



Celebrate babies the way they are

Breastfeeding support statement

Through appropriate information, products, and services, we support breastfeeding for as long as mother and child wish.

In cases where breastfeeding is difficult, for whatever reason, we offer a full range of products and solutions for healthy child development.

Research Report 2021-01

Sucking research : **Sucking behavior**

The research of Pigeon searching for the elucidation of the mechanism of the sucking behavior and reproduction of the functions

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■ Pigeon's research on sucking

It is needless to say that mothers' breastfeeding is most appropriate, but it may be difficult for some mothers to directly give breast milk to their infants for various reasons.

Even if it is difficult for mothers to directly breastfeed, we try to enable safe bottle feeding as needed without interfering with direct breastfeeding and support sucking of infants who need special care.

Thus, we understand the sucking behavior, aim at putting functions that mothers and infants truly need into practical use, and accumulate new knowledge by always trying new observation methods.

We aim to provide the best way to support the healthy growth of all infants even if breastfeeding is difficult for various reasons.

■ Pigeon's sucking research approach

Pigeon aims to elucidate the mechanism of the sucking behavior and investigate the function of "sucking" - how infants drink milk. We pursue each movement underlying the sucking behavior and aim to connect the key factors of sucking identified in the research to the development of products and services.

It is difficult to carry out research on infants including sucking behavior research because we need to have an insight into what is behind their behavior. First, we need to do thorough observation to elucidate how infants are sucking since they cannot describe their sense of use in words like adults.

Thus, we have continued to "watch infant's sucking behavior" over our 60-year history.

Various behaviors in the oral cavity of infants during sucking and their functions cannot be understood only by visual observation.

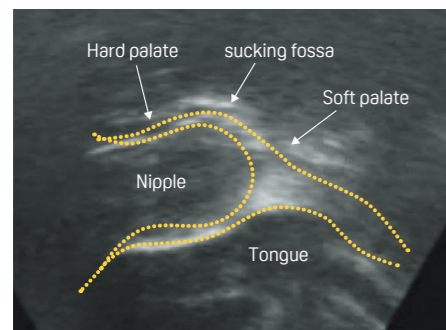
So, we have created "unique research observational technologies to observe infants" such as an intraoral observation camera that does not interfere with the behavior of infants, ultrasonography to observe the movement in the oral cavity, and a measurement device for the sucking vacuum pressure in the oral cavity (Figure 1).

Using these observational technologies, we assess and verify the key factors that enable the sucking behavior and whether our products can reproduce the sucking behavior of direct breastfeeding while obtaining cooperation of many specialists, infants, and mothers.

Figure 1 Examples of research observational technologies for "watching infant's sucking behavior"

● Visualization of tongue movement during sucking

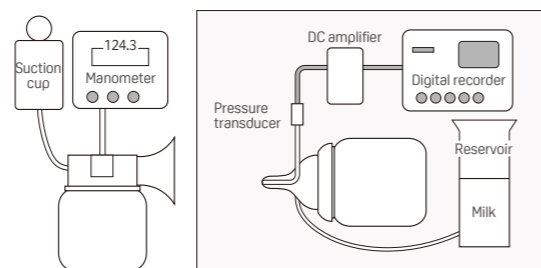
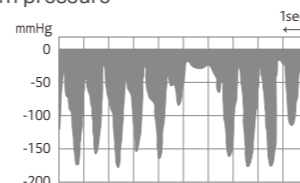
- Analyzing tongue movement during sucking with an ultrasonographic image and two-dimensional motion analysis
- Measuring change of the nipple size during sucking with an ultrasonographic image
- Observing the flow of milk during sucking



Example of intraoral observation with ultrasonographic image ¹⁾

● Measurement of sucking vacuum pressure

- Sucking vacuum pressure in the oral cavity during sucking
- Developmental changes of sucking vacuum pressure in premature/low birthweight infants
- Variability in sucking vacuum pressure in the oral cavity during sucking



Example of measuring sucking pressure ²⁾

■ Importance of the "Three Key Factors of Sucking" that became clear through 60 years of sucking research

Pigeon calls important factors for the sucking behavior clarified through the previous research the "Three Key Factors of Sucking" and puts them in the center of research and development.

