Physiological Stability during Oral Feeding in Preterm infants: associations with Feeding Behaviors and Cues

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The purpose of this study was to examine the relationship between measures of physiological stability/instability during feeding. An additional aim was to determine if behaviors associated with physiological stability were also perceived as readiness or stress cues. Participants included 5 preterm infants (<37 weeks gestation) with no craniofacial anomalies. Infants were videotaped when they were taking at least 90% of prescribed volume. This study analyzed the common behaviors seen in preterm infants during bottle feeding to determine if there were associations with measures of physiological stability. Behaviors were also analyzed to determine which were perceived as indicating stress or readiness to feed by novice observers. Coding was conducted offline using Noldus Observer software.

Results revealed a statistically significant relationship between behaviors classified as stress cues and HR instability. There was not a significant association between stress cues and
RR or SPO2. Binomial testing identified specific preterm infant feeding behaviors that were more often classified as stress cues, with significance noted in audible swallow and vocalization. Several of the specific preterm infant feeding behaviors were more often classified as stress cues by novice observers. This was not the case for readiness cues, which couldn’t be clearly classified. Vocalization was hypothesized a priori to be a readiness cue, however was more often perceived as a stress cue by novice observers. This finding reveals the need for additional study to identify different types of vocalizations and operationalize them in order to support caregiver’s perceptions and ability to respond appropriately, in order to maintain stability.

Additionally, there was a significant association of HR with preterm infant feeding behaviors, specifically those classified as stress cues. A significant association was found with audible swallow and furrowed brow with HR instability, which implies that feeders should pay close attention to these behaviors during the feeding. Heart rate has the potential to be used as a diagnostic tool as it may predict when specific behaviors are impacting physiological stability. Caregivers could then be taught to respond to those behaviors appropriately, thus supporting stable HR. The clinical implications of this have the potential to maximize overall feeding outcomes.
PHYSIOLOGICAL STABILITY DURING ORAL FEEDING IN PRETERM INFANTS:
ASSOCIATIONS WITH FEEDING BEHAVIORS AND CUES

BY
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A very special note of appreciation to all the families that participated in this study. I am grateful for your contributions. It is because of you that I continue to work for your beautiful babies.
DEDICATION

With a heart full of love and gratitude, I dedicate this work to my children,

William and Luella.

You amaze me with your kindness, grace, and resilience every day. May you always follow your passions

and never stop learning.

This dissertation is also dedicated to my parents, Jon and MaryAnn Lund. Your endless love and support

have encouraged me throughout this and every other journey in my life.
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Throughout the first year of life, infants transition from complete dependence on their caregiver during feeding to feeding independently (Pridham, Steward, Thoyre, Brown, & Brown, 2007). Unfortunately, this is not the case for many preterm infants who often require specialized care throughout the first year of life due to physiological instability as measured by heart rate (HR), respiratory rate (RR), and oxygen saturation levels (SPO2). Adapted and/or adjunctive feeding practices may include: nasogastric feeding, bottle feeding with adapted nipples and/or bottle systems, external pacing, and modified feeding positions. Prematurity is also associated with increased risk of feeding difficulties that persist beyond the toddler years (Dodrill, Donovan, Cleghorn, McMahon, & Davies, 2008). Preterm infants are at increased risk of chronic feeding difficulties and Pediatric Feeding Disorder (PFD) (Demauro, Patel, Medoff-Cooper, Posencheg, & Abbasi, 2011; Stark, Adamkin, Batton, Bell, Bhutani, Denson, …Cuoto et al., 2008; Thoyre, Hubbard, Park, Pridham, & McKechnie, 2016). Goday and colleagues recently published a consensus definition that stated, “PFD is defined as impaired oral intake that is not age appropriate, and is associated with medical, nutritional, feeding skill, and/or psychosocial dysfunction” (2019, p. 125).

Because of the significant consequences of early feeding difficulties, medical professionals and caregivers are searching for ways to improve infants’ feeding experiences and outcomes. One possibility for improving infants’ feeding experiences is to use established and
objectively quantifiable measures of physiology to determine when feeding is going well and when feeding should be stopped. Heart rate, RR, and SPO2 are objective measures of physiological stability in preterm infants and safe parameters have been agreed upon in the literature (Groh-Wargo & Sapsford, 2009; Lau, 2006; Manja, Saugstad, Lakshminrusimha, 2017; Poets, Stebbens, Alexander, Arrowsmith, Salfield, & Southhall, 1991; Shiao, Booker, & DiFiore, 1996; Yamamoto, Prade, Berwig, Weinmann, & Keske-Soares, 2016; Yamamotor, Prade, Bolzan, Weinmann, & Keske-Soares, 2017). The ability of preterm infants to maintain physiological measures within these limits is positively tied to quality feeding development and decreased length of time in the Neonatal Intensive Care Unit (NICU) (Pickler 2004; Thoyre & Brown, 2004). The Supporting Oral Feeding in Fragile Infants (SOFFI) algorithm created by Ross and Philbin (2011) supports this assertion, suggesting assessment of physiological stability as the first step in determining feeding readiness.

Even though the importance of physiological stability in relation to preterm infant feeding success is agreed upon, the use of measures of physiological stability alone is problematic for at least two reasons. First, caregivers do not have access to physiological monitors outside the NICU. Caregivers need to rely on observable infant behaviors to make decisions about their infant’s physiological stability and whether they should continue or stop feeding. Second, many intervention programs encourage caregivers to watch for infant behaviors that might signal a readiness to feed or a need to stop feeding (Ross & Philbin, 2011; Shaker, 2013a; Thoyre et al., 2016), even though we do not know what behaviors are linked to which physiological measures of instability or how caregivers perceive preterm infant feeding behaviors. Finding the answers to these questions seems critical if intervention programs are
going to use observable infant behaviors during feeding as a window into infants’ physiological states.

Focusing caregivers on infants’ behaviors during feeding is a standard part of intervention programs often referred to as co-regulated or cue-based feeding approaches. These approaches include a variety of protocols and programs focused on developing feeding skills, maintaining physiological stability, and enjoyment of feeding (Ross & Philbin, 2011; Shaker, 2013b; Thoyre et al., 2016). For example, Infant-Driven Feeding™ and SOFFI are available cue-based feeding protocols (Ludwig & Waitzman, 2007; Ross & Philbin, 2011) whose goals are to improve the quality of infants’ feeding experiences by allowing infants to guide feeding and influence caregivers’ responses. The protocols include some detail about infants’ engagement in feedings and provide guidelines for supporting the infant in engaged feeding, but do not objectively define specific feeding behaviors or relate them to infants’ physiological stability or instability. Researchers and clinicians agree that we need to know more about what feeding behaviors are related to which physiological measures to help refine feeding interventions (Lund-Hrdi & Fannin, 2017). Despite this acknowledgment, there is a paucity of research directly examining associations between preterm infants’ physiologic states and their behaviors during feeding.

