but none have been able to replicate all of the advantages that breast milk offers (Banapurmath, Banapurmath, & Kesaree, 1996; Heird, 2007). Many studies indicate that the advantages of breast milk may be due to the long-chain polyunsaturated fatty acids (LCPUFAs) that are abundant in breast milk up until the infant is four to six months of age (Petryk et al., 2007; Xiang, Alfven, Blennow, Trygg

& Zettserstrom, 2000). The LCPUFAs that are studied most widely are docosahexaenoic acid (DHA) and arachidonic acid (AA). It is thought that the lack of these LCPUFAs in formula milk can lead to disadvantages in the development of the central nervous system (Faldella, Aceti, & Corvaglia, 2011; Jing et al., 2010; Khedr, Farhaly, El-Din Amry & Osman, 2004).

McNeil, Labbok, and Abrahams (2010) point out that despite the abundance of research supporting breastfeeding as the superior feeding method, breastfeeding is not considered to be the preferred practice for many families; it is often formula use and bottle use that is used as the standard for infant feeding. The current study examined the physiological and psychological advantages that make breastfeeding superior to formula feeding.

#### *Factors Affecting Feeding Type*

According to the Center for Disease Control and Prevention's (CDC) 2011 Breastfeeding Report Card, breastfeeding initiation in the United States is near the Healthy People 2010 goal of 75%. However, rates of breastfeeding at six months and one year fall well below the goals of 50% and 25%, respectively. For instance, rates for exclusive breastfeeding were lower than targeted, with only 36% of mothers feeding their infants breast milk at three months and less than half of that (16.3%) exclusively breastfeeding at six months. In general, the numbers indicate that while many mothers initiate breastfeeding, they do not continue to do so for more than the first few weeks of their infant's life.

The decrease in rate of breastfeeding is due to multiple factors. Cultural and societal attitudes towards breastfeeding, as well as the necessity of returning to a workplace environment that commonly discourages mother-infant feeding patterns effects both a mother's choice to breastfeed and how long she breastfeeds for (Heird, 2007). The lack of breastfeeding support programs, particularly amongst women of low socioeconomic status, is also believed to play a role in women's decision to breastfeed (Bolton, Chow, Benton & Olson, 2009). Mothers' most commonly self-reported reason for ending breastfeeding is they feel their infant is not satisfied by breast milk alone (Fein, Grummer-Strawn, & Raju, 2010). This study aims to add new data that will

further emphasize the nutritional and neural benefits that breastfeeding offers to infants.

#### *Early Experience Affects Development*

Experiences, including feeding experiences, in infancy are thought to have a profound affect on later development (Fox & Rutter, 2010; Lamb, Bornstein & Teti, 2002). Lamb and his colleagues (2002) attribute this to factors such as the plasticity of the immature nervous system and infants' unrivaled ability for learning. Being that infants have few sources of input into their lives, their feeding experiences and patterns play a significant role in their development.

In a recent study, infants who were breastfed were rated as having more positive and approach-oriented individual characteristics than infants who were bottle-fed. This was found to be true even of infants born to depressed mothers (Jones, McFall, & Diego, 2004). These findings may have implications for the developmental outcomes in breastfed versus formula fed infants.

#### *Psychological Processes Associated with Feeding Type*

A longitudinal study comparing the effects of feeding type on EEG activity performed by Jing and colleagues (2010) reported differences between breastfed, milk formula-fed, and soy formula-fed infants. They found significant differences on EEG power scores between the breast-fed and formula-fed infants but found similar EEG power scores between the milk formula fed and soy formula fed infants. EEG power is a measurement of the wattage of power released across time by a specific electrode as compared to a reference electrode within the frequency spectrum. Historically higher power scores in alpha frequency bands have been associated with less neural activity (Allen, Coan & Nazarian, 2004; Jones, 1994). Results from the Jing's study displayed lower power scores for the breast fed infants indicating greater EEG maturation and greater neural development in the breastfed infants over the formula-fed infants.

