Sucking on the Breast and on the Bottle

A report written for MAM Babyartikel GesmbH

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Introduction

This report seeks to summarise the way a baby or infant sucks on a human nipple or feeding bottle teat to obtain nourishment and to highlight some essential differences between the two feeding methods.

The first part of the report examines the mechanisms of sucking on the breast, and this is followed by some views on the similarities and differences compared with bottle-feeding.

Although this report has concentrated on the sucking component, it must be understood that feeding is a complex act in which various components such as sucking, swallowing, and breathing must be co-ordinated.

Finally, the report comments on the 'new' bottle that was the subject of a recent focus group in the USA.

The Mechanics of Sucking on the Breast

The baby draws the breast nipple, with surrounding and underlying breast tissue, into a teat shape by suction created within the baby's mouth.

This 'teat' is about three times as long as the breast nipple itself at rest, and extends back as far as the junction between the hard and soft palates. At its base it is held between the upper gum and the tongue which covers the lower gum. See Figure 1.

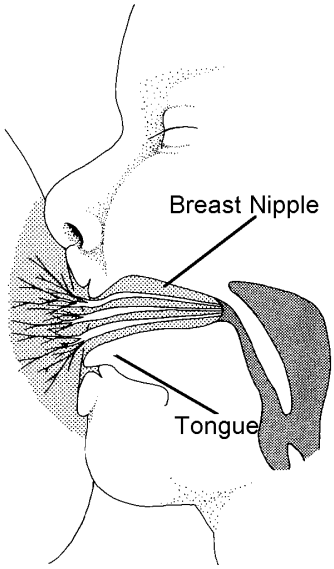


Figure 1

The tongue forms a spoon shape around the nipple so that the nipple lies in a central trough formed by tongue.

The suck cycle begins by the jaw being raised and the front tip of the tongue (marked with an arrow in Figure 2) pressing up into the 'neck' of the nipple.

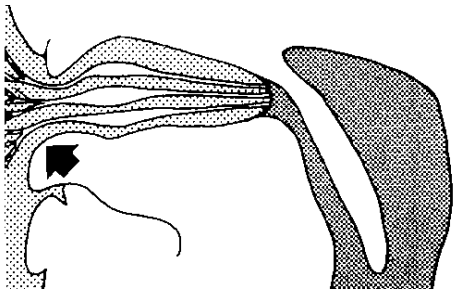


Figure 2

The tongue is then moved backwards along the underside of the nipple. This roller-like (or peristaltic) action squeezes milk from the nipple. The nipple is reduced to approximately half its former width. See Figure 3.

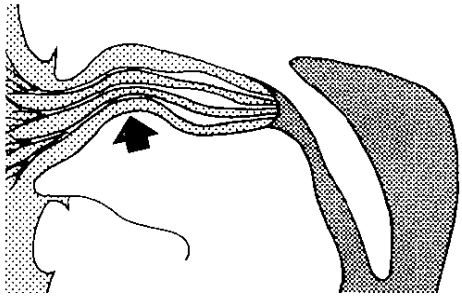


Figure 3

The wave of compression by the tongue passes back towards the tip of the nipple. See Figure 4. This action expresses (or draws) milk from the breast tissues.

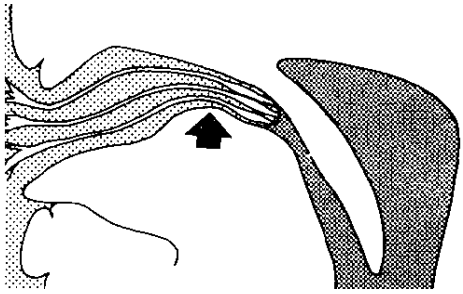


Figure 4

The compression passes back past the tip of the nipple and pushes against the soft palate. See Figure 5.

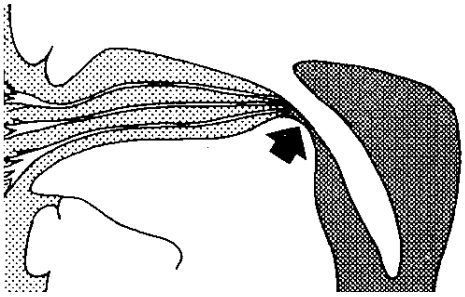


Figure 5

Palate muscles contract raising it to seal off the nasal (nose) cavity. Milk is pushed into the oropharynx and is swallowed if sufficient has collected.