Existing studies examining physiological stability during feeding have not directly evaluated associations between specific preterm infant feeding behaviors and measures of physiological stability (Groh-Wargo & Sapsford, 2009; Lau, 2006; Manja et al., 2017; Poets et al., 1991; Shiao et al., 1996; Yamamoto et al., 2016; Yamamoto et al., 2017). Thoyre, Park, Pados, and Hubbard (2013) reported physiological measures as part of a descriptive case study of one child across two feedings. The infant’s HR and SPO2 fluctuated through the feeding, though
they were stable prior to the feeding (Thoyre, et al., 2013). Physiologic measures (HR, SPO2, and breathing patterns) were reported but not linked to infant feeding behaviors or cues. Therefore, the current study is the first to directly identify the relationship between measures of physiological stability and infants’ behaviors during feeding.

Infants’ behaviors during feeding have been described in the current literature as two broad categories of cues: readiness and stress cues that have been anecdotally linked to measures of physiological stability (Gennattasio, Perri, Baranek, & Rohan, 2015; Hodges, Wasser, Colgan, & Bentley, 2016; Jones, 2012; Kish, 2013; McGrath & Braescu, 2004; Newland, L’Huillier, & Petrey, 2013; Ross & Philbin, 2011; Shaker, 2013a; Thoyre et al., 2013; Thoyre & Brown, 2004; Thoyre, Shaker, & Pridham, 2005; Whetten, 2016). Feeding readiness cues are thought of as behaviors that signal to the caregiver that the infant is engaged and ready to begin or continue feeding. For example, McGrath and Braescu (2004) state:

Oral feeding readiness can be defined in terms of readiness for initiation of oral feedings and in terms of readiness for a particular feeding event. Parameters used for assessing readiness to initiate oral feedings are usually more related to maturation than to other physiologic or behavioral factors, for example, post conceptual age (PCA). Parameters used for assessing readiness for a particular feeding are more often related to behavioral and physiologic factors, for example, display of hunger cues or alertness. (p. 354)

Common readiness cues include: awake/alert state, moving toward the nipple, bringing hands to mouth, rooting, smacking lips, positive vocalizations, and active engagement during feeding (Gennattasio et al., 2015; Hodges et al., 2016; Jones, 2012; Kish, 2013; McGrath & Braescu, 2004; Newland et al., 2013; Ross & Philbin, 2011; Shaker, 2013a; Thoyre et al., 2013; Thoyre & Brown, 2004; Thoyre et al., 2005; Whetten, 2016). Thoyre et al. (2016) recommends that the assessment of feeding readiness cues should include the ability of the infant to maintain attention and energy for feeding, maintain organized oral motor skills, maintain coordinated suck-
swallow-breath patterns, and maintain physiologic stability. Alternatively, Ludwig and Waitzman (2007) indicate that feeding readiness is demonstrated by rooting, by sucking on a pacifier actively, by bringing a hand to the mouth, or by having “good tone for age” (p. 157). For all of these recommended readiness cues, no study to date has confirmed whether they are linked to physiological stability or if caregivers consistently perceive these behaviors as readiness cues.

In contrast to readiness cues, preterm infants also show stress cues during feeding that are thought to signal that an infant is not ready to feed or needs a break. Shaker (2013a) describes preterm infants’ stress cues during feeding as signs that an infant needs a break from feeding or that feeding should not begin. Lack of active rooting and sucking, passive engagement, and decreased state regulation are described as cues that infants are not ready to feed. In addition, Shaker (2013a) describes pulling off the nipple, pushing the nipple out, and “purposeful use of a weak or ‘compression-only’ suck” (p. 406) as behavioral cues that a caregiver should disengage from feeding. Stress cues in preterm infants can also include postural control changes, altered levels of alertness, color change, altered cardiopulmonary status (tachypnea, nasal flaring, bradycardia, chin tugging, shallow breathing, unstable oxygen saturations, apnea, etc.), and decreased suck-swallow-breathe coordination (Shaker, 1999; Shaker 2013a). Uncoordinated suck-swallow-breathe is often distinguished by excessive drooling, audible swallows, multiple swallows, gurgly sounds in the pharynx, and coughing/choking (Shaker 2013a). However, as with feeding readiness cues, no study has directly determined if there is a link between specific stress behaviors and physiological instability.

Unfortunately, it is also largely unknown whether preterm infant feeding behaviors discussed in the literature are consistently perceived as readiness or stress cues by novice observers, including the caregivers who are typically novice feeders of preterm infants and are
often told to watch for readiness and stress cues. Therefore, the current study also aimed to
determine which feeding behaviors are reliably categorized by novice observers as readiness or
stress cues and if those cues are related to physiological stability or instability. Based on the
recommendations of previous researchers, the following behaviors are predicted to be perceived
as infant feeding readiness cues: hands to mouth, moving toward the nipple, rooting, lip
smacking and vocalizations. Furthermore, the behaviors predicted to be classified as stress cues
by novice observers include: altered tone, audible swallow, breath holding, liquid loss, head
bobbing/nasal flaring, and uncoupling of suck-swallow-breathe. All hypothesized behaviors (that
may be categorized as readiness or stress cues) targeted in this study are presented in the Coding
Manual (Appendix C).

Purpose

In summary, the current study had two main purposes. The first aim was to examine the
relationship between measures of physiologic stability/instability (HR, RR, SPO2) and infant
behaviors during feeding. The second aim was to determine if the infant behaviors associated
with physiologic stability or instability were also identified by novice observers as readiness and
stress cues. It is hoped that findings will improve feeding training for caregivers, and ultimately
improve the quality, safety, and enjoyment of preterm infant feedings.
CHAPTER 2

REVIEW OF THE LITERATURE

The purpose of this review of the literature is to summarize and synthesize the current knowledge related to preterm infant feeding. This review will include descriptions of feeding cues, cue-based feeding vs. volume-driven feeding approaches and discussion of the outcomes of specific feeding protocols. A discussion of specific feeding cues and how they are defined and/or categorized is also included, as well as the impact of physiologic stability on feeding skills of preterm infants. The aim of this review is to provide an understanding of cue-based feeding, preterm feeding outcomes, and identify inconsistencies/gaps in the literature.

Preterm Infant Feeding Outcomes

Greater than 50% of all individuals who receive surgical gastrostomy or percutaneous endoscopic gastrostomy (PEG) feeding tubes are under 1 year of age at the time of placement (Fox, Campagna, Fridlander, Patrick, Rees, & Kempe, 2014). Approximately 80% of preterm infants develop chronic feeding problems (Mathisen, Worrall, O’Callaghan, Wall, & Shepherd, 2000) that can result in decreased nutritional intake, which can negatively affect growth and feeding development (Demauro et al., 2011; Stark, et al., 2008; Thoyre et al., 2016).
Growth

Ross and Browne (2013) reported that preterm infants have growth complicated not only by potential medical problems, but also as a result of poor feeding skill development. In addition, infants born prematurely have an increased risk of feeding difficulties, which directly impacts length of stay in the hospital (Stark et al., 2008). Demauro et al. (2011) reported that up to one-third of very premature infants continue to have feeding difficulties throughout their first year of life. More specifically, feeding difficulties that persist throughout the first year of life include: emesis, decreased appetite, oral motor impairments, physiological instability, impaired transition to age-appropriate food textures and extended feeding times (DeMauro et al, 2011; Thoyre et al., 2016), all of which may have an impact on growth. Pridham, et al., (2007) reported that the contribution of maternal behavior to infant growth and feeding skill development through the first year of life is largely unknown.