While EEG power scores have been shown to be a significant indicator of infant neural development (Jing et al., 2010; Jones et al., 2004), EEG coherence needs to be

further looked at because EEG power does not offer the same type associations offered by EEG coherence such as “spatial resolution and network analysis” (Thatcher, Walker & Guidice, 1986). According to Cuevas, Raj, & Bell (2012) “EEG coherence is the squared cross-correlation between two scalp electrode sites within a designated frequency band.” The values of coherence indicate the amount of communication between the two sites (Cuevas & Bell, 2011; Thatcher, North, & Biver, 2005). Due to the range of differences between electrode sites, coherence consists of both long and short bands. Coherence values range from zero to one. Zero represents no relation between the two sites (suggesting the two sites are acting independently of each other) and one represents the two sites are completely in relation with each other; that is, they are exhibiting synchronization of the neural oscillations (Fox, Schmidt, Henderson & Marshall, 2004; Murias, Webb, Greenson & Dawson, 2007).

There have been few studies relating early feeding patterns to EEG development (Jing et al. 2010). Jing and colleagues point out that studies that have previously related diet/nutrition and EEG have not looked directly at diets influences on EEG development. A review of the literature has examined measures of EEG coherence in the context of mother-infant feeding patterns across the first few months of development. There have been no studies previously conducted in which the development of EEG coherence is directly related to early infant nutrition. This study aims to investigate the effects of feeding and level of breastfeeding on EEG coherence in order to understand how feeding affects the development of the brain during infancy.

#### *The Developing Infant Brain*

The development of the brain is a process that proceeds well into adolescence. Therefore, neurodevelopment and behavioral abilities emerge over time. In fact, the frontal lobes of the brain do not reach maturity until the age of 16-18 years old (Kolb & Whishaw, 2003) and the left hemisphere is more protracted than the right hemisphere during development (Bell & Fox, 1992). It is because of this slow process during development that we should expect to see significant differences in the brains of infants as compared to the brains of older

children and adults. In adults, the dominant frequency band is labeled alpha and is found in the 8-13 Hz range (Stroganova, Orekhova, & Posikera, 1999). It is most logical then to label the dominant band in infants “alpha.” Because infant EEG is at a much lower frequency than adult EEG this band in infants is found at a lower range, most commonly agreed to be the 6-9 Hz range for the second half of the first year of life (Bell & Wolfe, 2007; Stroganova et al, 1999) and in the 3-6 Hz range for infants younger than 3 months (Jones et al., 2004). A study by Stroganova et al. (1999) found the developmental changes of alpha rhythm proceeds from the posterior to anterior regions of the brain.

The present study will be examining infant EEG coherence at both one and three months of age, including anterior to posterior region communications and within hemisphere communications. Scores for both the 3-6 Hz band and 6-9 Hz band will be analyzed from each visit to take into account the assumption that younger infants (infants in the first half of their first year of life) should have even lower frequency than infants in the second half of their first year of life.

#### *Levels and Duration of Feeding*

It is crucial to define the different levels of infant feeding in order to test for differences in breastfed infants compared to formula-fed infants. Clear categories between the two must be defined to prevent results from being confounded by variables such as the level of nutrients the infant is receiving (Petryk et al., 2007). The levels of breastfeeding are defined as follows: Exclusive breastfeeding: Infant receives only breast milk. Almost exclusive: Infant is predominantly fed breast milk but may receive tastes of other liquids such as water or water-based drinks. Partial breastfeeding: Infant receives both breast milk and other feeds such as formula milk and/or cereals. This category can be split into high, medium, or low based on the amount of calories an infant receives of each type of feed. Token: Breastfeeding is minimal (less than 10% of nutrition is provided from breast milk. Exclusive formula feeding: Infant receives no breast milk, directly or expressed. These levels are based on the International Group for Action on Breastfeeding Consortium (IGAB) definitions. Without these

levels, we are unable to establish the effect of feeding type on infant development.

It is thought that not only type of feeding, but also duration of type of feeding, that is, the length of time a mother breastfeeds or bottle feeds her infant across infancy (Kramer et al. 2008) also plays a role in infant development. Therefore, not only breastfeeding, but also how long an infant is breastfed for should show an effect when testing for differences between breastfeeding and formula feeding (Harmon-Jones, 2006).

