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Dr. Jen 4 Kids

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The Sensory Experiences of the Newborn

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Disclosure

- I have no relevant financial relationships with the manufacturers(s) of any commercial products(s) and/or provider of commercial services discussed in this activity.
- I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.

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Overview

- Olfactory development
- Gustatory system development and the development of flavor
- Visual system development
- Auditory system

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Introduction

A baby comes into the world totally dependent on adults for survival but also equipped with a set of characteristics and behaviors capable of eliciting attention and care from them. In addition to having a mother, it is necessary that the baby establish a focused relationship with her.

The baby has a set of sensory skills which help create the relationship with mother.

These skills help them latch

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Olfactory Development

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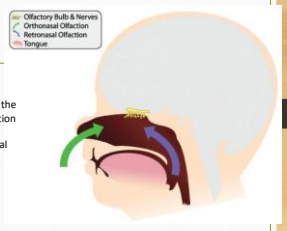
Olfactory System

The receptors for the olfactory system, located high in the nasal chambers, are stimulated not only during inhalation (orthonasal route, green arrow) but also when infants suck and when children and adults swallow, as chemical constituents in foods and beverages reach the nasal receptors by passing from the oral cavity through the nasal pharynx (retronasal route, purple arrow).



Lipchock SV, Reed DR, Mennella JA. The gustatory and olfactory systems during infancy: implications for development of feeding behaviors in the high risk neonate. Clinics in perinatology. 2011;38(4):627-641.

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Olfactory System

The baby's sense of smell guides survival and social interaction

Unlike other sensory systems, behavioral and physiological responses to olfactory stimuli can easily be demonstrated in the newborn

In fact, the newborn has a highly functioning olfactory system at birth which helps guide early feeding behaviors.

Arichi T, Gordon-Williams R, Allievi A, Groves A, Burdet E, Edwards A. Computer-controlled stimulation for functional magnetic resonance imaging studies of the neonatal olfactory system. *Acta Paediatrica (Oslo, Norway : 1992)*. 2013;102(9):868-875.

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Olfactory System

The calming effect of a maternal breast milk odor on the human newborn infant.

Forty-eight healthy infants were assigned to four groups

- an own mother's breastmilk odor group (Own MM),
- another mother's breastmilk odor group (Other MM),
- a formula milk odor group (Formula M)
- a control group.

The babies crying, grimacing and motor activities during a heelstick were recorded.

Nishitani S, Miyamura T, Tagawa M, Sumi M, Takase R, Doi H, et al. The calming effect of a maternal breast milk odor on the human newborn infant. Neurosci Res. 2009 Jan;63(1):66–71.

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Olfactory System

- After the heelstick, the pain indices of the Own MM group were lower than those of other groups.
- Salivary cortisol concentration in Control and Own MM infants was measured before and after heelstick.
  - After the heelstick, the level of salivary cortisol was significantly increased in Control infants, but not in Own MM infants.
- These results suggest that pain is relieved in human newborns when they are exposed to odors from their mother's milk

Nishitani S, Miyamura T, Tagawa M, Sumi M, Takase R, Doi H, et al. The calming effect of a maternal breast milk odor on the human newborn infant. Neurosci Res. 2009 Jan;63(1):66–71.

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Olfactory System

- Healthy, full-term neonates respond to a wide range of olfactory stimuli, including food odors, artificial odors, and natural scents emanating from their mother.
- Physiological and behavioral responses to odors like changes in respiratory rate and facial expressions, body movements and directional orientation, have been described during the first days following birth.

Winberg J, Porter RH. Olfaction and human neonatal behaviour: clinical implications. Acta Paediatr. 1998 Jan;87(1):6–10

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Olfactory System

- Infants less than 2 days old oriented preferentially towards an odor that had been present in their nursery bassinet for the preceding 24 hours, rather than in the direction of a completely novel scent.
- Similar exposure treatments restricted to the first 1–2 days postpartum resulted in specific olfactory preferences that were still evident 2 weeks after the odor exposure was discontinued.

Winberg J, Porter RH. Olfaction and human neonatal behaviour: clinical implications. Acta Paediatr. 1998 Jan;87(1):6–10

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Olfactory System

- A baby exposed to a novel odor while breastfeeding can learn to associate that odor with breastfeeding.
- A novel odor can be learned at the breast and gain similar attractive power as the odor of mother's milk.
- Reinforcements related with the early episodes of breastfeeding mediate the rapid development of novel odor preferences in human infants.