Chronic Feeding Difficulties

There is existing literature, though sparse, indicating the ongoing struggles that preterm infants have related to feeding throughout the months and years following discharge from the NICU. Persistent feeding difficulties, food selectivity, food refusals, and difficulty transitioning to age-appropriate textures have been reported in preterm infants (Hawdon, Beauregard, Slattery, & Kennedy, 2000), each of which may affect growth. Hawdon, et al. (2000) noted that more than half of the neonates had continued feeding difficulties at 6-months of age. Mathisen et al. (2000) looked at otherwise healthy preterm infants at 6-8 months corrected age. They found that 80%
of the infants had ongoing, chronic feeding problems characterized by feeding fatigue, delayed development of feeding skills, and decreased intake. Mathisen et al. (2000) also found that 40% of the sample had episodes of aspiration as compared to zero in the full-term controls. These preterm infants were described as more demanding and frustrated, less persistent and adaptable, and more likely to be on non-textured purees.

According to Thoyre (2007), “Infant feeding skills and problems are based on the child’s biological capabilities, the health of the child, and the repeated experiences they encounter while eating. Thoyre (2007) also stated that there is sufficient evidence that that preterm infants are at increased risk for feeding difficulties in their early years, however, there is a need for more evidence to identify what the implications are and what specifically is experienced by these preterm infants and their families when they are discharged home from the NICU. Much of the published research addresses identification of and descriptions of feeding difficulties in preterm infants while they are still in the NICU, as well as the impact of feeding techniques on time to full oral feeding and length of stay in the NICU. According to Thoyre (2007), feeding difficulties are impacted by the infant’s biology, physical capacity, physical health, and repetitious experiences over time during feedings.

Physiological Stability in Preterm Infants

Physiological stability in preterm infants is a primary concern during feeding and is often discussed as a goal of feeding approaches (Thoyre et al., 2016). In addition, there is consensus in the literature related to recommended levels of stable HR, RR, and SPO2 during feeding. Preterm infant’s HR, RR, and SPO2 are measured by leads attached to the infant and displayed
on a monitor. Preterm infant’s heartrate is considered stable when between 120-160 beats per minutes (Yamamoto et al., 2016) and respiratory rates are described as stable in preterm infants when they are from 40-70 breaths per minute (Groh-Wargo & Sapsford, 2009; Lau, 2006). Consensus regarding oxygen saturation (the estimated amount of oxygen in the blood) is that >90% is considered stable (Manja et al., 2017; Poets et al., 1991; Shiao et al., 1996; Yamamotor et al., 2017). However, even though there is consensus that physiologic stability is an important prerequisite to preterm infant feeding success, specific associations between physiological stability and preterm infant behaviors such as readiness and stress cues have not been determined (Ludwig & Waitzman, 2007; Ross & Philbin, 2011; Shaker, 2013a; Thoyre et al., 2005; Thoyre et al., 2016).

Ross and Philbin (2011) also discuss the need for awareness of preterm infant’s physiologic stability in addition to their behavioral cues. Physiologic stability is a precursor to the establishment of behavioral feeding readiness, which the infant then conveys to the caregiver through a set of behavioral responses (Ross & Philbin, 2011). Ross and Philbin (2011) also discuss the need for awareness of preterm infant’s physiologic stability in addition to their behavioral cues. Physiologic instability puts preterm infants at increased risk of aspiration and aspiration consequences.

Thoyre, Holditch-Davis, Schwartz, Melendez Roman, and Nix (2012) looked at physiological stability in preterm infants with lung disease when fed using a co-regulated (CoReg) approach, which focuses on proactively interpreting infant behaviors while feeding. They looked at three broad categories of behavioral disorganization, disorganized fluid management, and increased work of breathing. The behaviors associated with these categories were stated but not defined. Thoyre et al. (2012) found heart rate and oxygen saturations were
similar during the pre-feeding period across the categories. They did not, however, look at the specific behaviors and their impact on physiological stability.

Pados, Thoyre, Knafl, and Nix (2017) found that heart rate variability was a reliable measure of physiological stress in preterm infants and could be used to measure effectiveness of feeding interventions. Thoyre et al. (2012) found a statistically significant difference in the maximum heart rate of preterm infants with lung disease during feeding. Those fed with a CoReg approach had decreased severity of heart rate declines (p = .002) during feeding. In addition, they found decreased heart rate variability in the CoReg. In addition, respiratory irregularities are often a precursor to instability and accompanied by preterm infant behaviors (Thoyre & Carlson, 2003).

These behaviors often lead to oxygen desaturations, though specific associations between the behaviors and physiological measures have not been identified. Grunau, Holsti, Whitfield, and Ling (2000) found increased extensor behaviors during suctioning (finger splay, brow raising, leg extension), a stressful event for preterm infants. Extension behaviors were also found to occur more frequently either immediately prior to or during oxygen desaturation (Peters, 2001). In contrast, flexion behaviors (hands to mouth, hand clasp, foot clasp, grasping, fisting) were more likely during periods of increased oxygenation (Peters, 2001). These findings demonstrate the potential for specific readiness and stress cues to be predictive of physiological stability or instability.
Feeding Approaches and Outcomes

Infant feeding skill development and feeding challenges are based on medical stability and repeated experiences during feedings (Thoyre, 2007). There are two schools of thought on feeding approaches: scheduled/volume-driven feeding and cue-based feeding. The main cue-based approaches discussed in the literature include: Co-Regulated (CoReg) (Thoyre et al., 2013; Thoyre et al., 2016), Infant-Driven Feeding™ (IDF) (Ludwig & Waitzman, 2007), and Supporting Oral Feeding in Fragile Infants (SOFFI) (Ross & Philbin, 2011).

The literature in the area of infant feeding and swallowing has been primarily focused on outcomes of cue-based or co-regulated feedings with regard to length of stay in the Neonatal Intensive Care Unit (NICU). Ward & Fan (2018) found a statistically significant difference in the time to full oral feeding with preterm infants fed via a cue-based approached vs. controls. In addition, the intervention group was discharged home from the NICU an average of 1.3 days sooner. There have been few studies that continue to look at growth and feeding skill development following discharge from the NICU (Horner, Simonelli, Schmidt, Cichowski, Hancko, Zhang, & Ross, 2014).

Traditionally, premature infants have been fed using a volume-driven approach. A general shift away from volume-driven feedings toward cue-based or co-regulated feedings has been identified in the literature (Ross & Philbin, 2011; Shaker, 2013a; Shaker, 2013b). Shaker (2013a) described volume-driven feeding as feedings focused on the amount of formula or breastmilk the infant takes in during a feeding. Success of volume-driven feeding is measured by the amount or volume the infant ingests regardless of behavioral cues from the infant (Ludwig & Waitzman 2007; Shaker, 2013a, Whetten, 2016). In the traditional volume-driven model,
nipple feedings are ordered by the physician on time intervals (e.g., every other feeding, once a shift, etc.) and readiness to feed is determined by the time or predetermined schedule rather than infant cues, state, and level of alertness. McGrath and Braescu (2004) noted that this results in infants being pushed to do more than they are physiologically ready for, thus increasing infants’ stress and risk of developing feeding difficulties. The goal of the volume-driven approach is to get the infant to eat the full volume in an effort to speed up weight gain, time to full oral feeding, and time to discharge.