They are composed of the sucking behavior as follows (Figure 2):

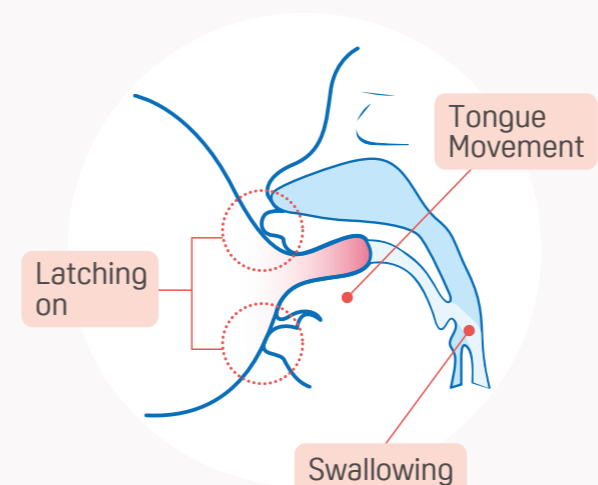
"Latching on," the function of latching on to the nipple and sealing of the area from the areola to the nipple with the lips and tongue of infants
 "Tongue movement," the tongue's wave-like motion to draw milk
 "Swallowing," the function to transfer milk down to the esophagus

We think that we can find the functions necessary for sucking support and the functions that are really necessary for nursing bottles by understanding sucking of infants based on these three types of behavior.

■ Latching on : Sealing function from the areola to nipple with the lips and tongue

Latching on is the first step of the sucking behavior and the base function for the subsequent sucking behavior. When sucking, an infant turns the lips outward, attaches the lips like a suction cup, and firmly holds not only the nipple but also the areola. At this time, the

Figure 2 Three main factors that compose sucking behavior (Three Key Factors)



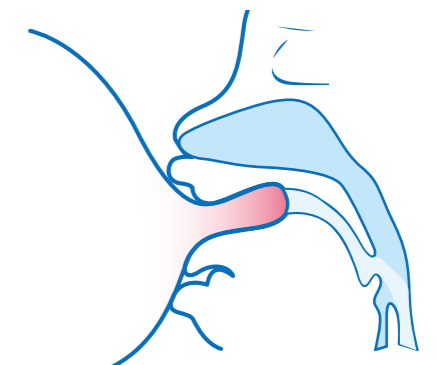
infant's tongue crosses the alveolar ridge, extends beyond the tip of the lips, and places the nipple at a certain position in the oral cavity. It is considered that latching on maintains attachment and sealing in the oral cavity, prevents the leakage of milk from the corners of the mouth, and draws the milk smoothly by the sucking behavior³⁾ (Figure 3).

■ Results brought by effective latching on³⁾⁵⁾

Appropriate breastfeeding posture and "latching on" are emphasized for the successful breastfeeding in UNICEF/WHO Guidelines.

Appropriate latching on prevents sore or cracked nipples that are likely to occur due to shallow holding, prevents leakage of breast milk by maintaining the sealing of the oral cavity by the suction cup effect of lips, and achieves milk transfer by effective sucking. Inappropriate latching on causes poor sucking of milk due to sore or cracked nipples and results in breast tension, which is said to increase the risk of decrease in secretion of milk. Effective latching on is an important step to promote breastfeeding.

Figure 3 Signs of appropriate latching on^{3) 4)}



- 1 Both upper and lower lips turn outward.
- 2 An infant attaches the lips to the outline of the breast like a suction cup and firmly holds the area from the nipple to areola.
- 3 The tip of the tongue protrudes to the lower lip and the nipple is supported with the tongue.

Attachment and sealing are maintained in the oral cavity, which prevents the leakage of breast milk from the corners of the mouth and helps an infant smoothly draw the milk.

