Optimizing Neonatal Prefeeding Habilitation: A Holistic Approach Integrating Neonatal Learning Behaviors, Motor Development, and Evidence-Based Interventions

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ABSTRACT

Neonatal clinicians utilize prefeeding interventions with premature infants to promote a natural process of oral-sensory development, hoping to prepare the infant for future oral feeding. Prefeeding interventions require a holistic approach, ensuring infants are actively involved in learning. Therapists can achieve this by prioritizing the development of intentionality, which is the conscious pursuit of action driven by motivation. The authors present a conceptual model of six neonatal behavioral states of learning called the "Neonatal Intentional Capacities." This model illustrates how purposeful actions evolve into extended learning sequences and helps determine how well an infant can participate in learning experiences. The authors will elucidate the dynamic relationship between intentionality and the development of adaptive motor skills of prefeeding. Lastly, this article presents a consolidated and categorized grouping of current evidence-based prefeeding interventions. Utilizing the framework presented, the authors offer clinical guidance to support prefeeding treatment planning.

Keywords: prefeeding; feeding; nutrition; development; NICU care; evidence-based practice

Infants born prematurely are forced to learn how to orally feed in the suboptimal environment of the NICU. These infants are often deprived for many weeks of the sensory-motor learning experiences the womb provides.[1] Essential skills such as sucking and swallowing, typically developed and explored in utero, rely on facilitated bedside interactions. Tasting and smelling experiences may be entirely lacking until bottle feeding begins around 34 weeks' gestation. Delayed mastery of oral feeding can result in surgical and prolonged supplemental feeding interventions, delaying discharge to home and furthering the socioeconomic impact on families and society.[2–4] Achieving full oral feedings is considered the "gold standard"[5] for safe discharges and relates to more optimal long-term

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cognitive and developmental outcomes for infants.[6] Neonatal clinicians strive to promote a smooth transition from gavage to oral feeding by promoting a natural neurodevelopmental learning process through prefeeding interventions. Since the occupation of feeding is intrinsically motivated for survival, prefeeding interactions provide infants with a rich learning opportunity where clinicians can witness the growth of intentionality and the adaptive motor behaviors that are crucial aspects of prefeeding development.

Neonatal behavior and motor learning theories are intricate and built on solid foundations laid by pioneers in the field. While contributing significantly to the clinical practice of neonatal professionals, further investigation is necessary to understand the behaviors that aid infants in acquiring new skills in the NICU environment. Current prefeeding research emphasizes the procedural implementation of a protocol but provides minimal guidance about how to analyze the infant's learning process. To fill this gap, the authors explore the development of *intentionality*, defined as the conscious pursuit over action driven by motivation. Intentionality enables growth and development across all domains. The authors developed a conceptual model called the "Neonatal Intentional Capacities," which features six neurobehavioral states of learning that describe the progression of intentional actions across extended learning sequences. The authors will describe the dynamic relationship between learning behaviors and the development of adaptive motor skills involved in oral feeding. Current evidence-based prefeeding activities are consolidated and differentiated into three intervention categories to help foster an individualized approach to prefeeding habilitation. Therapeutic strategies and clinical guidance are offered to support prefeeding treatment planning using a holistic framework incorporating learning behaviors, motor development, and evidence-based interventions.

UNDERPINNING THEORIES

The following theories provide foundational knowledge on neonatal behavior and the motor learning theories pivotal to the prefeeding habilitation of premature infants. Dr. Brazelton's theories on state development marked a pragmatic shift in recognizing that infants must actively engage in the interaction process by attaining a "quiet-alert" state.[7] He has contributed to the collective knowledge of neonatal behaviors through the Neonatal Behavioral Assessment Scale (NBAS). The NBAS evaluates infants' interactive behaviors in response to stimuli, describing the infant's strengths, adaptive responses, and vulnerabilities. Dr. Brazelton emphasizes the infant's state of consciousness throughout his works as the "single most important element to the behavioral assessment"[7] and uses a scale describing six levels of arousal. He stresses that state development and stability are crucial for the infant to generate responses to interactions.

Dr. Heidelise Als, founder of the Newborn Individualized Developmental Care and Assessment Program Federation International, had a mission to support neonatal nurseries and practitioners in their pursuit of providing individualized, developmentally supportive, and family-centered care through better observation and interpretation of neonatal behavior.[8] The synactive behavioral theory has generated awareness of the "stress, regulatory, and organizing" behaviors that enhance our ability to create an optimal caregiving experience.[9] We interpret these communication efforts to attune to the infant's needs and adjust our interactive approach while providing nurturing, medical, or therapeutic interventions.