Delaunay-El Allam M, Marlier L, Schaal B. Learning at the breast: preference formation for an artificial scent and its attraction against the odor of maternal milk. Infant Behav Dev. 2006 Jul;29(3):308–321

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Olfactory System

- Repeated presentations of the same odors under the infant's nostrils result in reduced responsiveness (habituation.)
- Infants also develop learned preferences for artificial odors that are associated with positive reinforcement like body stroking.
- Smell plays a role in the baby's sucking behavior

Winberg J, Porter RH. Olfaction and human neonatal behaviour: clinical implications. Acta Paediatr. 1998 Jan;87(1):6–10

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Olfactory System

- Olfactory recognition is part of the early stages of the mother–infant attachment process.
- Such selective social relationships can only be established if the mother can be discriminated from others.
- Moreover, the mother's feelings about her neonate may become increasingly positive as the baby begins to demonstrate that it can recognize her (by its discriminative responsiveness).

Winberg J, Porter RH. Olfaction and human neonatal behaviour: clinical implications. Acta Paediatr. 1998 Jan;87(1):6–10

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Olfactory System

Under experimental conditions, where a mother has one breast washed and the other left without intervention, babies placed on their mother's chest right after birth will move preferentially to the unwashed breast.

Since the mother provides an abundance of sensory information, what is helping the baby find that breast?

Natural breast odors unsupported by other maternal stimuli appear to be sufficient to attract and guide neonates to the odor source.

Varendi H, Porter RH. Breast odour as the only maternal stimulus elicits crawling towards theodour source. Acta Paediatr 2000; 90: 372–375.

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Olfactory System

Odors emanating from the mother's breasts contribute to nipple localization and effective breastfeeding

Baby moving towards a breast pad saturated with his mother's milk

Varendi H, Porter RH. Breast odour as the only maternal stimulus elicits crawling towards theodour source. Acta Paediatr 2000; 90: 372–375.

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Olfactory System

- In an experiment by Varendi et al, neonates delivered by cesarean section were exposed to an odor for 30 min shortly after birth. Fifteen births had uterine labor contractions before delivery; 16 were without contractions.
- Those babies who experienced contractions had higher levels of norepinephrine.

Varendi H, Porter RH, Winberg J. The effect of labor on olfactory exposure learning within the first postnatal hour. Behav Neurosci. 2002;116(2):206–211

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Olfactory System

All babies were later tested for their responses to the familiar exposure odor and a novel odor presented on either side of the face.

Overall, the babies spent more time turned toward the exposure odor than toward the novel scent. Babies in the labor condition, but not those born without labor, displayed a significant preference for the exposure odor.

Varendi H, Porter RH, Winberg J. The effect of labor on olfactory exposure learning within the first postnatal hour. Behav Neurosci. 2002;116(2):206–211.

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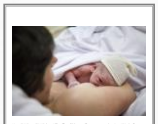

Olfactory System

- Olfactory learning may therefore be particularly efficient shortly after birth
- Brief exposure to a new odor immediately after birth is sufficient for the development of olfactory learning.
- Norepinephrine may help with heightened olfactory learning

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Olfactory System

The areola of the breast contains Montgomery's glands; glands which secrete a substance, the odor of which is important to the latching behavior of newborns.

Doucet S, Soussignan R, Sagot P, Schaal B. The Secretion of Areolar (Montgomery's) Glands from Lactating Women Elicits Selective, Unconditional Responses in Neonates. Hausberger M, ed. PLoS ONE. 2009;4(10):e7579.

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Olfactory System

The composition is similar to that of amniotic fluid and both act as "chemosignals" that help the baby figure out who mom is and how to respond to her.

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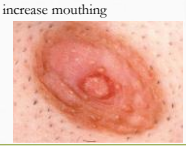
Olfactory System

- Newborns respond to the secretions of Montgomery's glands with increased oral behaviors and changing autonomic responses.
- When babies smell the odor from the glands, they increase mouthing behaviors, like licking.
- Their respiratory rate increases, perhaps to help them breathe in the odor better.
- This signaling even works when they sleep.



Doucet 2009

• Consultant. 2016;56(4):375

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Olfactory System

- Breastfeeding infants can identify their mother through her axillary odor.
  - Breastfeeding infants discriminated between their mother's axillary odor and odors produced by either nonparturient or unfamiliar lactating females.
  - In contrast, breast-feeding infants displayed no evidence of recognizing the axillary odors of their father

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Olfactory System

Breast odors from lactating women elicit preferential orientation when paired with a variety of alternative scents.

- 2-week-old girls who had been exclusively bottle-fed (formula) since birth spent more time oriented toward the breast odor of an unfamiliar lactating mother than to either that same woman's axillary odor or the breast odor of a nonparturient female.
- Chemical cues from the breast region are particularly important for neonates.

Porter RH, Winberg J. Unique salience of maternal breast odors for newborn infants. Neurosci Biobehav Rev. 1999;23(3):439–449.

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Gustatory System and Flavor

- Flavor: a product of several sensory systems, most notably those of the chemical senses, taste and smell.
- Tongue taste perception: sweet, salty, bitter, sour, and savory.