The cycle of compression continues and ends at the posterior (back) base of the tongue. See Figure 6.

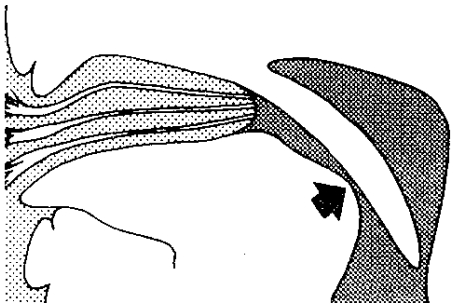


Figure 6

Depression of the back portion of the tongue creates negative pressure drawing the nipple and its milk contents once more into the mouth. This is accompanied by a lowering of the jaw which allows milk to flow back into the nipple.

It should be remembered that sucking is a dynamic process, and that the Figures shown above are merely pictorial representations of brief moments of the cycle which lasts for approximately 1 to 1.5 seconds.

It is clear from the various descriptions and studies that normal breast sucking is essentially free from frictional movement. If sufficient breast tissue has been formed into a 'teat', as shown in Figure 1, then there should be little movement of this nipple in and out of the baby's mouth, simply unidirectional exchange of milk from the breast into the body of the nipple, and on into the baby's mouth.

Similarly, the now outdated view that the tip of the tongue moves back and forth along the underside of the nipple, thus creating friction along its entire length has been shown to be false. It is the rippling or wave motion of the tongue's length which causes the peristaltic action described.

We should also understand that there are two quite different pressure forces during the sucking cycle:

- **Positive pressure** – The application of positive pressure on the nipple by the *surface* of the tongue is the primary force in evacuating milk from the nipple, and despatching it down the oesophagus.

- **Negative pressure** – The baby clearly generates negative pressure in its mouth during the process of milk removal. However the role of negative pressure has not been categorically determined, but the two most likely functions are (i) to retain the nipple and breast in position within the mouth (i.e. to counter the naturally elastic nature of this tissue), thus maintaining the 'teat' shape from the nipple and breast tissue; and (ii) to aid refilling of the nipple by milk from the ducts and sinuses entering it.

The border of the mouth (lips, gums and tongue) form an effective seal against the breast allowing negative pressure to be created. When the nipple is drawn into the oral cavity it occupies as much of the space available as there is free nipple tissue to fill it. The shape of the nipple is therefore dictated by the internal geometry of the mouth.

As has been shown (see Figure 1) the human nipple is highly elastic in the horizontal plane, elongating during active feeding to over twice its resting length. Also it's height can be

reduced by half when compressed between the tongue and the palate. Milk ejection occurs immediately after maximal compression.

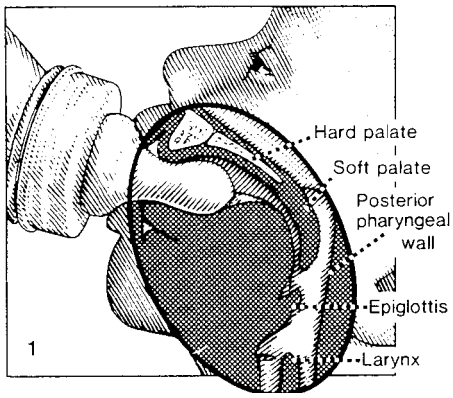
Is it is probably incorrect to refer to the process of milk removal from the breast as ‘sucking’, when stripping would be physiologically more correct.

The average volume of milk swallowed in each cycle by new-born infants is about 0.6 ml.

Sucking on an Artificial Teat

A number of studies have shown that the mechanics of sucking on an artificial (bottle) teat in a nutritive fashion similar to that with a human nipple. This maybe demonstrated by the following sequence:

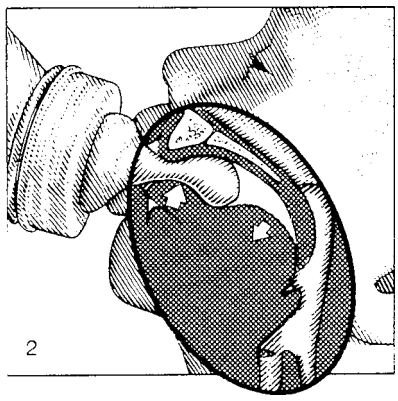
When the teat is introduced into the baby's mouth the inside surface of the baby's lips adheres to the surface of the base (the bulbous section) of the teat.