Piaget describes adaptive motor capacity as the ability to change motor output in response to experiences to meet situational demands. He describes a learning process driven by "circular reactions,"[10] which are intentional, repetitive actions that bring an infant pleasure and support learning. The infant cycles through these "circular reactions" to build complexity and refine adaptive motor skills. Dr. Jean A. Ayres, a pioneer of the sensory integration theory, similarly proposed that "adaptive motor skills are the product of successful sensory integration."[11] Sensory integration is achieved through the perception, interpretation, organization, and response to multisystem sensory information.[11] An important consensus among these sensory-motor learning theories is that infant motivation is necessary for this learning process. Motivation precedes the motor actions crucial for skill acquisition.[11–14] Studies with preterm infants that explore goal-directed and adaptive behavior describe a learning process in which the infant's purposefulness precedes and supports motor complexity.[15–19]

The topics in this article draw upon these vital theories but also acknowledge a gap in the current literature: the need for a comprehensive framework for examining the presence and development of neonatal motivation and purposefulness that is the foundation for early learning behaviors. This begins with monitoring the expression of intentionality. By qualifying the infant's level of persistence in initiating and sustaining circular reactions[10] of adaptive motor output, the authors captured a hierarchy of neonatal learning behaviors. These are outlined in the "Neonatal Intentional Capacities" model.

THE MODEL OF NEONATAL INTENTIONAL CAPACITIES

The Development of Learning Behaviors

The "Neonatal Intentional Capacities" is a conceptual framework that analyzes premature infants' ability to engage in purposeful actions over extended learning sequences. Executing sustained learning sequences is crucial to acquiring new skills and is a foundational behavioral capacity driven by inner motivation. The authors found that learning and growth were prolific in certain states of intention, while in others these were restricted. This repertoire of behaviors can be monitored during various prefeeding interventions to reveal how well an infant can participate in learning experiences.

The authors created this behavioral model through a multidisciplinary effort analyzing clinical interactions with premature infants in level 3 and level 4 NICUs. By leveraging the distinct viewpoints of their different disciplines, the authors' collaboration reveals an in-depth analysis of neonatal behaviors during learning interactions. It underscores the advantages and value of strong partnerships in clinical pursuits.

Six states of intention capture the spectrum of the foundational learning behaviors observed in the neonate during targeted prefeeding experiences: *reactive*, *seeking*, *sustained sequences*, *goal-directed*, *diminished*, and *disengagement*. The first four states (*reactive*, *seeking*, *sustained sequences*, *and goal-directed*) describe a behavioral evolution from the absence of intentionality to the development of complex intention. The *reactive* and *seeking* states are considered emerging intentional capacities because they signify the beginning of purposeful engagement and directed attention. Meanwhile, the *sustained sequences* and *goal-directed* states are maturing capacities that facilitate a more profound learning process. The infant's capacity to learn ultimately depends on their ability to attain and sustain mature states of intention. These are the most desired behavioral capacities when facilitating a learning experience.

The last two states of intention, *diminished* and *disengagement*, are called terminal intention states because they describe how infants transition out of a learning interaction. It is important to note how an experience ends because it completes the scope of learning behaviors observed. It signifies whether the infant reached their learning threshold or, alternatively, underwent a significant stress response that abruptly concluded the learning experience.

During a learning interaction, the infant may achieve a single intentional state, move through all six learning states, or exhibit any variation of this spectrum of behavioral capacities. Clinicians assess the progression of intentional capacities observed to communicate the infant's learning proficiency or behavioral obstacles. It is important to recognize that learning behaviors have a distinct developmental trajectory but can also be hindered by vulnerable physiology and other biological factors related to premature birth.

Functional regulatory behaviors are described within each of the six states, serving as an additional set of purposeful actions, enhancing and regulating the overall experience for the infant. Identifying *functional regulatory behaviors* allows the clinician to respond with coregulatory support so learning can continue.

Emerging Intention States

Reactive. The *reactive state* of intention is when an infant primarily responds to the caregiver's stimuli, lacking the intrinsic initiation of purposeful action. The *reactive state* is preintentional, mostly passive, and can be regarded as the gross absence of intention. The infant is vulnerable to stress responses and may demonstrate a significant amount of *functional regulatory behaviors.* During a *reactive state* of learning, a provider may feel like they are constantly coaxing the infant to interact. The infant frequently responds to the clinician's actions but does not initiate any significant, purposeful behavior toward the goal of the interaction.