Shaker (2013a) describes how the volume-driven approach often leads to maladaptive feeding behaviors due to the feeder ignoring or misinterpreting stop or stress cues by the infant. Nursing staff and caregivers are asked to primarily document the amount of liquid the infant took, which results in focus on volume rather than feeding skill development (Ludwig & Waitzman, 2007). Documentation completed in a narrative or categorized form (poor, fair, good) is also easily misinterpreted and further contributes to the focus on volume (Ludwig & Waitzman, 2007). While volume is an important factor for preterm infant growth, it does not account for specific feeding skill development, which impacts growth and development.

**Cue-Based Feeding**

In contrast, cue-based feeding provides a framework to support physiological stability during feeding by identifying cues and behaviors the infant is sharing to indicate stress, which may lead to physiological instability. Because of the significant consequences of early feeding difficulties, Shaker (2013b) and Thoyre (2007) argue for the need to focus on a co-regulated approach to feeding premature infants as a way to improve outcomes for preterm infants. The
terms co-regulated or cue-based feeding include a variety of protocols and programs focused on developing feeding skills, enjoying feeding, and maintaining physiological stability, rather than the volume of liquid consumed (Ross & Philbin, 2011; Shaker, 2013a; Shaker, 2013b; Thoyre et al., 2016).

Cue-based feeding is an umbrella term used to describe feedings guided by infant cues (behavioral and physiological). Feeding behaviors are typically divided into readiness and stop/stress cues (Ross & Philbin, 2011, Shaker, 2013a), however, there is inconsistency across the literature in the use of terms to describe readiness and stress cues. Other terms utilized to describe infant cues include: regulated/dysregulated (Thoyre et al., 2016; Thoyre et al., 2012; Thoyre et al., 2013) and engaged/disengaged (Newland et al, 2013).

In a cue-based approach, success is measured by development of skills, state regulation, enjoyment of the feeding, and maintenance of physiological stability throughout the feeding, rather than volume consumed. Cue-based feedings are built upon a reciprocal relationship between the infant and caregiver during feeding (Shaker, 2013a). The infant communicates a desire/readiness to feed or a need to stop. Infant behaviors are observed by the feeder who responds accordingly (Ross & Philbin, 2011; Shaker, 2013a; Thoyre et al, 2016). Readiness cues described in the literature include, but are not limited to: physiologic stability, rooting, bringing hands to mouth, suckling on own hands, and increased state arousal. Shaker (2013a) breaks stop or stress cues into infant disengagement and stress cues. Preterm infants who stop rooting and are not demonstrating active sucking or suckling are not demonstrating nipple feeding readiness. In addition, infants demonstrating a passive state, difficulty re-alerting, pushing the nipple away, or transitioning to a weak or compression only suck are identified as communicating their disinterest or disengagement in the feeding (Ross & Philbin, 2011; Shaker, 2013a). Common
stress cues reported in the literature, include but are not limited to: altered state or level of alertness, altered postural stability, movement, and change in muscle tone. Cardiorespiratory changes and/or decreased coordination of suck-swallow-breathe are also signs of distress often seen in preterm infants during nipple feedings (Ross & Philbin, 2011; Shaker, 2013). Descriptions of commonly reported cue-based feeding approaches, including Co-Regulated (CoReg) feeding, Infant-Driven Feeding™ (IDF), and Supporting Oral Feeding in Fragile Infants (SOFFI) are provided to better understand the current state of the field.

Co-Regulated Feeding

Co-regulated feeding has been referred to as regulation or “pacing” (Law-Morstatt, Judd, Snyder, Baier, & Dhanireddy, 2003). Thoyre et al. (2012) state that pacing and co-regulated approaches to feeding (CoReg) are not synonymous because CoReg is individualized based upon an infant’s skill and safety. In CoReg, the feeder works proactively to identify and respond to dysregulation and the need for breathing breaks or pacing (Thoyre, et al., 2012). The goal of the feeding is to optimize safety and skill development through ongoing assessment of the infant’s behaviors/cues (Thoyre, et al., 2013). They state that CoReg and Cue-based Feeding in general should focus on anticipation of support or stress. By utilizing this proactive approach, rather than simply responding to episodes of distress or physiological instability, the feeder is supporting the infant’s communication and respecting their limits (Thoyre, et al., 2013).

In a CoReg approach, the infant’s readiness to feed is determined by assessing sustained attention, oral motor control and organization, suck-swallow-breathe coordination, and physiological stability (Thoyre et al., 2005). Barriers to the implementation of CoReg include:
mothers’ availability due to health, weather, and work. In addition, Thoyre, et al., (2016) indicate that although involved in the study and training related to CoReg, mothers were presented with inconsistent direction and ideas related to how to feed their infant, increasing their confusion. Thoyre, et al. (2012) found a statistically significant decrease in behavioral disorganization, disorganized fluid management, and work of breathing with a CoReg approach as opposed to the traditional usual care in preterm infants with lung disease.

Infant-Driven Feeding™

Infant-Driven Feeding™ (IDF) is another cue-based approach to feeding. Similar to CoReg, IDF is based on developing a reciprocal interaction between the infant and feeder by encouraging an understanding of feeding readiness, quality feeding experiences, and guidance for feeders (Ludwig & Waitzman, 2007). The Infant-Driven Feeding Scales were designed for assessment of feeding skill and readiness, intervention guide, and a source of documentation (Ludwig & Waitzman, 2007). The IDF scales break down feeding into three major categories: feeding readiness, quality of nippling, and caregiver techniques. The feeding readiness skills are scored based on a 1-5 scale with 1 being awake/alert, rooting, and good tone to demonstrate the highest level of feeding readiness. A score of 1 or 2 should be achieved in order for the feeding to be initiated and scores of 3 – 5 indicate that feeding should be deferred.

The Quality of Nippling Scale scores the infant on how well he/she did during the feeding. Scoring is based on coordination of suck-swallow, fatigue, liquid loss, pacing, and physiological instability. A score of 5 is given when the infant is unable to coordinate suck-swallow-breathe, even with external pacing, resulting in tachypnea, liquid loss, apneas or
bradycardia. In this model, the feeder determines readiness to feed and then scores the infant based on the quality of that feeding in addition to external supports provided by the caregiver. Interventions may include: external pacing, modified sidelying, chin support, cheek support, and/or oral stimulation.

As with other cue-based feeding models, IDF often results in shorter time to full oral feeding and decreased length of stay in the NICU. Wellington & Perlman (2015) reported length of stay decreased by 9 days in the IDF group. Infants fed using the IDF model achieved full oral feedings 17 days sooner than the practitioner-driven group. In addition, Chrupcala, Edwards, and Spatz (2015) found mean length of stay in the NICU was decreased by 6.63 days post IDF implementation as part of a quality improvement study.