### **Purpose and Hypothesis**

The present study will examine infant feeding patterns and EEG measures. Specifically, the effects of level of breastfeeding compared to primarily formula feeding will be examined in relation to measures of EEG coherence across different regions and within the two hemisphere of the brain during the first three months of life. The aim of the study is to examine which feeding method displays the greatest coherence between electrode sites and for each hemisphere as a measure indicating neural integrity and communication.

It was hypothesized that infants who were exclusively breastfed would have the greatest coherence between measured electrode sites (taking into account underlying differences due to long and short coherence distances) and that the partially breastfed infants and the formula fed infants would display lower coherence between the measured electrode sites. It was also expected that breastfed infants would demonstrate greater coherence in left hemisphere that are more anterior in regional location by 3-months than formula fed infants.

### **Methods**

#### *Participants*

A total of 113 healthy infants and their mothers were participants in this study. They were recruited from birth announcements placed in local newspapers, lactation centers, and hospitals. Families were predominantly White (86% Caucasian, 9.3% African American, 1.2% Hispanic, and 3.5% mixed race). Infants were born full-term (more than 37 weeks gestation) to primarily middle-class (self reported on Hollingshead scale = 2.6) adult women (mean age = 30.0 years, S.D. = 5.0 years).

All 113 mother-infant dyads participated in a laboratory visit when the infant was one month of age (mean age = 37.14 days, S.D. = 5.88 days). Of these, 86 were included in the coherence analysis. Eighty-seven of the original 113 mother-infant dyads returned for a second laboratory visit when the infant was three months of age (mean age = 95.0 days, S.D. = 11.4 days). Of these 59 were included in the EEG coherence analysis.

Infant demographics were similar across feeding type (Table 1). Mothers who breastfed their infants were, on average, 31.18 (S.D. = 4.77) years of age and were middle income (a Hollingshead score of 2.44, S.D. = 0.99). Mothers who bottle fed their infants were, on average, 28.83 (S.D. = 6.95) years of age and were also middle income (a Hollingshead score of 2.96, S.D. = 0.85).

#### *Feeding Type*

The IGAB Consortium definitions were used to determine whether mothers were full breast feeders, partial breast feeders, or token breast feeders (Labbok, 2000). For the purpose of this experiment, we used full breast-feeding, exclusive breast-feeding and almost exclusive breast-feeding as encompassing the same metric. Partial breast-feeding included mothers who breastfed for a minimum of three weeks up to almost exclusive and token breast feeding included mothers who breastfed for less than three weeks or not at all (all bottle feeding).

The following are the number of infants in each feeding group who were included in the EEG coherence analysis. In the full breastfeeding group there were 39 participants at one-month and 32 participants at three-months. In the partial breastfeeding group there were 28 participants at one-month and 17 participants at three-months. In the token breastfeeding group there were 19 participants at one-month and 10 participants at three-months.

Florida Atlantic University's Institutional Review Board approved the study. Parent participation was voluntary and infant's participation was obtained by parent consent. Participants were treated in accordance with APA ethical standards.

## Procedure and Materials

### 1 Month Visit

The mother-infant dyads came to the laboratory for the visit. Upon arrival mothers signed consent forms and filled out demographic and feeding questionnaires. The Hollingshead Scale was based on four factors: marital status, gender, education, and occupation. The feeding interview was based on experiences in feeding the infant and included the length of time for breastfeeding as well as experiences and quantity of all other foods ingested (including formula type and amount, if applicable).

Following an initial play interaction mothers were asked to feed their infants. The feeding session lasted as long as it took for the mother to feed her infant. Once the infant began feeding, the mother-infant dyad was left alone. Methods of feeding included breastfeeding or formula feeding. Other foods were reported on but were not observed. Both mother and infant were videotaped during the session. Infant EEG was also collected during each session at a time when the infants were maximally alert and non-distressed. Infant EEG was obtained from 3-5 minutes.

### 3 Month Visit

Procedures conducted at the three-month visit were identical to that of the one-month visit.

### Physiological Recordings

EEG recordings were obtained using equipment manufactured by James Long, Inc. A stretchable lycra cap, manufactured by Electro Cap, Inc., with the international 10-20 system was used. Eight electrode sites were measured; electrode gel was inserted for good conductance and Omni prep was inserted to gently abrade the specific sites. The vertex, Cz, was used as a reference for the on-line recordings. The recordings were taken from frontal, central, parietal and occipital sites, specifically sites F3 and F4, C3 and C4, P3 and P4, and O1 and O2, respectively. Sites were re-abraded if impedances were not less than 5K ohms. Eye movement artifacts were removed from the EEG data using EOG obtained from the outer cathus and the supra-orbit position of one eye (Beckman mini electrodes were used).