Seeking. A *seeking state* of intention is observed when an infant begins to demonstrate an internal drive toward learning and interacting, showing "islands of intentionality." The infant shows episodic *seeking* behaviors through motor initiations and adaptations. These can be frequent or infrequent. These short bursts of intentionality are followed by a substantial pause in purposeful behavior or *functional regulatory behaviors* like eye closing, squirming movement, or guarding with the tongue/jaw/hand. A *seeking state* of neurobehavioral intention is an optimal starting point for interacting and relates to a "readiness"[9] clinicians recognize.

Maturing Intention States

Sustained Sequence. Short chains of initiated actions occur during the *sustained sequence* behavioral state of learning. Infants spontaneously initiate and transition in and out of these distinct learning cycles. The time between the cycles of intention is typically shorter than during the "islands of *seeking* intentions," and there is a steady characterization of deliberate persistence in the motor adaptations observed. *Sustained sequences* are often

seen when an infant has learned to trust the stimuli and desires more of the experience. Infants may demonstrate an approach with less caution and have a sense of determination to learn and interact. *Functional regulatory behaviors* are lessening but continue to support the infant's ability to sustain the interaction.

Goal-Directed. A *goal-directed* intention state describes when an infant performs long, extended sequences of maintained and self-initiated learning behaviors through adaptive motor skills. These long chains of learning interactions have clear motor and behavioral objectives. Performance skills can more easily advance and develop in this state of learning; however, optimal skill is not required. *Functional regulatory behaviors* may be present, although instead of interrupting the interaction, they will assist in maintaining a *goal-directed* state. For instance, infants might close their eyes to focus on the targeted task. These extended chains of intentions vary in length, although long enough for the infant to demonstrate a capacity for occupational engagement.

Terminal Intention States

Diminished. *Diminished* intentions imply the infant has reached their threshold of interaction and learning capacities. There is a slow loss in the ability to employ deliberate actions toward the targeted task. Using the term *diminished* is purposeful to connotate a positive withdrawal from the experience. The infant may even appear satisfied, content, or blissful. They will cease to show further motor adaptation, typically observing a gentle fading of engagement behaviors, ultimately leading to a positive ending to an interaction.

Disengagement. *Disengagement* occurs when an infant withdraws from the experience because of an overload of stress or abrupt termination of capacity. *Disengagement* appears less voluntary and is a protective response of the infant's nervous system. *Disengagement* relates to terms like *shut-down* and *instability*, which neonatal clinicians use to describe a reaction to overwhelming stress.[9] A clinician aims to avoid this terminal intention state, and it is essential to recognize the events or stimuli that may have led an infant to disengage abruptly.

The Learning Curve

The transition from one intention state to another represents an infant's behavioral repertoire when learning and exploring within these novel situations. Figure 1A and B depict an example of an optimal and suboptimal learning curve. Identifying the individual learning curve an infant demonstrated during an interaction is an essential component of a holistic therapeutic assessment. A visual figure can help illustrate the infant's pattern of learning behaviors and can be an effective communication tool with NICU staff and for training new neonatal clinicians.

Functional Regulatory Behaviors

It is important to emphasize the role of *functional regulatory behaviors* and differentiate them from unmitigated stress responses. *Functional regulatory behaviors* are adaptive and communicative and distinguished by their motivation in allowing the infant to take needed breaks from learning or modulate from an overload of information. *Functional regulatory behaviors* are interwoven throughout an interaction and integrate within the six intention states. The authors view their role as essential in allowing the infant to communicate the threshold of their nervous system. The following are examples of *functional regulatory behaviors*:

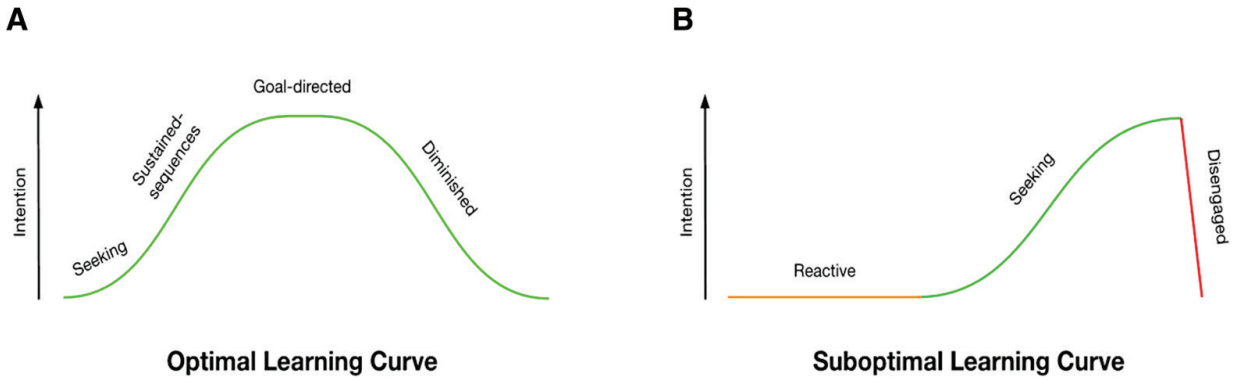
- Motor pauses
- Reducing external stimuli by closing the eyes
- Avoiding stimuli by turning the head
- Using a hand to block stimuli
- Squirming body movement
- Pushing with the tongue or clenching the jaw