Supporting Oral Feeding in Fragile Infants

Supporting Oral Feeding in Fragile Infants (SOFFI) (Ross & Philbin, 2011) is an interdisciplinary cue-based feeding approach which utilizes an algorithm to guide the feeder through the feeding. The decision matrix provides a set of questions to guide evaluation of infant feeding readiness through the use of “yes” or “no” questions. (Ross & Philbin, 2011). The algorithm guides the feeder to make decisions related to feeding readiness, continuation of the feeding, providing additional supportive interventions for the infant and/or discontinuation or deferment of the feeding session (Ross & Philbin, 2011). The SOFFI focuses on training the caregiver to provide direct attention to the infant throughout the feeding and continuously assess the infant’s status related to continuation of the feeding.
The SOFFI algorithm begins with an assessment of physiological stability prior to and during routine care. If physiological instability is observed the oral feeding is not pursued. If stability is observed, the feeder then assesses the infant’s level of alertness and hunger cues. If drowsy or awake with hunger cues, the infant is offered the opportunity for non-nutritive sucking. Again, the infant’s stability and level of alertness are assessed. If stable and alert, the infant is offered the bottle. Ongoing assessment of physiological stability continues throughout the feeding. Anytime the infant presents with decreased levels of alertness or instability, readiness is reassessed. If stress cues or instability are ongoing, the feeding is stopped (Ross & Philbin, 2011).

Horner et al. (2014) studied preterm infants pre and post implementation of the SOFFI in a Level III NICU. They found that preterm infants (<37 weeks gestation) post SOFFI implementation achieved full oral feeding 8.47 (p = .01) days earlier than the pre SOFFI group (Horner et al., 2014). They did not find a statistically significant difference in infants born ≥ 37 weeks gestation. There was a statistically significant difference in reports of ongoing feeding problems at 3-5 months post-term (p = .01), specifically arching with meals, enrollment in feeding therapy, and gagging during meals (Horner, et al., 2014).

Feeding Behaviors and Cues of Preterm Infants

Even with the improved outcomes noted using cue-based feeding approaches, there are barriers to promoting the approaches. One of the challenges facing professionals and caregivers is a lack of consensus on how to define and label infant behaviors during feeding. Feeding behaviors are the implicit and explicit actions that preterm infants demonstrate during feeding.
Feeding behaviors are then classified into cues. For example, some researchers and clinicians classify feeding behaviors as readiness and stress cues, while others classify them as engagement and disengagement cues. Such inconsistencies make it difficult to compare findings across studies and make it difficult to give caregivers guidance on which feeding behaviors are indicative of stress or readiness to feed.

Readiness cue is an overarching term used in the literature to describe an infant’s ability to begin safe and pleasurable oral feeding. Inconsistencies in the terminology used have made consistent implementation of cue-based feeding challenging. Feeding readiness cue is used by many researchers to describe behaviors indicating that the infant is prepared to engage in feeding. Ross and Philbin (2011) include behaviors of arousal, moving extremities, mouthing, and bringing hands to mouth when describing feeding readiness cues. Ludwig and Waitzman (2007) state that feeding should begin only if the infant is demonstrating physiological stability and demonstrating readiness cues. Similarly, Ross and Philbin (2011) instruct that physiological stability should be assessed during nursing cares (diaper change, temperature check, medication administration, etc.) prior to feeding. If the infant cannot maintain stability during cares, he/she is not in a readiness state and the feeding should be deferred.

Engagement is a term used synonymously to describe an infant’s ability to maintain an awake state with enough energy to complete the feeding while maintaining interaction with the feeder and the environment (Thoyre et al., 2005). Newland et al. (2013) also use the term engagement to describe feeding readiness or hunger cues, however they do not provide an explicit definition of the cues. They indicate behaviors associated with engagement include: hands to mouth, fussy and other cues present, sucking on fingers or pacifier, awake, relaxed facial expression, good tone, and rooting (Newland, et al., 2013).
Conversely, disengagement was described as a decreased level of alertness limiting the infant’s ability to coordinate suck-swallow-breathe, resulting in a negative impact on respiratory stability. Newland and colleagues (2013) also use disengagement to describe stress cues, which include: inconsolable crying, worried or frowning face, yawning, averting eye gaze, poor tone, drowsy state, splayed fingers or hands in “stop” position, and arching or pulling off the nipple. They do not provide explicit definitions of stated behaviors. Thoyre, et al (2012) also used the “disorganized behavior” to describe “observable indicators that the infant is actively trying to pull away from the nipple, extending fingers or arms, pushing nipple away, eyebrow raise or eye flutter, and furrowed brow” (p. 245). Cues are further broken down into “disorganized swallowing” and “dysregulated respiration”. They define disorganized swallowing as “signs that the infant is not managing fluid: drooling; hard swallows’ fluid remaining in pharynx or nasopharynx that is audible during respiration; and multiple swallowing” (Thoyre, et al., 2012, p. 245). Behaviors that are signs of dysregulated respiration include: work of breathing (use of accessory muscles such as head bobbing and pulling head back to take a deep inhalation) and prolonging the exhalation with audible grunt (Thoyre, et al., 2012, p. 245).

Kish (2013) suggests that there are inconsistencies in the identification of feeding behaviors, specifically those associated with readiness to feed. She offers a broad definition of feeding readiness, along with a list of behavioral and physiologic factors, however specific behaviors are not clearly defined. She defines oral feeding readiness as, “readiness for initiation of oral feedings and in terms of readiness for a particular feeding” (Kish, 2013, p. 231). Thoyre (2005, 2015) discusses the assessment of feeding readiness cues, including the ability of the infant to maintain attention and energy for feeding, organized oral motor skills, coordination of suck-swallow-breath, and physiologic stability. Readiness cues, however, are not consistently
identified or defined in a quantitative manner. Feeding behaviors typically associated with or
categorized as readiness include rooting, moving toward the nipple, hands to mouth, positive
vocalizations, awake/alert state, physiological stability, and coordinated suck-swallow-breath.
Objective identification of readiness cues can lead to improved training protocols for parents,
caregivers, and staff in the NICU. Watson & McGuire (2016) refers to hands-to-mouth,
mouthing fingers or fist, quiet awake state, lower extremity movement, and grunting as common
feeding readiness cues. He indicates that missing readiness cues can, in fact, increase preterm
infant stress, resulting in wasted energy from crying (a late readiness feeding cue).