Electrical signals from the EEG were amplified with filters bandpassed from 1-100 Hz using Instrumental Bioamps. After being streamed onto a computer screen, data was saved and analyzed using Snapstream data acquisition software (v. 3.21, HEM Data Corp., 1991). The online sampling rate of the EEG data was digitized at 512 samples per second for each channel.

### Data Reduction and Analysis

To examine the relationship between feeding type and infant neural activity, participants were categorized into three groups: exclusive/full breast feeders, partial breast feeders, and bottle feeders/token breast feeders.

EEG coherence is a statistical procedure used to measure the relationship of two specific electrode sites at a specific frequency band. As noted previously we used 2 infant-specific frequency bands, one from 3-6 and the other from 6-9 Hz. Coherence consists of both long and short bands with values ranging from 0-1. 0 represents no relation and 1 represents the two sites either being completely in or out of relation with each other (Fox et al., 2004; Grieve, 2008). Calculating the relationship of the bands within each hemisphere was used in the analysis of EEG coherence. The specific sites for each hemisphere measured were: F3 + C3, F3 + P3, F3 + O1, C3 + P3, C3 + O1, P3 + O1, F4 + C4, F4 + P4, F4 + O2, C4 + P4, C4 + O2, and P4 + O2.

### Statistical Analysis

To assess EEG coherence as a function of feeding type, average EEG coherence values were computed for each hemisphere to examine which electrode site pairs displayed the greatest coherence. The 3-6 Hz frequency band was used for the one-month old infants and the 6-9 Hz frequency band was used for the three-month old infants.

Multivariate analyses of variances (MANOVAs) were conducted to examine each of the research questions. The within-subjects factors consisted of region, length (short or long), hemisphere, and age. The between-subjects factor was feeding type (breast or bottle). Feeding differences, breast versus bottle, and duration of type of feeding, full, partial, or token, was of particular interest in our EEG coherence analysis. Level of feeding

was compared across brain regions and for left versus right hemispheres, to determine if there was a significant difference in regional development for infants who received breast milk compared to infants who received formula milk.

Multiple regression analyses were conducted to examine the degree to which breastfeeding duration and quality of feeding-type predicted brain development parameters (region, short/long and hemisphere) in the three-month old infants.

#### *EEG Coherence*

Overall, a series of repeated measures MANOVAs performed on the EEG coherence values demonstrated significant effects for infant feeding type on infant EEG coherence. Table 2 displays the mean values. For measures of EEG coherence at 1- and 3-months, a significant 4-way interaction was obtained only for the 3-month-old infants between region (anterior vs. posterior), length of communication (short, medium, and long), side (left hemisphere vs. right hemisphere), and feeding type (breast vs. bottle). Significant main effects were obtained across region,  $F(1,57) = 50.28$ ,  $p < .000$ , indicating differential influence of the anterior and posterior leads. Thus further analyses were conducted separately for anterior and posterior regions.

To assess our main hypothesis, a subsequent MANOVA comparing communication from the frontal region to other regions showed a significant 3-way interaction for length, side, and feeding type,  $F(1,57) = 4.44$ ,  $p < .05$ . As noted in the figure (see figures 1 & 2), the pattern of EEG coherence differed, with breastfeeding infants exhibiting a pattern of greater coherence values, theoretically indicating greater coherence between the frontal region and all other sites.

Multiple regression analyses (Table 3) showed that both duration of feeding type and quality of feeding type uniquely predict infant's brain development at 3-months of age for the F3 + P3 and C3 + O1 intrahemispheric brain communication. No significant regression effects were obtained for the right-sided brain communication.

## **Discussion and Conclusion**

### *Overview of Results*

The goal of the present study was to determine the influences of different feeding patterns on infant brain development. As hypothesized, breastfed infants displayed greater communication between measured electrode sites than did bottle fed infants. This is consistent with findings from previous studies that emphasize breast-feeding promotes optimal neurodevelopment outcomes (Jing et al., 2010; Jones et al., 2004).