These differ from an overwhelmed stress response, which is typically abrupt and will derail the interaction altogether. Severe stress responses can evoke protective and nonfunctional physiological, motor, or state changes, that is, hypotonia, changes in color and vital signs, crying/frantic, or abrupt downshift in state of consciousness. These will typically require additional support to return to equilibrium and should redirect the therapist's approach.[9,20] *Functional regulatory behaviors* connotate a productive struggle in the learning process. Caregiver attunement, achieved through coregulation, is crucial in avoiding a full-blown stress response, which will shorten the learning period. *Functional regulatory behaviors* can communicate the thresholds of a nervous system before an infant decompensates and should be celebrated as adaptive functions employed as a form of self-preservation within the desire to learn.

THE DEVELOPMENT OF ADAPTIVE PREFEEDING MOTOR SKILLS

Intentionality is most clearly witnessed through the expression of adaptive motor skills and therefore plays a dynamic role in our holistic understanding of prefeeding development. During prefeeding experiences, we can

FIGURE 1 ■ Examples of neonatal learning behavior curves.



observe task-specific voluntary and adaptive responses in posture, the extremities, and the oral-facial system. These deliberate adaptations support the behavioral capacities and motor skills required for future oral feeding.

There is a growing consensus that the sucking and swallowing network is intentional, adaptive, and modified through experience, not just reflexive.[21,22] Motor skills and reflexes take on more refined, voluntary, and goal-directed qualities as the infant grows.[7,10,23–26] This refinement leads to greater proficiency and mastery over performance skills and is the motor learning process clinicians typically focus on in neonatal habilitation. Existing evidence demonstrates that premature infants can adapt and modify their motor behaviors in response to changing demands.[17,19,27–29] However, when examining long-term outcomes, research indicates that premature infants may face challenges in the adaptation process and can benefit from specific therapeutic interventions to refine their skills.[18,30]

During clinical interactions of prefeeding, the authors monitored the desired motor adaptations infants made to improve their overall performance. They correlate with a widely accepted hierarchy of prefeeding motor development gathered from various multidisciplinary sources.[21,25,31–33] A skilled clinician, typically an occupational therapist or a speech language pathologist, can evaluate these adaptive motor actions and create focused intervention protocols to address the areas of weakness. The summary in Table 1 familiarizes neonatal clinicians with a full scope of possible adaptive motor actions that aid in prefeeding development and preparation for future oral feeding.

Embracing a Holistic Developmental Approach

Applying a holistic mindset to neonatal prefeeding habilitation involves monitoring and distinguishing between various observed behaviors. Tracking and analyzing the *intentional learning capacities*, *functional regulatory behaviors*, and the progression of adaptive motor skills from basic to complex guide clinicians about where to focus their intervention efforts. Identifying the intention state at the beginning, peak capacity, and end of the interaction can convey the range of an infant's learning behaviors. Clinicians utilize the prevalence of *functional regulatory behaviors* and strengths/weaknesses in adaptive motor skills to determine the choice and grading of activities.

The following strategies for treatment planning derive from the authors' expertise as certified neonatal therapists and are guided by the understanding of the delicate nature of the infant's nervous system. Applying the underpinning theories in this guide, the authors argue that a safe and infant-led practice aligns with the following clinical reasoning.

Beginning Intention State

Determining the beginning intentional behavioral capacities, either *reactive* or *seeking*, allows the clinician to record the infant's readiness to learn when first approached with oral-sensory experiences. Beginning in the *seeking* state is favorable, facilitating a smoother transition into more complex intention capacities. Suppose the infant is in a *reactive state* at the beginning of an interaction. In that case, there is a need for the clinician to thoughtfully consider the support they can offer to encourage a transition into a *seeking state*.