Behaviors that are signs of distress in preterm infants are often identified as: splayed
fingers, arching, decreased tone, cyanosis, and furrowed or raised eyebrows. Caregivers often
misinterpret or miss the behaviors and cues all together. Thoyre (1997, as cited in Thoyre &
Carlson, 2003) found that mothers often misinterpret their preterm infant “pulling away from the
nipple” during oxygen desaturations as being difficult, not liking the taste or feeling satiated,
when the behavior was likely related to respiratory distress. Again, these descriptions of stress
cues are inconsistent, include clusters of behaviors, and may be difficult to differentiate. For
example, Newland, L’Huillier, and Petrey (2013) refer to a worried or frowning face as a stress
or disengagement cue. In contrast, raised eyebrows are designated as behavioral disorganization
and lack of engagement, which can be interpreted as a stress cue (Thoyre, Park, Pados, &
Hubbard, 2013; Thoyre et al., 2012). It is not clear what constitutes a “worried face” or if “raised
eyebrows” are the same construct.
Using Dynamic Systems Theory as a framework, Shaker (2013b), suggests that differentiating readiness from stress cues during feeding is important because “physiologic stability is the foundation for organizing movement, behavioral state, attention/interaction, and self-regulation.” (p.53). She states that typical feeding patterns are difficult to establish without infant physiological stability and that infant behaviors during feeding are windows into infants’ physiologic stability. Therefore, modification of feeding in response to these behaviors supports the maintenance of physiological stability throughout feeding (Shaker 2013b). Ross and Philbin (2011) also discuss the need for awareness of preterm infant’s physiologic stability in addition to their behavioral cues because this forms the basis for the reciprocal feeding experience recommended in cue-based feeding approaches. The proposed study builds on the framework that physiological stability supports feeding experiences and that caregivers need to understand what feeding behaviors signify physiological stress or readiness in order to create a positive feeding experience for their infants.
CHAPTER 3: METHODS

Participants

Participants in this study included 5 preterm infants born at <37 weeks gestation with no structural or craniofacial anomalies. Infants included in this study had initiated bottle-feeding per physician order. Infants born with cardiac complications were included if the condition had resolved prior to the enrollment period in the study. Preterm infants receiving supplemental oxygen through a nasal cannula (NC) at less than 2 liters were included (Groh-Wargo & Sapsford, 2009). No changes were made to the participant’s feeding plan, which followed the hospital’s nipple feeding protocol (see Appendix A). Participants included 3 female and 2 male preterm infants. More boys than girls were expected to participate given that fifty-five to sixty percent of preterm infants are boys (Martin, Hamilton, Osterman, Driscoll Drake, & Martin, 2018).

Recruitment

Five preterm infants were recruited from two local Level III Neonatal Intensive Care Units (NICU) that are part of the Ascension Healthcare system in Milwaukee, Wisconsin. Sample size was altered from the original proposal due to Covid-19 negatively impacting access to the NICU during the pandemic. The primary investigator has a collaborative relationship with the NICU staff at two Ascension Healthcare hospitals, Columbia-St. Mary’s and St. Joseph
Hospitals. The hospital system where participants were recruited from has a diverse patient population across race, gender, ethnicity, and socio-economic status. Of the 5 participants, 4 were African American and 1 was Hispanic/Latino. The investigator has approval from the Institutional Review Board (IRB) at Northern Illinois University (NIU), Ascension Healthcare, and Concordia University Wisconsin (CUW), where the majority of data analyses took place. Written permission was obtained to post recruitment fliers in staff nursing areas, public areas of the NICU and waiting rooms. The NICU patient care supervisor, Speech-Language Pathologist, and nursing staff at Columbia-St. Mary’s and St. Joseph’s hospitals disseminated IRB approved recruitment fliers to families who met the inclusion/exclusion criteria and will notify the primary investigator of interested participants. Parents were also able to contact the primary investigator directly via the contact information on the fliers. All recruitment and consent forms were in English. Families for whom English was not their native language were provided with a HIPPA trained interpreter at the data collection site to review the consent process and intake forms. Parents of participants were informed that enrollment in this study is voluntary and they may choose not to participate at any time. They were also be informed that if they decided not to participate, the decision would have no impact on their infant’s care.

Procedures

Overview

The primary investigator completed a background intake form (see Appendix B) after reviewing infants’ medical records, interviewing parents, and interviewing the infant’s speech-language pathologist and/or primary nurse. Infants and mothers were video-recorded during
feeding and specified preterm infant feeding behaviors were coded and classified as readiness or stress cues by undergraduate coders, who had not yet had any feeding/swallowing coursework nor experience feeding preterm infants (i.e., akin to novice feeders) and blinded to the hypotheses. The coders were undergraduate students in Communication Sciences and Disorders who have not had any feeding/swallowing coursework and no experience feeding preterm infants. The coders were trained to the coding manual and use of Noldus Observer software (Zimmerman, Bolhuis, Willemsen, Meyer, & Noldus, 2009). Physiological data that occurred within 3-5 seconds of the behavior timestamp were collected (by a different coder blind to how the initial coder rated each behavior) during the feeding session from infants’ NICU monitors, which were video recorded. The second coder identified and documented the heartrate (HR), respiratory rate (RR), and oxygen saturation level (SPO2), determining if each physiological measure was stable (i.e., within the predetermined parameters of preterm infant physiological stability) or unstable (i.e., outside the predetermined parameters of preterm infant physiological stability). Details are provided in the following sections (See Figure 1).

Data Acquisition

Video Recording

Infants were videotaped when they were taking in at least 90% of prescribed volume of breastmilk or formula by bottle. At that point, parents had received training regarding safe and supportive bottle-feeding and were independently feeding their infant. Mothers were instructed to feed the infant as they typically would.
Infants were videotaped during bottle feeding with one camera focused at eye level on the infant, one camera focused at eye level on the mother, and one camera focused on the bedside monitor (see Figure 2). Videotapes were collected using AXIS M1054 Stationary POE Cameras. Audio was captured using a lapel microphone attached to the infant’s clothing or blanket. The videos were uploaded to a password protected Dell laptop used exclusively for this project and were saved on a password protected, encrypted external hard drive, kept in the primary investigator’s locked office on the CUW campus. Coding of preterm infant feeding behaviors and physiological measures was completed offline using the Noldus ObserverXT13 (Zimmerman, Bolhuis, Willemsen, Meyer, & Noldus, 2009).
Behavioral Coding of Feeding

Video sessions of feedings were analyzed offline using Noldus Observer software (Zimmerman, et al., 2009) to identify preterm infant behaviors during bottle-feeding with their mothers. Infant behaviors that occurred simultaneously or in an unbroken sequence were coded using Noldus Observer (see Appendix C coding manual). Preterm infant feeding behaviors were coded because they are commonly discussed in the literature and are identifiable through video recording (Gennattasio et al., 2015; Hodges et al., 2016; Jones, 2012; Kish, 2013; McGrath & Braescu, 2004; Newland et al., 2013; Ross & Philbin, 2011; Shaker, 2013a; Thoyre et al., 2013; Thoyre & Brown, 2004; Thoyre et al., 2005; Whetten, 2016). Specific infant behaviors were identified, and their frequencies of occurrence were calculated for analyses (Appendix C).
Physiological measures

The camera focused on the bedside monitor synchronized with the Noldus Observer software (Zimmerman, et al., 2009) to collect heart rate, respiratory rate, and oxygen saturation levels that co-occurred with infants’ behaviors as they were feeding. Coders determined if each physiological measure was stable or unstable (i.e., within or outside the parameters of physiological stability for preterm infants) within 3-5 seconds of the onset of each infant feeding behavior (Groh-Wargo & Sapsford, 2009; Lau, 2006; Manja et al., 2017; Poets et al., 1991; Shiao et al., 1996; Yamamoto et al., 2016; Yamamotor et al., 2017). See Table 1 for physiologic parameters indicating physiological stability. Monitoring of physiological measures for each participant was not altered from physician prescribed care. Typical daily care and all physician orders were followed during data collection.