The teat is held firmly and fully in the mouth, with the tongue beneath the teat. The soft palate is relaxed.

The lips effect airtight closure with the teat when starting to suck, but this may not be completely maintained during sucking. The airtight closure helps to create negative pressure inside the mouth. The tip of the nipple is surrounded by the tongue as the lateral (outside) margins of the tongue come up and surround both sides of the nipple, with no space remaining between the tongue, buccal (cheek) surfaces, hard palate and teat.

The view below is approximately 0.25 sec later than in 1 above (similar interval separates subsequent views). The lower jaw is elevated, compressing the base of the teat, while the front of the tongue moves upwards.

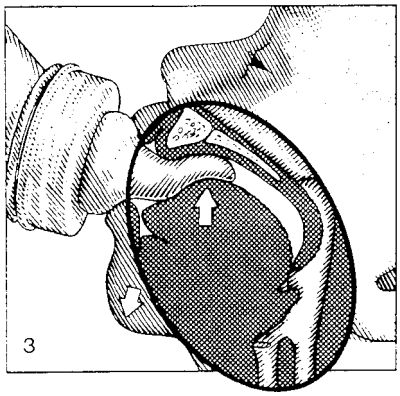


This initiates the expression of milk from the teat.

The general section of the teat is normally a circle but it collapses between the hard palate and the tongue to form an ellipse.

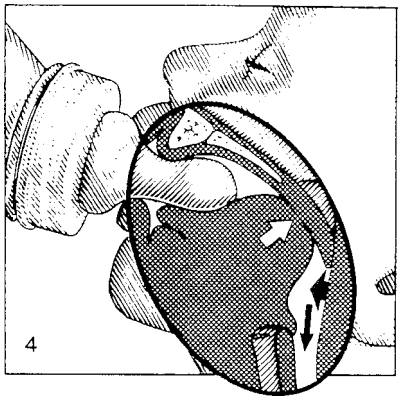
The back of the tongue is depressed, leaving space for the milk to collect.

The wave of upward movement of the tongue progresses backward, further expressing milk from the teat into the mouth.



This is further facilitated by negative pressure generated by downward movement of the back of the tongue and of the lower jaw.

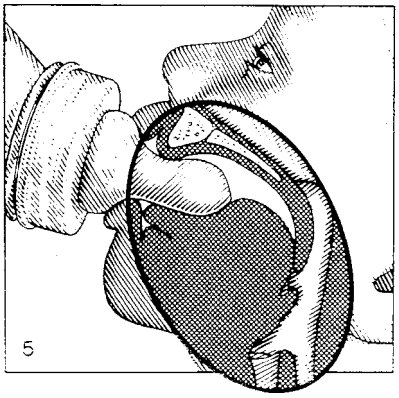
As the wave of tongue contraction sweeps off the back of the teat, it impinges on the soft palate, thus sealing the milk within the oropharynx.



Swallowing is triggered, muscles of the palate contract and the nasal cavity is sealed off from the milk. Only at this point in the feeding cycle is the airway closed and breathing temporarily interrupted.

Milk is then propelled into the upper oesophagus, whence it is expelled into the stomach by peristalsis.

The soft palate returns to the resting position, larynx descends and the airway reopens.



The tongue is then in position for another sucking cycle to commence, a complete cycle lasting approximately 1 – 1.5 sec.

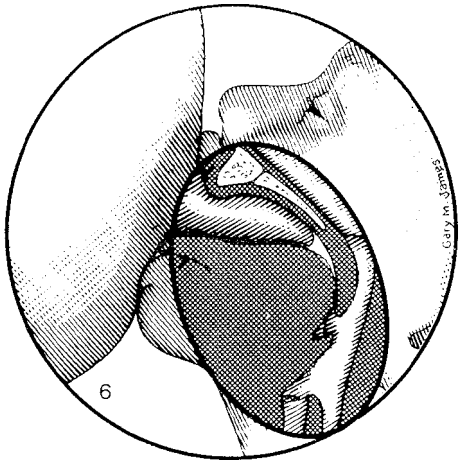
Some Difference between Breast Feeding and Bottle Feeding