Transitioning an infant into a *seeking* state can be achieved by *enticing* the infant to express a desire for a stimulus, but not fully *imposing* it. This is an essential distinction. *Imposing* stimuli forces that experience onto the infant regardless of their active participation. *Enticement* strategies aim to draw out the infant's intention. This can include wafting milk's scent under the nose, eliciting a rooting response, and static placement of a swab, finger, or pacifier at the lower lip. Still, the caregiver must wait for a self-initiated and

TABLE 1 ■ Adaptive Prefeeding Motor Responses

Postural adaptations	• Head and neck alignment toward midline • Accommodation of the head toward stimuli • Flexion of limbs • Trunk flexion
Hand-to-face adaptations	• Flexion of arms • Hands-to-face behaviors • Actively seeks to suck fingers/hands • Hands-to-mouth behaviors • Supinates and brings fingers further into mouth • Independently maintains hand in mouth
Rooting/latching adaptations	• Head turns toward stimuli • Shallow mouth openings • Opening mouth to accept pacifier/infant's hand/gloved finger • Wide mouth opening • Lingual depression and extension • Lip rounding/shaping around objects • Sustained lingual contact
Licking adaptations	• Opening mouth seeking tastes • Lingual extension seeking tastes • Licking action emerges seeking tastes • Rhythmical licking action/lapping action • Sustained rhythmical licking action/lapping action
Sucking adaptations	• Initial compression of nipple/swab • Lingual cupping • Lingual/palate contact sustained • Intraoral suction emerges • Lingual peristaltic movements • Intraoral suction sustained • Arrhythmic suckling pattern emerges • Suckle strengthens • Rhythmic suckling pattern • Sustained rhythmic suckling pattern
Perceptual adaptations	• Sniffing toward scent • Head turns to scent • Reacts to smell/taste with pleasure/displeasure

(*Continued*)

TABLE 1 ■ Adaptive Prefeeding Motor Responses (*Continued*)

Cross-modal adaptations	• Intraoral suction emerges when combined with tasting/swallowing • Intraoral suction sustained when combined with tasting/swallowing • Suckle strengthens while tasting/swallowing • Arrhythmic suckling pattern while tasting/swallowing • Emerging rhythmic suckling pattern while tasting/swallowing • Rhythmic suckling pattern sustained while tasting/swallowing • Self-initiated pauses and reinitiating of bursts while tasting/swallowing • Pauses and restarts become timelier • Suckling bursts become longer while tasting/swallowing • Sustained rhythmic suckling pattern with timely pauses and reinitiating while tasting/swallowing

purposeful response before furthering the interaction. The extent of caregiver attunement can influence the ability to progress toward more complex capacities of intentionality. Additionally, the infant's distinct medical, biological, developmental, or physiological profile may cause a stagnated *reactivity* state and is not always related to the caregiver's approach.

Peak Intention State

Identifying the peak intentional learning capacity captures the infant's most robust ability for initiating and sustaining purposeful motor action. *Reactive*, *seeking*, *sustained sequences*, and *goal-directed intentional states* were all observed by the authors as possible peak capacities during interactions with infants.

In order to enhance peak intentional capacities, ensure the complexity of the infant's intentionality *matches* the complexity of the activity. *Reactive* or *seeking* intentions require less demanding activities such as hands-to-mouth, positive touch in perioral regions, or scent exposure. More advanced activities become appropriate as intentionality develops into *sustained sequences* or *goal-directed capacities*. For example, if the infant demonstrates *sustained sequences* of intention during nonnutritive sucking on a pacifier but exhibits a poor latch, oral-motor exercises to strengthen the latch may now be utilized. This is possible because the infant's intentionality supports the complexity of these more challenging exercises. Through *matching complexity*, we seek to maintain intention as a leading component of the interaction.

Another *matching* method involves aligning your action to theirs. For instance, if the infant only slightly opens their mouth to investigate a pacifier, an appropriate *match* is to position the pacifier at the gum line without inserting it fully into the oral cavity. Allow the infant to show further intention before placing the pacifier further into the mouth. On the other hand, if the infant actively roots toward the pacifier and shows eagerness to suck, you can *match* their vigorous action by allowing the pacifier to enter their mouth fully. *Matching* ensures a clinician does not dominate an interaction and allows slow activity grading without overwhelming the infant's developing systems. *Matching* should happen throughout the entire therapeutic exchange, not just at the beginning.