Table 1

Physiologic Parameters Indicating Stability

<table>
<thead>
<tr>
<th>Physiological Measure</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heart Rate</strong></td>
<td>120 bpm</td>
<td>160 bpm</td>
<td>Yamamoto, Prade, Berwig, Weinmann, &amp; Keske-Soares, 2016</td>
</tr>
<tr>
<td><strong>Respiratory Rate</strong></td>
<td>40 breaths per minute</td>
<td>70 breaths per minute</td>
<td>Groh-Wargo &amp; Sapsford, 2009; Lau, 2006;</td>
</tr>
<tr>
<td><strong>Oxygen Saturation Levels</strong></td>
<td>90%</td>
<td>100%</td>
<td>Manja, Saugstad, Lakshminrusimha, 2017; Poets, Stebbens, Alexander, Arrowsmith, Salfield, &amp; Southhall, 1991; Shiao, Booker, &amp; DiFiore, 1996; Yamamotor, Prade, Bolzan, Weinmann, &amp; Keske-Soares, 2017</td>
</tr>
</tbody>
</table>
Inter-rater reliability

Video recordings were reviewed by two trained, blinded coders who completed Collaborative Institutional Training Initiative (CITI) and Health Insurance Portability and Accountability Act (HIPAA) training. Once the coders completed CITI and HIPAA training, they were trained by the primary investigator to code videos for this study. A behavioral coding and procedures manual was developed and fine-tuned as part of a pilot study (Lund, 2019). The coding manual (Appendix C) was used to support training of the blinded coders.

Two blind coders established reliability with one another (Cohen’s Kappa = 0.81) on 20% of the videos. Finally, a coder, blinded to the perceived cues coded by the first coder, identified and recorded physiological measures (HR, RR, and SPO2) within 3-5 seconds of each coded behavior and indicated if measures were physiologically stable. Any coding discrepancies were resolved through group discussion with the primary investigator.

Hypothesis and Planned Data Analysis

The purpose of this study was to examine the association between the coded behaviors and three measures (heart rate, respiratory rate, and oxygen saturation levels) of infants’ physiological stability. The study also aimed to identify behaviors used by preterm infants during bottle-feeding and determine which behaviors were classified as readiness or stress by novice observers. The study addressed the following specific research questions and hypotheses were addressed.
Research Questions

1. Are infant readiness and stress cues during feeding associated with physiological stability/instability as measured by heart rate, respiratory rate, and oxygen saturation levels?
2. Which preterm infant behaviors are consistently identified as readiness or stress cues by novice observers?

Hypotheses

Hypothesis One (H1): Physiological instability, as measured by heart rate, respiratory rate, and oxygen saturation levels, is associated with stress cues during feeding in preterm infants.

The following sub-hypotheses will be tested:

H1-1: Decreased respiratory rate is associated with breath holding.

H1-2: Decreased oxygen saturation levels are associated with breath holding.

H1-3: Decreased respiratory rate is associated with audible swallow.

H1-4: Decreased oxygen saturation levels are associated with decreased coordination of suck-swallow-breathe.

H1-5: Decreased heart rated is associated with decreased coordination of suck-swallow-breathe.

H1-6: Increased respiratory rate is associated with head bobbing.

H1-7: Increased respiratory rate is associated with stridor.
H₁-₈: Decreased oxygen saturation levels are associated with stridor.

Hypothesis Two (H₂): Specific preterm infant feeding behaviors are more often classified as “stress” cues.

It is predicted that the following behaviors will be more likely to be classified as stress cues:

H₂-₁: Altered tone is more likely to be perceived as a stress cue.
H₂-₂: Audible swallow is more likely to be perceived as a stress cue.
H₂-₃: Breath holding is more likely to be perceived as a stress cue.
H₂-₄: Color change is more likely to be perceived as a stress cue.
H₂-₅: Excessive drooling/liquid loss is more likely to be perceived as a stress cue.
H₂-₆: Furrowed brow is more likely to be perceived as a stress cue.
H₂-₇: Head bobbing is more likely to be perceived as a stress cue.
H₂-₈: Uncoordinated suck-swallow-breathe is more likely to be perceived as a stress cue.
H₂-₉: Lips pursed is more likely to be perceived as a stress cue.
H₂-₁₀: Splayed fingers or “stop” hands in front of mouth is more likely to be perceived as a stress cue.
H₂-₁₁: Stridor is more likely to be perceived as a stress cue.
H₂-₁₂: Turning head away is more likely to be perceived as a stress cue.
Hypothesis Three (H₃): Specific preterm infant feeding behaviors are more often classified as “readiness” cues.

It is expected that the following behaviors will be more likely to be perceived as readiness cues:

H₃-1: Moving forward toward the nipple is more likely to be perceived as a readiness cue.

H₃-2: Rooting is more likely to be perceived as a readiness cue.

H₃-3: Smacking lips is more likely to be perceived as a readiness cue.

H₃-4: Vocalization is more likely to be perceived as a readiness cue.

H₃-5: Hands-to-mouth/mouthing is more likely to be perceived as a readiness cue.
CHAPTER 4

RESULTS

The current study examined the following research questions:

1. Are infant readiness and stress cues during feeding associated with physiological stability/instability as measured by heart rate, respiratory rate, and oxygen saturation levels?

2. Which preterm infant behaviors are consistently identified as readiness or stress cues by novice observers?

Analyses

To answer these questions, three overarching hypotheses were tested using the total frequency of occurrence of each feeding behavior as the unit of measurement in all analyses. Frequency of occurrence was used because we were interested in understanding the association between specific preterm infant feeding behaviors, stress/readiness cues, and physiological stability, rather than the behaviors of each individual infant in the sample. Descriptive statistics for each behavior can be found in Table 2. Physiological data was not available for one infant due to a corrupted video file and for one infant because the oxygen saturation monitor was not used during the feeding. Therefore, data from those infants was only included in hypothesis testing related to stress/readiness cues.
### Table 2