At three-months there were developmental differences found within frontal and posterior regions of the brain. This may be indicative of the impact of breast-feeding duration on brain development, suggesting that by three months of age infants who are exclusively breastfed may have more mature brain development in the frontal region of their brain.

Thatcher and his colleagues (1987) found that the left and right cerebral hemispheres develop at different rates and that within the hemispheres different specific anatomical connections develop at different rates: it was found that right frontal-occipital region developed earlier than the left frontal-occipital region. This is consistent with findings from our study but our study extends this by demonstrating that left hemisphere communication was more mature in breastfed infants by 3-months. It must also be noted that within the frontal-occipital region it was found that the full breast-fed infants displayed the greatest coherence, followed by the partial breast-fed infants and token breast-fed infants, respectively. This supports our hypothesis that feeding type plays a role in optimal brain maturation.

In addition, Thatcher et al. (1987) found that the right frontal pole developed earlier than the left frontal pole. Results from our coherence analysis displayed more consistent coherence scores across the right hemisphere than the homologous left hemisphere with not only more variance in left hemisphere coherence scores but also more mature development as displayed through higher coherence values for the breastfed infants. This suggests that feeding type may be playing a role in development of particularly the frontal region and the left hemisphere, a hemisphere and region linked to the de-

**Table 1**  
**Infant Demographics**

Measure	1 Month		3 Month	
	Breastfeeding	Bottle feeding	Breastfeeding	Bottle feeding
	62	24	44	
Infant Variables				
Female (%)	53	62	48	47
Age (days)	38.67 (4.96)	36 (6.1)	93.60 (10.24)	95.47 (12.85)

*Note.* Values represent mean scores. Standard deviations are in the parentheses

**Table 2**  
**EEG Coherence Scores**

Measure	1 Month			3 Month		
	Full	Partial	Token	Full	Partial	Token
Left Hemisphere						
F3 + C3	.57 (.04)	.56 (.43)	.53 (.07)	.55 (.04)	.64 (.05)	.53 (.06)
F3 + P3	.36 (.04)	.37 (.04)	.28 (.05)	.35 (.03)	.31 (.02)	.25 (.03)
F3 + O1	.31 (.03)	.29 (.03)	.23 (.04)	.29 (.02)	.28 (.02)	.25 (.03)
C3 + P3	.56 (.04)	.53 (.05)	.52 (.06)	.54 (.05)	.44 (.04)	.37 (.05)
C3 + O1	.37 (.04)	.38 (.04)	.39 (.05)	.38 (.03)	.33 (.03)	.26 (.04)
P3 + O1	.52 (.04)	.62 (.05)	.64 (.06)	.63 (.03)	.69 (.04)	.66 (.06)
Right Hemisphere						
F4 + C4	.44 (.04)	.46 (.05)	.33 (.06)	.38 (.04)	.41 (.04)	.35 (.05)
F4 + P4	.36 (.04)	.43 (.05)	.35 (.06)	.38 (.03)	.34 (.03)	.34 (.03)
F4 + O2	.29 (.02)	.31 (.03)	.22 (.03)	.28 (.02)	.26 (.02)	.23 (.03)
C4 + P4	.50 (.05)	.49 (.06)	.44 (.09)	.44 (.05)	.49 (.06)	.50 (.08)
C4 + O2	.36 (.03)	.38 (.04)	.38 (.06)	.36 (.03)	.32 (.03)	.29 (.03)
P4 + O2	.57 (.04)	.62 (.04)	.54 (.07)	.59 (.03)	.51 (.04)	.55 (.05)

*Note.* Values represent mean scores. Standard deviations are in the parentheses.