Concluding Intention State

Respecting thresholds of intentional capacities will enhance the therapeutic relationship and build security during attuned interactions. A safe learning experience respects infant communication by terminating the activity when the infant's motivation or adaptability *diminishes*, or regulatory efforts dominate an interaction. By monitoring the frequency and persistence of *functional regulatory behaviors* and responding appropriately, clinicians aim to avoid stress responses. Observing abrupt *disengagement* behaviors should elicit a reflective process where the clinician investigates possible causes to prevent this in the future. Observing *diminished* intentions expresses the infant's limits for learning and allows the experience to end positively.

Distinguishing Between Motor, Behavioral, and Physiological Limitations

To differentiate between limitations in prefeeding behavioral intention or motor performance problems, clinicians may need to try various interventions to grasp the scope of abilities. For instance, an infant might show *sustained sequences* of licking milk from a swab but be reluctant to engage with a pacifier. This suggests the infant has a capacity for mature learning behaviors, but the act of sucking poses a challenge for the infant. Although the exact cause of reluctance

to sucking may still be unknown, it can now be assessed more precisely and considered a primary goal of intervention.

There are instances where an infant may show brief but adequate motor skills for sucking or licking, but cannot sustain that purposefulness during either activity. In these cases, the clinician identifies learning behaviors as the main limitation during that interaction. Since motor skills are not the primary issue, the clinician investigates why the infant could not sustain purposeful behaviors and focuses on creating a supportive experience that captures the infant's interest in learning and sustaining interactions.

Lastly, learning behaviors and motor skills may both have limited developmental capacities, or both can be impacted by a vulnerable physiological system. Continuous monitoring of neonatal physiological systems is necessary and could potentially affect the infant's capacity to demonstrate behavioral or motor abilities.[9] The clinician can focus on supporting all domains simultaneously by using strategies of *enticement*, *matching*, and *respecting threshold*, while incorporating motor and sensory therapeutic interventions.

NEONATAL PREFEEDING INTERVENTIONS

Current evidence-based prefeeding interventions are consolidated and categorized in Table 2 under somatosensory, chemosensory, or combined sensory activities. This will guide clinicians in choosing and grading activities based on the motor skills or behavioral immaturities that require support. Activities that fall under the combined sensory prefeeding activities are called *simulated feeding* interventions. *Simulated feeding* interventions aim to improve the coordination of oral-motor-sensory systems without requiring the same precise synchronization of swallow or influence on the respiratory system needed during actual oral feeding.

Sensory systems mature at different times during fetal development and tend to have low thresholds for taking in, organizing, and responding to stimuli.[7] Using this knowledge, we reason that at-risk infants benefit from targeted interventions with lower sensory processing demands before focusing on activities stimulating multiple sensory systems. Prefeeding interventions should aim to foster a mature intentional capacity (*sustained sequences* or *goal-directed*) during focused somatosensory (oral-motor) and focused chemosensory (taste-smell) experiences before moving onto combined sensory interventions.

Some infants are more inclined to suckle and will show complex intention and motor skills with oral motor activities but cannot demonstrate the same behaviors during activities involving tasting and smelling. Alternatively, infants who may be aversive to touch around the face may avoid sucking but demonstrate robust intention and motor development around milk tastes and smells. Clinicians should aim to achieve motor and behavioral competence in both these systems before advancing to activities that combine these types of stimuli. Distinguishing these strengths and weaknesses will support individualized prefeeding treatment planning. Slow scaffolding of prefeeding experiences can lead to effective adaptive

TABLE 2 ■ Evidence-Based Prefeeding Interventions

Somatosensory interventions	Chemosensory interventions	Combined sensory interventions (simulated feeding)

• Positive touch to perioral regions
• Hands-to-mouth suckling
• Sucking therapies
  • Nonnutritive sucking[34,35]
  • NTrainer[36,37]
  • NNS at the breast[34,38,39]
  • Pacifier-activated devices[40,41]
• Oral motor exercise protocols
  • Fucile protocol[42]
  • Premature infant oral-motor interventions[43,44] (see website for full review on PIOMI research)
  • Other oral motor stimulation protocols[5,45,46]
	• Scent cloth/odor exposures[47–49]
	• Kangaroo care[39,45,50]
	• Colostrum care[51–54]
	• Milk drops protocol[55]—drops on lips protocol
	• Additional smell and taste intervention protocols[56]
		• Level 1: "paci-dips"[38,45,57,58]
		• Level 2: syringe with pacifier[55]
		• Level 3: syringe with open nipple/finger feeder[21,45,59,60]

Abbreviation. NNS = Nonnutritive suck.

learning behaviors and more robust proficiencies for intentional behavior.