- **Sucking Pressure**

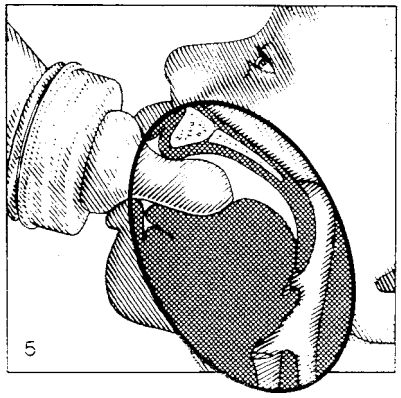
Several studies have shown that more muscle activity and therefore greater sucking pressure is required to suck milk from a human nipple than from a bottle teat. This is not surprising as in most cases a bottle teat has a single feeding hole, whereas mother's nipple has up to 15 relatively small pores. The extra effort needed to suck from the human nipple may be the cause of the elevated heart rates as compared with bottle feeding, found in some research studies.

- **Horizontal Elasticity**

It is useful to compare the appearance of a human nipple and a bottle teat in the baby's mouth at rest:



Breast-fed infant at 'rest'



Bottle-fed infant at 'rest'

In the case of the breast-fed infant the tongue is extended more forwards, and there is deeper penetration of the nipple than of the bottle teat.

Perhaps the most significant difference is found with the reduced amount of lengthening of an artificial teat during the sucking cycle. This lengthening is generally only about $1^1/_2$ times that of the length at rest and is significantly less than that of the human nipple, which can 'stretch' to 2-3 times its normal length.

The effect of this is that in the human nipple, the milk is delivered to area at the back of tongue. Thus, when milk is ejected from the breast, swallowing is automatic or reflexive in nature.

- **Vertical Elasticity**

Unlike the bottle teat the human nipple does not recoil elastically in the vertical plane, so it is maintained in a moderate state of compression. The effect of this has not been extensively researched.

- **Compression**

Compression with different teats tend to be variable – in some cases the compression is similar to that of the human nipple, but in one notable case (NUK) the compression is significantly greater.

Bottle feeding concurs with some aspects of breast feeding, where, if the latex or silicone rubber teat is suitably compliant, the baby can constrict the neck of the teat and squeeze the milk out. If the material is too stiff the neck cannot be constricted, so when it is compressed milk flows *back* into the bottle reducing the efficiency of feeding.

Under these circumstances, suction pressure generated by the baby will be more effective in milk removal and is likely to become the predominant mechanism. However, we must remain cautious about assuming, by analogy, that negative pressure is of equal importance in removing milk from the breast.

- **Volume of Feed Ingested**

Because of the considerable variation between individuals in the case of breast feeding and between teats in the case of bottle feeding comparisons between these two modes is invidious.

However, some authorities consider that the pattern of milk flow during feeding is significantly different in the two groups. In bottle fed infants, there appears to be a linear pattern of milk intake over the first 10 min of feeding, by which time 81% of the feed has been consumed. This contrasts with a two-phase intake pattern in breast fed infants in whom a total 84% of the feed was consumed either in the first 4 min or between 15 and 19 min after the start of the feed. It is speculated that these differences in the pattern of milk intake could influence the physiological responses to feeding and might account for differences between breast and bottle fed infants in gut hormonal responses to milk feeds.

Another study has also shown that breast fed infants ingest 50% of the feed within the first 2 minutes of sucking and 80-90% after 4 minutes. The second half of a ten-minute feed from either breast was almost all non-nutritive. Similar patterns were found for six-day-old children and after one month.

The different results reported by the published studies only serves to demonstrate (a) the difficulty of measurement and (b) the extreme variability between subjects, and within the same subject over a series of feedings.

Probably the best study in this area found that breast feeders consumed per day a mean of 656 g at one month of age, 773 g at two months and 776 g at three months. The equivalent results for breastmilk substitutes were 713 g, 811 g and 853 g respectively. When expressed as kcal/kg it appeared to be practically no difference between the two feeding groups. The

bottle-fed infants had fewer meals and had a more even consumption from meal to meal. It is concluded that infants largely regulate themselves the intake they require.

- **Vacuum**

In a conventional feeding bottle the vacuum formed above the milk limits the supply of milk and can cause a soft rubber teat to collapse or partially collapse. Under such circumstances, sucking is not rewarded by milk until the infant releases the teat, this allowing air to enter the bottle. This can also have the effect of causing air to enter the baby's mouth during the brief time he has released his seal on the teat, thus resulting in the phenomenon known as "colic".

