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# Breastfeeding Is a Dynamic Biological Process—Not Simply a Meal at the Breast

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Sometimes, even the most obvious facts need to be reiterated.

An infant suckling at his or her mother's breast is not simply receiving a meal, but is intensely engaged in a dynamic, bidirectional, biological dialogue. It is a process in which physical, biochemical, hormonal, and psychosocial exchange takes place, designed for the transfer of much needed nutrients, as well as for building a lasting psychosocial bond between the mother and her infant. Among mammals, breastfeeding has evolved over millions of years as a multitiered interaction to meet the biological and psychosocial needs of the progeny, enhancing its well-being and survival chances, as well as complementing the nurturing role of the mother. Thus, this unique, dynamic process benefits both the mother and her infant.[1] Breastfeeding needs to be considered quintessentially as a continuation of the more intense, intrauterine dialogue, mediated through the placenta and the umbilical cord between the mother and her fetus.

Whether feeding at the breast is complementary to the nutritional value of human milk, which might explain the diverse range of benefits to the mother and her infant,[1] remains to be studied. Perhaps, innovative methods from different scientific disciplines, such as behavioral, cognitive, and developmental neurosciences, and social anthropology may be useful to study this unexplored territory. In this commentary, a brief overview is presented concerning the possible link between the process of breastfeeding and neurocognitive outcomes.

Among the many benefits from breastfeeding during the first year of an infant's life, the effects on long-term cognitive development and IQ have been most controversial.[2–7] The reasons for the controversy include methodological limitations in breastfeeding research, inability to adjust for unmeasured confounders (residual confounding), and the possibility that women who can, and choose to, breastfeed may be inherently different from those who cannot, or choose not to, breastfeed their infants.[4] On the other hand, some scientists contend that breastfeeding should be considered the social norm, and *lower* cognitive scores in infants fed formula should be considered *abnormal*.[7] Sullivan[7] asked, "Is it possible that some property in the infant formula may not be conducive to full cognitive development?" It is an interesting question that needs to be elucidated in future studies.

Be that as it may, the above arguments require one to critically consider the cause-and-effect relationships between breastfeeding and cognitive outcomes. In this regard, two recent publications answer the concerns about the causal relationships.

In a longitudinal study of neurodevelopmental evaluation from Poland, Jedrychowski et al.[3] assessed 468 infants of nonsmoking women over five different time points: at 1, 2, 3, 6, and 7 years of age. Infants who were exclusively breastfed consistently demonstrated between 2.1 and 3.8 higher IQ points at *each* measurement session compared with those who received mixed feeding (human milk plus infant formula). The longer the duration of exclusivity of breastfeeding, the higher was the IQ benefit. In this and and similar studies,[1–4] the overall IQ advantage from breastfeeding appear to be small, but the effect size is highly significant from a public health perspective. Improvements of even a few IQ points, especially at the lower end of the IQ distribution, will reduce the number of children who might otherwise need special education.[4]

Brion et al.[8] took a different approach to study the causal relationship between breastfeeding and cognitive outcomes. They compared two cohorts: one from a high-income country, the British Avon Longitudinal Study of Parents and Children (ALSPAC), with a sample size of about 5,000 children, and another from a low- and middle-income country, the Brazilian Pelotas cohort, with a sample size of about 1,000 children. Using novel analytical methods to establish causal inferences, the study found beneficial effects of breastfeeding on children's blood pressure and body mass index *only* in the ALSPAC cohort, whereas there was a robust positive effect of breastfeeding on children's' IQ in *both* cohorts. Such differential effects of breastfeeding on blood pressure and body mass index were perhaps due to residual confounding, whereas the consistent positive association of IQ in *both* populations suggested a causal biological effect.