The utilization or omission of any prefeeding method should be determined through careful clinical judgment, supported by clinical evidence, and informed by observations of the physiological profile, intentional capacities, and adaptive motor functions witnessed during therapeutic interventions. The purpose of this exploration is not to endorse a specific protocol of prefeeding intervention but to consolidate the current evidence so that clinicians can make educated, informed, and effective decisions in their practice. Please refer to the cited research articles for the specific guidelines of each intervention presented.

Somatosensory Prefeeding Experiences

Somatosensory prefeeding experiences refer to the sensory input related to touch and body movements involved in the process of sucking.[11,21] These experiences include oral motor patterns and coordination, the infant's sensory perception of the feeling of texture and temperature of objects, exploring the environment around the mouth and face, and becoming aware of the tactile sensations associated with feeding-related activities.

Chemosensory Prefeeding Experiences

Chemosensory prefeeding experiences involve the sensory aspects related to the taste and smell of milk.[11,21] These early sensory interactions help infants recognize and respond to different tastes and smells and shape an infant's preferences for various flavors and scents. Chemosensory prefeeding experiences include the motor skills involved in attaining these sensory experiences, such as licking, sniffing, or swallowing.

Combined Sensory Prefeeding Experiences

Combined sensory prefeeding or *simulated feeding* experiences integrate both somatosensory (related to touch and body movements) and chemosensory (related to taste and smell) elements.[11,21] They combine the sensations of touch, pressure, taste, and smell to form a holistic sensory experience during the prefeeding stage and encourage coordinated efforts from multiple systems.

Simulated feeding interventions are generally referred to as "paci-dips" in the neonatal therapy community, and despite being frequently endorsed they are also inadequately described and differentiated.[21,38,58] The authors deepen the exploration of this category of interventions and highlight a few distinct and essential variations of activities found in the literature.

Using the foundational theories presented and thorough task analysis, the authors have categorized these activities as level 1, level 2, and level 3, progressing from lower to higher physiological and sensorymotor demands. Tables 3, 4, and 5 present the authors' clinical opinions on the advantages and disadvantages of each activity. Practitioners should consider these factors when using them. Future research should rigorously test and compare these *simulated feeding* interventions to understand their diverse effects on neonatal outcomes.

Simulated Feeding Interventions

- Level 1: "paci-dips": These are typically described in the neonatal therapy community and literature as dipping the pacifier into a small cup of milk to deliver single drops into the mouth while encouraging nonnutritive sucking.[38,45,57,58] This process requires the removal of the pacifier to reapply the milk drop.

TABLE 3 ■ Level 1: "Paci-Dips"

Advantages	Disadvantages
• A single drop of milk allows for a gentle multisensory experience with low demand on the developing sensory system. • The intervention delivers scant amounts of milk while facilitating the occurrence of multimodal stimulation and ideally leads the infant to respond with suspected swallows. • The pauses imposed by removing the pacifier to replace more milk drops have the following benefits: • Increase opportunities to practice the adaptive skills of rooting and latching • Allow for respiratory and regulatory breaks • Allow the infant more opportunities to demonstrate intentional seeking behaviors	• Removal of the nipple to reapply milk drops has the following disadvantages: • Can disrupt the developing nonnutritive sucking pattern of *sustained sequences* involving self-initiated pauses and reactivation • Can disrupt the adaptive motor process of oral structures that occurs when an infant sustains sequences of prolonged engagement in the suckling activity • Results in repeated stimulation that may distress an infant, especially those with hyperreactive responses in and around the mouth • Reduces the infant's ability to develop endurance through sustained sequences of oral feeding patterns • There are limited ways to advance this intervention as the infant masters the basic components, limiting its value as a multisensory activity.

TABLE 4 ■ Level 2: Pacifier With Syringe

Advantages	Disadvantages
• The infant suckling pattern is allowed to adapt and develop without external disruption. • The infant practices a piston-like motion for suckling to propel the milk drops from the front of the oral cavity to the pharynx. This facilitates the occurrence of multimodal stimulation and ideally leads the infant to respond with suspected swallows. • The interventionist can provide paced drops for a continuous, anticipatory multisensory experience (see ORourke [55] for recommendations of quantities per post-menstrual age). • The provider can grade the demands of the intervention by delivering the milk drops at different intervals and quantities. • The infant can demonstrate sustained intentionality through self-initiated pauses and reactivation without external disruption. • Increased chemosensory input allows the infant to practice the coordination of suckling and swallowing of their saliva, as well as small boluses of milk drops.	• Empirical data and description are limited in the current literature. • The clinician must ensure controlled delivery of single, appropriate, bolus-sized drops to ensure safe swallowing practice and decrease the risk of mismanagement. • The multisensory experience is continual and, without the imposed pauses, can potentially overwhelm a developing nervous system. • Sustained suckling and tasting/swallowing without imposed pauses may impact the respiratory system of the infant. • This practice necessitates that the infant can manage their own secretions and coordinate suckling and swallowing of bolus-sized milk tastes.