A valve in the reservoir of the bottle opens whenever a negative pressure is generated, and this permits the infants to have an unrestricted supply of milk. The presence of a valve in the bottle ensures that all sucks deliver milk. Indeed it has been shown that the presence of a valve in the feeding bottle can have a much greater influence on the withdrawal of milk per suck than does the size or orientation of the hole (or slot) in the teat.

There is also some suggestion that feeding from an 'open' bottle (such as the boat shaped popular 35 years ago) results in sucking being the most important process of milk extraction as the baby has no need to avail itself of the peristaltic or 'stripping' procedure.

- **Holes**

Another fundamental difference between the human nipple and a bottle teat is that typically the bottle teat has a single hole, whereas the nipple has up to 15 pores.

The complete surrounding of the teat by the tongue as described above for bottle feeding (which is totally analogous with breast feeding) is, an ideal situation. It has been found that with a teat having a small hole, this surrounding may be incomplete. With a large hole there may be no surrounding of the teat by the tongue and the peristaltic action has minor influence in the milk extraction cycle. Undoubtedly the influence of peristaltic action is greater with teats containing a small hole.

Therefore it is apparent that the baby adapts to the situation presented during feeding. In the case of a large hole teat, milk flows out easily, so the tongue need neither to surround the teat to make negative pressure to draw out milk nor to move in a peristaltic motion to squeeze out milk.

The medical literature appears to be unanimous in agreeing that cross-cut teats result in faster flow rates as compared to single hole teats. Perhaps more importantly, a cross-cut opens wider to stronger sucking, and there is a strong suggestion that the baby maybe able to adapt and indeed control the flow rate with this type of teat.

- **Other Differences**

Some investigators have noted that during breast feedings, infants breathed within sucking bursts. In contrast, during bottle feedings, the infants breathed before and after sucking bursts. They suggested that different characteristics between the human nipple and the

feeding bottle teat - for example, extensibility, pliability, thinness of structure – accounted for these findings.

It should be remembered however that breast feeding involves not only the sucking of the infant but also the physiological responses of the mother to the stimuli that sucking provides, which elicits the release of hormones (oxytocin and prolactin) from the pituitary gland.

Comments on the 'New' MAM Bottle

Introduction

From the above descriptions it can be suggested that the worst possible scenario for bottle feeding is a stiff teat which has limited compression and extensibility in the horizontal plane, coupled with a bottle without a vacuum release valve.

The baby is unable to use the stripping (peristaltic) action described above and has to resort entirely to sucking pressure. This not only may be beyond his capabilities (with a small hole) but may also be counter-productive as the vacuum caused by his sucking effects will naturally make the task of removing milk from the bottle progressively more difficult. The child may then either reject the teat and/or take in excess quantities of air, causing 'colic'

However, if the teat has a degree of compression and horizontal extensibility, then perhaps a small hole (better peristaltic action) or a cross-cut would be an ideal solution.

Features of the 'New' Bottle and Teat

1. Valved Bottle

The valve arrangement in the bottom of the bottle appears to be extremely sound from an engineering point of view.

Provided the valve works efficiently in practice, particularly with very young babies, then this is in my view the biggest "plus" point for the system.

The vented bottle will assist the child to take milk without having to work against a vacuum build up and should also reduce the chance of air be ingested.

2. "Flattened" Teat

Purely by feel, the silicone appears to be more pliant as compared with a standard silicone teat, particularly in the frosted flattened area. Certainly in the position of the frosted area the silicone appears to compress inwards easier than with a standard teat which should assist "stripping" action. However, whether this will actually improve stripping so that breast feeding is simulated is debatable. Or putting it another way, the flattened shape, inside ridges and frosted texture looks innovative and "scientific" and cannot do any harm. But that does necessarily warrant a direct claim to mimic breast-feeding

From a purely subjective point of view, it maybe that the flattened shape, akin to the shape of a MAM soother, is possibly more important than the frosted area etc. Taking these two factors together certainly provides an improved product. If it could be shown that the teat lengthens during sucking more than with a standard silicone teat then we might have a 'story' which would make good copy for both the Mother and Opinion Leaders.

3. Teat hole

It is assumed that teats will be provided with the usual range of holes – small, medium and large. However, because of previous comments a version with a cross-cut teat might give MAM a more complete ‘story’ when tied in with the other features.

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