**Table 3**  
**Regression Analyses of 3 - month Feeding Duration and Quality and 3 - month Left and Right Hemisphere Coherence as a Predictor of Brain Development**

Variables	Multiple Regression					
	Left Hemisphere			Right Hemisphere		
	R	Adj-R <sup>2</sup>	β	R	Adj-R <sup>2</sup>	β
F3 + C3	.213	.010		F4 + C4	.117	-.022
Days			.351	Days		-.038
Quality			-.273	Quality		.144
F3 + P3	.316*	.068		F4 + P4	.180	-.001
Days			.197	Days		-.039
Quality			.136	Quality		.210
F3 + O1	.294	.054		F4 + O2	.287	.050
Days			.307	Days		.281
Quality			-.016	Quality		.007
C3 + P3	.363	.099		C4 + P4	.142	-.015
Days			-.036	Days		-.231
Quality			.391	Quality		.163
C3 + O1	.324*	.072		C4 + O2	.279	.044
Days			.017	Days		.278
Quality			.311	Quality		.001
P3 + O1	.229	.019		P4 + O2	.232	.021
Days			-.325	Days		.382
Quality			.141	Quality		-.300

\*p < 0.05

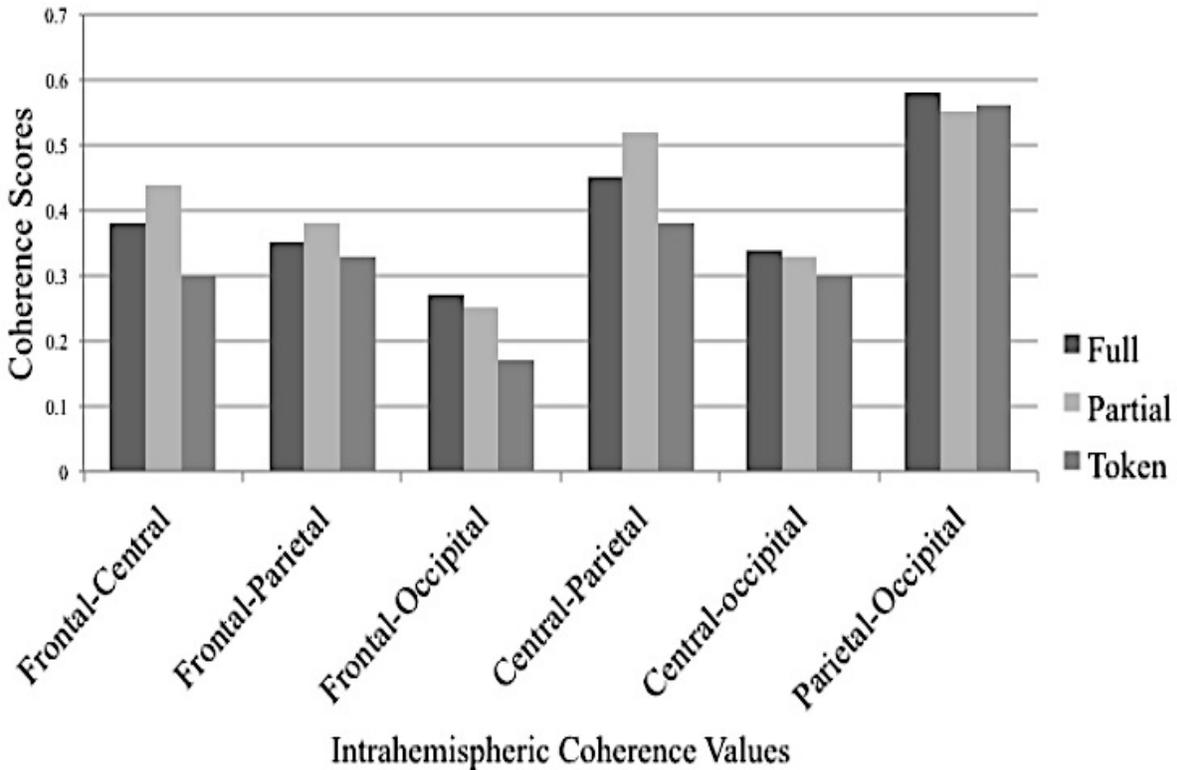


Figure 1 – Right intrahemispheric coherence scores for the 3-month old infants as a function of feeding type.