TABLE 5 ■ Level 3: Syringe With Open Nipple/Finger Feeder/Paci-Trainer

Advantages	Disadvantages
• The infant experiences direct oropharyngeal chemosensory input while suckling, which prepares them for the direct oropharyngeal chemosensory input experienced when demonstrating more functional nutritive suckling. • The infant experiences the natural sensory sequence of suckling, leading to the delivery of milk. • The clinician can control continuous or intermittent streams of milk while suckling to expose the infant to more complex multisensory integrative capacities. • Increased chemosensory input allows for the infant to practice the coordination of suckling and swallowing of boluses of milk through the independent use of their oral motor skills and under the guidance of a therapist-controlled intervention.	• Limited empirical data to support the efficacy of this protocol have been achieved. • The clinician must ensure controlled delivery of single, appropriate, bolus-sized drops to ensure safe swallowing practice and decrease the risk of mismanagement. • The infant must anticipate the swallow of the micro-bolus more quickly than in levels 1 and 2 simulated feeding. • The oral motor, sensory, and physiological demands on the infant are significant and have the possibility of causing instability in the infant. • The clinician must ensure the infant's active involvement in the activity through observing intentional prefeeding behaviors, or this may become a passive simulated feeding experience with the potential to have an aversive sensory and emotional response.[61]

- Level 2: syringe and pacifier activities[55]: These activities involve the introduction of controlled micro-boluses (<0.02 mL) of milk, with restricted volumes, at the junction of the pacifier and lip. The infant's sucking action draws the micro-bolus into the mouth, delivering a controlled, clinician-driven amount of milk that stimulates the chemosensory receptors.
- Level 3: syringe with open bottle nipple, "paci-trainer," or "finger feeder"[21,45,59,60]: This is described as using an open bottle nipple with a syringe or a "finger feeder" with a nasogastric tubing to deliver controlled volumes of liquid to the midblade of the tongue immediately before the oropharyngeal space. This is described in the literature as a prefeeding intervention, and nurses use it similarly to deliver oral medication.

THE SOCIAL CONTEXT OF LEARNING

Reciprocal interactions with caregivers form the basis of healthy infant attachment and help establish patterns of predictability.[62] Premature infants will show progressive capacities of intentionality and increasingly

complex adaptive motor skills when engaged in prefeeding occupations supported by attuned social learning experiences. The responsibility of a neonatal clinician is to create a secure and motivating learning experience that respects their communication and addresses underlying motor performance. The "dance"[63] between the infant and the caregiver, when involved in therapeutic exchanges, can create a pleasurable learning experience supported by motivation and intention or serve as a rudimentary interaction of reactivity. The differences are consequential. By embracing a mindful caregiving approach that values and prioritizes infant motivation and integrates it with goals of motor learning, clinicians can enhance developmentally supportive caregiving and strengthen neonatal outcomes.

CONCLUSION

Despite the obstacles that premature infants face when developing in the NICU, they continue to show resilience to learn. Clinicians can enhance prefeeding habilitation by monitoring volitional development through the "Neonatal Intentional Capacities." The holistic framework presented allows us to study and analyze the infant's self-initiated and deliberate behaviors and the achieved adaptive motor actions supporting long-term outcomes. Future research should identify age norms for intentional learning patterns and develop a prefeeding assessment tool using the framework presented. Incorporating insights from this guide into future research could enhance the therapeutic value provided during these critical periods of development.

This paper does not cover all the nuances of prefeeding habilitation. However, an emphasis has been placed on prioritizing the development of intention and tailoring the experience to the infant's sensory-motor needs to create meaningful learning interactions. A collaborative mindset allows neonatal clinicians to view behaviors through the complex lens it deserves. As our understanding of neonatal development grows, we benefit from the clinical expertise that each discipline can offer and should embrace a collective process in our practice. The aspiration is for this holistic multidisciplinary approach to improve the quality of life for the infants served and to enrich the training of future generations of all neonatal clinicians.

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