Might there be more direct biological explanations for the beneficial association between breastfeeding and neurocognitive outcomes? Many developmental neuroscience studies utilizing advanced outcome assessment tools provide insights into this possibility.[9–20]

Consider the neonatal brain. It weighs about 350–400 g at birth, or about 30% of the weight of the adult brain. During the

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first year, brain weight nearly doubles, to about 55% that of the adult brain. Much of the increase in brain weight comes from the growth of white matter,[10] myelination of the fiber tracts, and enrichment of the neuronal and dendritic arborization—the latter greatly facilitated by the dramatically increasing white matter (astrocyte) volume.

It is also significant that during this period of rapid brain growth, major developmental changes occur in the sensorimotor, visual, and voice processing regions of the brain, firming up the foundations for language acquisition.[16–20] Infants possess early capacity to process speech, and they rapidly learn to understand the properties of their native language. Infants as young as 3 months of age can preferentially distinguish native language from a foreign tongue. Human voices play a fundamental role in the development of infant social communication. Strong human voice-sensitive areas are already established in the temporal cortex of 3–7-month-old infants.[17] By then, the emotional component of the voice and language processing also gets established, further complementing future learning.

In this context, consider a 4-month-old infant who is exclusively breastfed, as opposed to one who is fed through a bottle. In the former case, the infant has about 2–4 hours of direct physical contact each day with his or her mother during breastfeeding (granted that the exact duration may vary depending on the duration per feed and the frequency of feeds each day). These are times during which the mother–infant pair is engaged in an intimate symphony of biochemical and psychosocial dialogue. This is a time when a mother can gaze directly into the eyes of her infant and speak to him or her; this sensory exchange is reciprocated by the infant through visual, auditory, and physical cues.

A mother (or father) using a bottle to feed her (or his) infant might *also* engage in pleasurable and positive interactions with the infant, which is certainly beneficial. But, the nature of the dynamic interaction is multitiered when the infant is suckling at his or her mother's breast. It is unclear how such differences in the sensory dialogue might affect the infant's trajectory of cognitive processing and development.

Might the combination of direct physical and emotional contact coupled with the supply of the most appropriate nutrients required for growth and development of the brain be the most appropriate biological signals to alter developmental trajectories for improved neurocognitive development and outcomes of breastfed infants? How important are the effects of temporal linkage of the biochemical and sensory stimuli emanating from all five sensory systems, coupled with the mother's socioemotional interaction? Do these complement the nutritional value of the breastmilk, helping to hard-wire the regions of the brain required for processing cognitive, sensory, and language stimuli?

It is also well known that the infant at the breast influences the biochemical content of breastmilk. A recent study reported higher levels of brain-derived neurotrophic factor levels in exclusively breastfed infants compared with exclusively formula-fed infants, and the former group demonstrated better behavioral scores than the latter.[20] It is an intriguing possibility that a suckling infant can influence components of breastmilk from feed to feed, matching the changing needs of the growing infant. Studies are needed to explore the effect of the temporal relationship between the supply of optimal food through the active process of suckling and lactation, coupled with other positive elements of the sensory dialogue.

At present, only indirect evidence can help address these questions. Several studies have measured auditory (sound), voice, pitch, and language processing in infants under 1 year of age, but most have not obtained information on the method of feeding. In a series of studies, Pivik and colleagues[12,13] reported strong differential effects of breastfeeding on the auditory-evoked potential responses during the processing and discrimination of speech sounds in 3- and 6-month-old infants while processing of human voice stimuli. It is therefore conceivable that the processes that lead to "hard wiring" of the neurocognitive developmental signals in the brain during the first year of life are enriched and complemented by the simultaneous nutritional, biochemical, and physical dialogue between the mother and her infant during breastfeeding. This can explain the positive effects of breastfeeding on the speech/language component of the IQ measured in later life, as well as its dose and duration effect.[2–4] More studies are needed in this important area of child development and nutrition.

This commentary is presented as food for thought. Renewed research efforts devoted to understanding the complex biological exchange during breastfeeding may provide a fresh perspective to explain the mechanisms of its positive and lasting benefits and bolster the reasons for promoting breastfeeding, as outlined in the U.S. Surgeon General's *Call to Action To Support Breastfeeding*, released in 2011.[21]

## Disclosure Statement

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