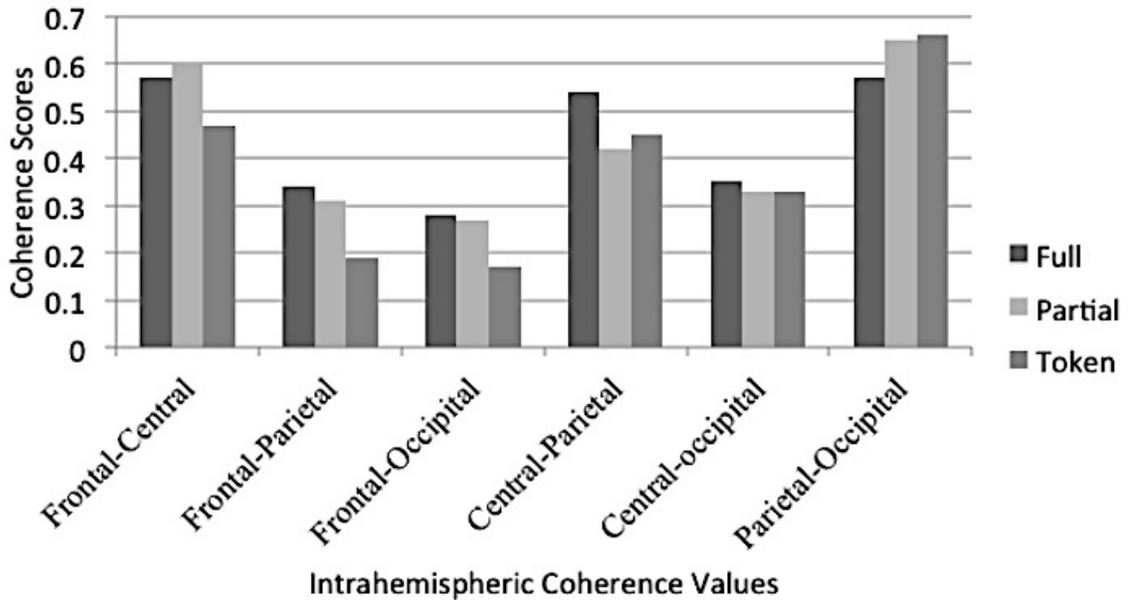


Figure 2 – Left intrahemispheric coherence scores for the 3-month old infants as a function of feeding type.

velopment of positive affect and approach styles (Fox et al., 2007).

#### *Study Limitations*

A limitation of this study was attrition. In some cases application of the EEG cap was difficulty and limited data were available due to movement artifact. This resulted in the absence of some infant EEG across ages. Also, in some cases there were missing leads (due to movement artifact or high impedances) in the EEG data, resulting in the EEG data being unusable for the coherence analyses.

In addition, the classification of feeding status proposed a limitation on the study. Mothers were broken up into three groups based on the limitations of the sample size: full breastfeeding which included exclusive breastfeeding and almost-exclusive breastfeeding, partial breastfeeding which included mothers who breast-fed their infants at least some breast-milk for a minimum of three weeks and token breast-feeding which included mothers who breastfed their infants for less than three weeks or not at all. Drane and Logemann (2000) found that studies that differentiated between partial and exclusive breast feeding found larger effect sizes than studies that grouped them together. Therefore, had we had a larger sample and been able to have these categories broken down more rigidly with exclusive breast feeders placed in their own group and partial breast-feeders broken up into several groups including high, medium, and low, our results may have had been less diffuse.

#### *Future Research*

The present study examined whether feeding type influences infant brain development at one- and three-months of age. However, previous studies have suggested that feeding type may play a role in brain development throughout life (Drane & Logemann, 2000; Fladella, Aceti, & Corvaglia 2011). "Thus, a longitudinal study across the infancy and early development in which feeding types affect on all types of brain processes (e.g. coherence, asymmetry as well as fMRI) are examined would be beneficial to see if it breast milk continues to play a role on brain development throughout the lifespan and in what areas of development, including cogni-

tion, affective and physiological development."

A study by Thatcher, North, and Biver (2008) found age-related increases in EEG coherence values up until four years of age. This suggests that coherence scores are efficient in determining if feeding type effects brain development into childhood and should be used by subsequent researchers in determining the longitudinal effects of feeding type.

#### *Concluding Remarks*

These data provide a unique contribution to the literature as EEG coherence measures had yet to be looked at in relation to infant feeding patterns. Data from this study suggest that the quality and duration of breastfeeding play a pivotal role in infant brain development.

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