**“Tongue movement,”
the tongue’s wave-like motion to draw milk**

Unlike adults, infants do not suck milk like using a straw during sucking. They drink milk through sucking, a rhythmical coordinated movement in which milk is squeezed out by compressing and expanding the nipple (papilla)⁶⁾. In particular, Pigeon has been focusing on the wave-like movement of the tongue (Figure 4). By intraoral videography⁷⁾ or ultrasonic tomography⁸⁾, we can observe that milk has been squeezed out by a continuous behavior of compressing and expanding the nipple by wavy and smooth tongue movement. Pigeon's research has shown that in sucking on a hard artificial nipple, the tongue movement is different from the smooth tongue movement during direct breastfeeding and the tongue movement similar to that during direct breastfeeding can be reproduced in sucking on an artificial nipple made of soft silicone rubber¹⁾⁹⁾.

**“Swallowing,” the function
to transfer milk down to the esophagus**

When adults drink fluid, they suck the fluid, store it in the oral cavity, stop breathing, and swallow it. Unlike adults, it is known that infants have a coordinated movement of breathing and swallowing specific to this period¹⁰⁾, which is called “infant swallowing (Figure 5).” Frequent breathing and reflex and frequent swallowing are observed at the same time in infants during sucking. In infancy, the larynx is positioned relatively high in the oral cavity, and the distance between the uvula and epiglottis is close, which makes it easy for infants to swallow while breathing¹¹⁾¹²⁾. However, it has also been revealed that the coordinated movement of breathing and swallowing is not complete. According to a series of observational research on breathing and swallowing conducted by Pigeon Central Research

Institute between 2007 and 2009, it was revealed that breathing was momentarily suppressed during the moment of swallowing while breathing became active during the pause of swallowing¹³⁾¹⁴⁾ (Figure 6). It is also known that breathing is likely to be suppressed for a long time during sucking especially in premature infants and low birthweight infants and thus, attention needs to be paid⁶⁾. In subsequent research by Pigeon, the effect of milk flow is known as a factor that inhibits appropriate breathing during sucking¹⁵⁾. It has been shown when an artificial nipple with a large milk flow is used for low birthweight infants, the frequency of swallowing increases and milk tends to remain in the oral cavity, and at the same time, respiratory depression is likely to occur, which may cause a burden on the respiration.

Figure 5 Differences between oral cavity structures of adults and infants¹⁰⁾

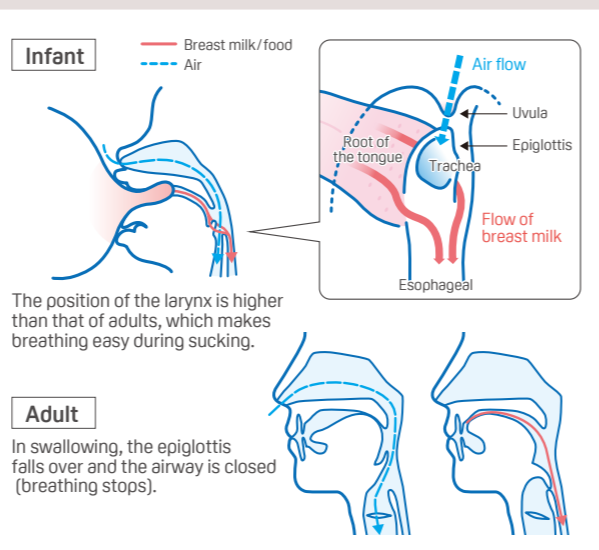


Figure 4 Characteristics of wave-like movement of the tongue²⁾

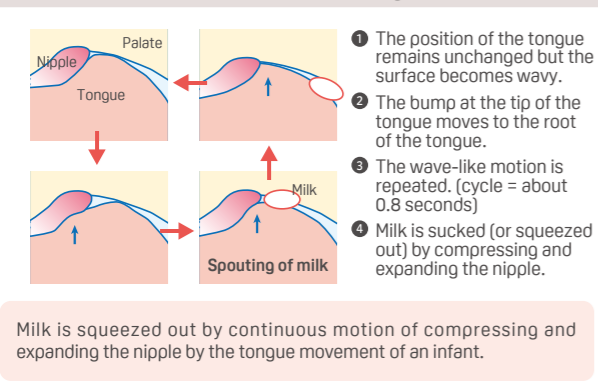
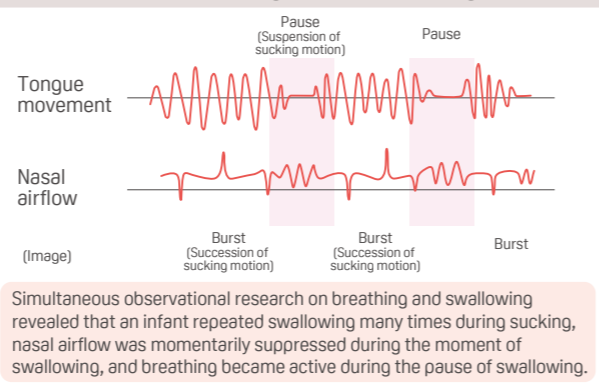