Lipchock 2011

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Gustatory System and Flavor

- Taste occurs when chemicals come into contact with taste receptors on the tongue, palate, throat, epiglottis, or esophagus that then send signals to the brain.
- Taste receptor cells are the interface between the oral environment and the nervous system
- These cells, arranged in groups of 50 to 100 to form *taste buds*, contain the proteins necessary to recognize each of the five types of taste: sweet, salty, sour, bitter, and savory.

Lipchock 2011

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Gustatory System and Flavor

- Taste receptors have been found in many extraoral tissues
- Gut:
  - Sweet receptors: regulate local glucose transporters to enhance glucose uptake
  - Bitter receptors: regulate the absorption of toxic secondary plant compounds or other poisons.
- Lungs, brain, and reproductive system: Function unknown

Lipchock 2011

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Gustatory System and Flavor

Development

- Both olfactory and taste receptors must be functional in order for a human fetus or infant to sense flavor.
- Olfactory receptors are formed by the 8th week of gestation and are functional as early as the 24th week.
- Taste cells begin to form at 7 to 8 weeks of gestation and by around 17 weeks they are considered functionally mature.

Lipchock 2011

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Gustatory System and Flavor

- After 6 months of gestation, amniotic fluid is also inhaled.
- The inhalation and swallowing of amniotic fluid are the first chemosensory experiences of the fetus and mark the beginning of flavor learning.

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Gustatory System and Flavor

Amniotic fluid

- The first food of infants
- Contains a wide range of nutrients that have particular tastes, such as glucose, fructose, lactic acid, fatty acids, and amino acids
- Contains the flavors of the foods consumed by the mother.

Lipchock 2011

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Gustatory System and Flavor

- The fetus can detect tastes and flavors
- Fetal swallowing frequency increases in response to the introduction of sweet solutions into the amniotic fluid and decreases in response to the introduction of bitter solutions
- This may be one of the first indications that our basic biology favors consumption of sweet tastes and avoidance of bitter tastes.

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Gustatory System and Flavor

- Provision of sweet or savory solutions to neonates elicits rhythmic tongue protrusions, lip smacks, lip and finger sucking, and elevation of the corners of the mouth, all of which have been interpreted as a positive.
- Bitter solutions cause neonates to gape, wrinkle their noses, shake their heads, flail their arms, interpreted as negative.

Lipchock 2011

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Gustatory System and Flavor

- Concentrated sour solutions elicit lip pursing and, to a certain extent, gaping, nose wrinkling, and arm flailing, as well as tongue protrusions and lip smacking.

Salt taste receives a neutral reaction from neonates—the taste for salt does not emerge until later in infancy and then remains throughout childhood and adolescence.

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Gustatory System and Flavor

These specific reactions to differing taste stimuli are strikingly similar across cultures

Suggests a basic biological underpinning for the flavors and foods children prefer and avoid

The innate preference for sweets and rejection of bitter tastes in humans are consequences of selection, favoring consumption of high-energy, vitamin-rich fruit and vegetable diets and avoidance of bitter, poisonous fruits and plants.

Lipchock 2011

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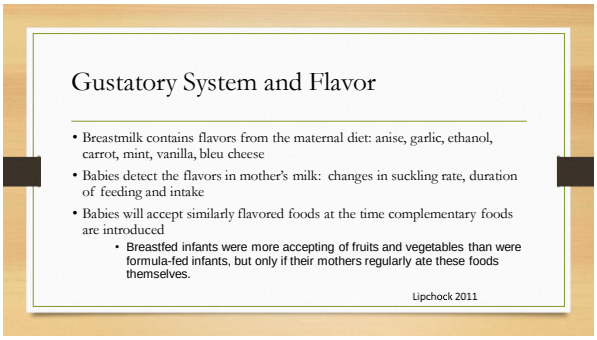

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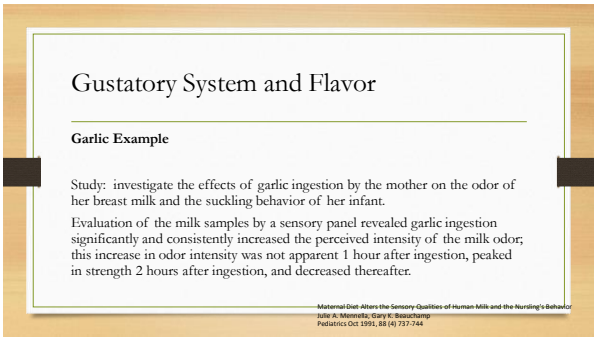