Figure 6 Elucidation of coordinated movement of breathing and swallowing¹³⁾¹⁴⁾



**Product development based
on the research results
in the Three Key Factors of Sucking**

Pigeon has decided that a basic requirement for nursing bottles must meet the Three Key Factors of Sucking (latching on, tongue movement, and swallowing) clarified in the research. As mentioned earlier, in “latching on,” the nipple and areola need to be firmly held with the lips and tongue and sealing and attachment in the oral cavity need to be maintained. In “tongue movement,” the function that enables natural tongue movement is required without inhibiting wave-like movement of the tongue that draws milk like squeezing out. And in “swallowing,” the function of safely pouring milk into the esophagus is required without inhibiting the coordinated movement of breathing and swallowing in the infant swallowing. We aim to support sucking without inhibiting breastfeeding by reproducing these direct breastfeeding functions with nursing bottles (Figure 7).

**Reflection of the “functions”
of the Three Key Factors of Sucking
in the products**

The following functions of the Three Key Factors are reflected in actual nursing bottles. For example, in “latching on,” we aim to reproduce the functions of attachment and sealing with the infant's lips like a suction cup and have been developing a product with a “shape” which supports the function of “turning the lips outward and deeply” holding the nipple, the most important function in “latching on,” instead of imitating the shape of the breast and nipple (Figure 8). From the perspective of “tongue movement,” we measure changes of the nipple during sucking and develop artificial nipples that reproduce the “softness” and “shape change.” From the perspective of “swallowing,” we investigate the coordinated movement of breathing and swallowing and develop artificial nipples providing a milk flow that does not pose a burden on infant's respiration. Thus, we are working on developing high-quality nursing bottles by reflecting the results of the research on the sucking behavior in products.

Figure 7 Product development based on the research results in the Three Key Factors of Sucking