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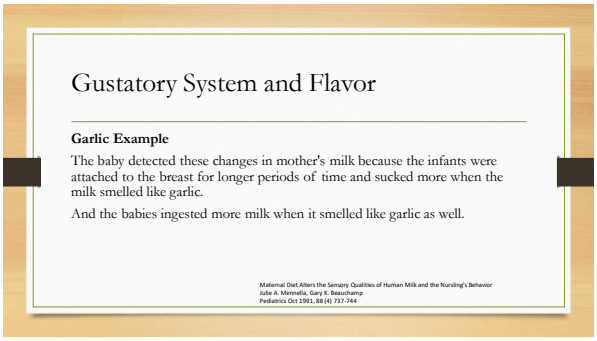

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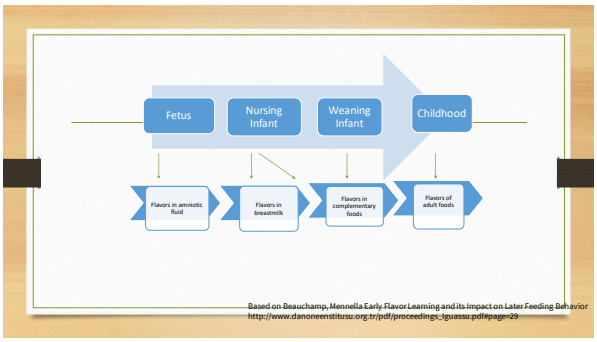

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Visual System

Development (weeks)

- 26: Blink in response to bright light
- 30: Pupils constrict to light
- 32: Ability to fixate on a large object in close proximity
- 34: Neonates have sufficient cone development to see color and discriminate between dark and light (at a limited distance)
- 34: Color perception, red is the first color

Birth: Limited: infants can only focus approximately 25 cm

Clark-Gambelunghe, 2015

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Auditory System

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Auditory System

The auditory system:

- Peripheral components: outer, middle and inner ears
- Auditory nerves: cranial nerve VIII
- Auditory regions of the brain: brainstem and temporal lobe

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Auditory System

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Auditory System

- Development
- 20 weeks: Fluid-filled middle ear reaches to adult size
- 25 weeks: Middle ear ossicles become bone, and myelination occurs from the brainstem to the higher level auditory structures.
- 25-27 weeks: Functional hearing develops
- Hearing is the first sense exposed to stimulation that promotes development of the neural pathways.

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Auditory System

- Low frequency sounds like mother's heartbeat and speech cause physiologic responses in the fetus.
- As the weeks advance, the baby responds to a wider range of sound frequencies.
- This progresses throughout the third trimester and birth.

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Auditory System

Mother's Voice and its effect on suckling

Mehler J, Bertoncini J, Barriere M. Infant recognition of mother's voice. Perception. 1978;7(5):491–497.

Two experiment conditions: the mother's speech was aimed at communicating with the infant or the mother's speech lacked prosodic and aspects of normal speech (monotone). Infants will suck more for their mother's voices under the normal speech condition only.

Infants prefer their own mother's voice, provided the mother speaks normally.

From Skin-to-Skin to Latch

- Birth cry
- Relaxation
- Awakening
- Activity
- Resting
- Crawling
- Familiarization
- Sucking
- Sleeping

Brimdyr, 2020

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Familiarization Stage

- Around 40 min after the birth.
- Newborn arrives at the breast and nipple.
- The newborn may massage the breast or nipple, move the hand from the mouth to the breast, put the hand or fingers in the mouth, protrude the tongue above, around, near and on the nipple, suck on the nipple, suck on the hand and make soliciting sounds.
- The nipple and breast change shape, as the oxytocin levels increase, and the breast prepares for suckling.
- It is important not to rush or 'help' the newborn during this time. Research shows that 'helping' a newborn to breastfeed during this first hour may be related to later breastfeeding difficulties

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Sucking Stage

- The newborn will self-attach and suckle around 50 min after the birth.
- The newborn's latch will be appropriate for this early learning experience of suckling colostrum. The newborn may begin to make soliciting sounds, lick, suckle and then adjust the mouth-to-nipple contact several times to optimize the suckling position.
- The baby picks the latch
- Labor medications may impede this stage

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From Skin-to-skin to Latch

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TABLE 2

Number of babies reported in each behavioural phase during skin-to-skin contact in the United States, Japan, Italy and Sweden studies

	United States (*n* = 11)	Japan (*n* = 13)	Italy (*n* = 17)	Sweden (*n* = 28)
Birth Cry	11	13	17	28
Relaxation	11	13	13	24
Awakening	11	13	17 (head movement)	28 (head movement)
Activity	10	13	17	28
Resting	8	5	17	25
Crawling	9	7	16	21
Familiarization	6	4	11	18
Suckling	5	2	7	15
Sleeping	1	0	10	28

Summary

- We are learning that smell is important to latching behaviors. Our current approach to latching often does not allow for the baby's instinctive behaviors.
- Our approach to solid foods should take the flavor experiences from amniotic fluid and human milk into account.
- The sensory information of the newborn makes mother the habitat for the baby

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