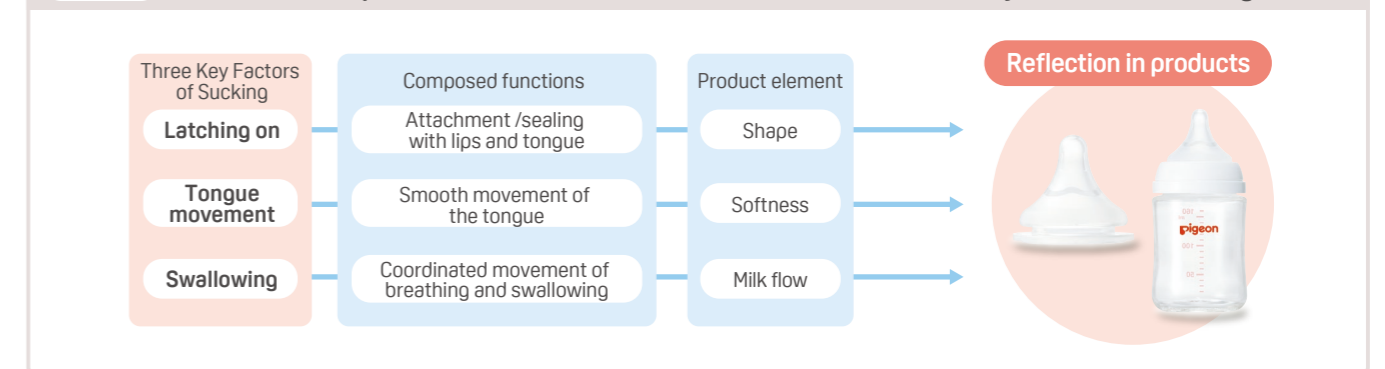
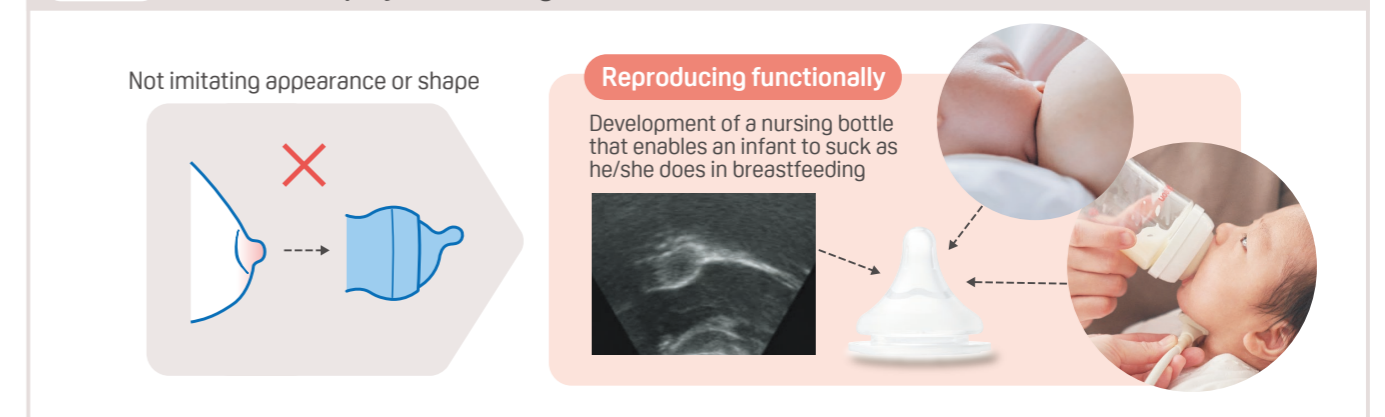


Figure 8 Functional inquiry for “sucking”



"Basic" which enables infants who are not good at sucking to drink milk without difficulty

We aim at providing nursing bottles that enable infants with insufficient sucking behavior such as newborn infants, premature infants, low birthweight infants to do the sucking behavior like direct breastfeeding and drink milk that they are originally supposed to have, which is our unchanged direction for nursing bottles we aim to provide and that is "basic."

We deep dive into the key factors to achieve through the research on the sucking behavior of infants and reflect the results in the "basic" products. Thus, we provide nursing bottles that support sucking of a wide range of infants.

From basic to solving various sucking issues

In addition to "basic" products that meet the Three Key Factors of Sucking, we are also developing products for infants with very weak sucking pressure and infants with anatomical problems such as cleft lip and cleft palate (Figure 9).

Again, the main focus of our research is to elucidate functional sucking problems and the inability that makes "sucking by themselves" difficult in infants who have difficulty sucking and require special care. Instead of putting vaguely "unable to drink," we are investigating which movement is impaired from the perspective of the Three Key Factors of latching on, tongue movement, and swallowing. We are carrying out research and development while always asking which function we should support with our products and how we can support sucking of infants with our products to make all nursing mothers feel happy.

Figure 9 "Basic product group" and "Developed product group"



Points of Pigeon's research on sucking behavior

- We are carrying out research to understand the sucking behavior and put the functions necessary for infants into practical use.
- In research and development, we not only develop products but also investigate "sucking of infants" itself mainly based on the Three Key Factors of Sucking (latching on, tongue movement, and swallowing).
- We aim to functionally reproduce the sucking behavior with Pigeon's nursing bottles based on the knowledge gained through research instead of imitating shapes.
- Our basic product is a nursing bottle that enables infants whose sucking behavior has not been sufficiently established to drink milk.
- For infants who need special care, we are carrying out research and development based on the Three Key Factors of Sucking while understanding in which part there are difficulties and always questioning about the product we should create to support the part with difficulties in order to help breastfeeding of infants and mothers.

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