**Means (and Standard Deviations) of Physiological Measures**

<table>
<thead>
<tr>
<th></th>
<th>Audible swallow</th>
<th>Cough/TC</th>
<th>Excessive drool</th>
<th>Furrowed brow</th>
<th>Hands to mouth</th>
<th>Head bobbing</th>
<th>Lips pursed</th>
<th>Smacking lips</th>
<th>Splayed fingers</th>
<th>Stridor</th>
<th>Turn head</th>
<th>Vocal</th>
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<tbody>
<tr>
<td><strong>Heart rate</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Frequency of Occurrence</td>
<td>33</td>
<td>23</td>
<td>6</td>
<td>11</td>
<td>3</td>
<td>2</td>
<td>17</td>
<td>5</td>
<td>3</td>
<td>22</td>
<td>22</td>
<td>22</td>
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<tr>
<td>Frequency outside of parameters</td>
<td>22</td>
<td>21</td>
<td>6</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>21</td>
<td>21</td>
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<tr>
<td>Mean HR</td>
<td>163</td>
<td>170</td>
<td>170</td>
<td>167</td>
<td>173</td>
<td>162</td>
<td>157</td>
<td>171</td>
<td>168</td>
<td>153</td>
<td>169</td>
<td>169</td>
</tr>
<tr>
<td>SD</td>
<td>12.6</td>
<td>5.9</td>
<td>5.3</td>
<td>8.2</td>
<td>1.0</td>
<td>2.8</td>
<td>10.6</td>
<td>3.0</td>
<td>4.9</td>
<td>12.3</td>
<td>5.9</td>
<td>6.3</td>
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<tr>
<td><strong>Respiratory Rate</strong></td>
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<td>Frequency of Occurrence</td>
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<tr>
<td>Frequency outside of parameters</td>
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<td>1</td>
<td>1</td>
<td>15</td>
<td>8</td>
<td>7</td>
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<tr>
<td>Mean RR</td>
<td>47</td>
<td>41</td>
<td>50</td>
<td>44</td>
<td>48</td>
<td>38</td>
<td>45</td>
<td>53</td>
<td>39</td>
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<tr>
<td>SD</td>
<td>20.8</td>
<td>14.1</td>
<td>16.6</td>
<td>13.6</td>
<td>17.8</td>
<td>1.4</td>
<td>10.3</td>
<td>9.1</td>
<td>9.5</td>
<td>14.2</td>
<td>13.3</td>
<td>13.8</td>
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<tr>
<td><strong>Oxygen Saturation</strong></td>
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</tr>
<tr>
<td>Frequency of Occurrence</td>
<td>13</td>
<td>14</td>
<td>6</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>21</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Frequency outside of parameters</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean SPO2</td>
<td>99</td>
<td>99</td>
<td>98</td>
<td>97</td>
<td>98</td>
<td>99</td>
<td>99.5</td>
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<td>99</td>
<td>99.5</td>
<td>98.8</td>
<td>99.1</td>
</tr>
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<td>SD</td>
<td>2.5</td>
<td>1.0</td>
<td>3.3</td>
<td>4.0</td>
<td>1.0</td>
<td>1.4</td>
<td>0.5</td>
<td>2.7</td>
<td>0.6</td>
<td>2.4</td>
<td>0.7</td>
<td>0.9</td>
</tr>
</tbody>
</table>
Finally, nonparametric statistics were utilized for hypothesis testing due to the small sample size (N=5). Associations between stress cues and specific behaviors were tested using Chi Square when frequencies of occurrence were large enough to rely on approximation (Kim, 2017). Fisher’s Exact Test was used to test associations between physiological instability and behaviors that were identified as stress cues. Fisher’s Exact Test is specifically designed for use when cells have frequencies less than 5 and was therefore used for analyses of behaviors and their association to physiological stability/instability (Kim, 2017). Fisher’s Exact Test could not be used when behaviors were noted to be a constant (coded in one category 100% of the time). The exact Binomial Test was used to test the likelihood that behaviors were classified as stress or readiness. The exact Binomial Test is a non-parametric measure used when data are dichotomous, nominal data with the same probability of an outcome for each of the categories (Li & Fu, 2018). The results of hypothesis testing follow:

**Infants’ Physiological Stability**

**Hypothesis 1: Physiological instability, as measured by heart rate, respiratory rate, and oxygen saturation levels, is associated with stress cues during feeding in preterm infants**

Five behaviors consistently noted in the literature as stress cues were initially analyzed as a group to determine if they were associated with physiological instability (Kish, 2013; Newland et al., 2013; Shaker, 2013a; Thoyre et al., 2005; Thoyre et al., 2016). Increased heart rate was associated with those stress cues during feeding in preterm infants ($\chi^2 (1, N = 170) = 4.35, p = .037$). There was not a statistically significant association between those stress cues and
respiratory rate ($\chi^2 (1, N = 170) = 0.27, p = .606$) or oxygen saturation levels ($\chi^2 (1, N = 170) = 0.59, p = .444$) during feeding in preterm infants.

The following sub-hypotheses were posed to test potential relationships between specific feeding behaviors and physiological stability.

**H$_{1.1}$:** Decreased respiratory rate is associated with breath holding

This hypothesis could not be tested because there was no accompanying physiological data for the occurrences.

**H$_{1.2}$:** Decreased oxygen saturation levels are associated with breath holding

This hypothesis could not be tested because there was no accompanying physiological data for the occurrences.

**H$_{1.3}$:** Decreased respiratory rate is associated with audible swallow

Decreased respiratory rate was not associated with audible swallow ($p = .296$) using Fisher’s Exact Test. Audible swallow was within parameters for respiratory rate in 13 of 33 (39.3%) occurrences.

Although there was no significant association between audible swallow and decreased respiratory rate, there was physiological instability associated with audible swallow. Unexpectedly, heart rate was elevated on 22 of 33 (66.7%) occurrences of audible swallow.
Results from the Fisher’s Exact Test indicated a significant ($p = .040$) association between elevated heart rate and audible swallow (Figure 3). Because audible swallow was not always rated as a stress cue by novice observers in Hypothesis 2-2, the relationship between audible swallow and heart rate was analyzed separately for the 7 occurrences that were rated as readiness cues and the 26 that were rated as stress cues. Heart rate was elevated for all occurrences rated as readiness. In the 15 of 26 (57.5%) occurrences of audible swallows that were coded as stress cues, there was a significant association ($p = .040$) with heart rate elevation.

Figure 3. Audible swallow: heart rate.
\( H_{1.4} \): Decreased oxygen saturation levels are associated with decreased coordination of suck-swallow-breathe

This hypothesis could not be tested as there were no occurrences of decreased coordination (uncoupling) of suck-swallow-breathe with accompanying physiological data.

\( H_{1.5} \): Decreased heart rate is associated with decreased coordination of suck-swallow-breathe

This hypothesis could not be tested as there were no occurrences of decreased coordination (uncoupling) of suck-swallow-breathe with accompanying physiological data.

\( H_{1.6} \): Increased respiratory rate is associated with head bobbing

Head bobbing was associated with respiratory rates that were outside parameters 100% of the time (2 of 2 occurrences). Therefore, the Fisher’s Exact Test could not be completed.

\( H_{1.7} \): Increased respiratory rate is associated with stridor

Respiratory rate was outside of parameters 15 of 22 (68%) occurrences. An exact Binomial Test indicated that stridor was not associated with respiratory instability \((p = .134)\). Unexpectedly, an exact Binomial Test revealed a significant association between stridor and heart rate instability \((p = .004)\).
**H1-8: Decreased oxygen saturation levels are associated with stridor**

An exact Binomial Test indicated that stridor was not associated with unstable oxygen saturation levels. Rather, there was a significant association in 19 of 21 (90%) occurrences with stable oxygen saturation levels ($p < .001$).

**Post hoc Analysis of Physiological Stability**

Due to trends in the data, furrowed brow was tested for associations with physiological instability. Surprisingly, furrowed brow was associated with elevated heart rate during feeding in preterm infants ($\chi^2 (1, N = 170) = 4.56, p = .035$). Since furrowed brow was not always rated as a stress cue by novice observers in Hypothesis 2-6, the relationship between heart rate and furrowed brow was analyzed separately for the 6 occurrences that were rated as readiness cues and the 5 that were rated as stress cues. There was not a significant relationship ($p = .727$) between heart rate instability and furrowed brow in the 5 of 6 (83.3%) occurrences of furrowed brow that were coded as readiness cues, nor in the 4 of 5 (80%) occurrences that were coded as stress cues.

**Classification of Stress and Readiness Cues**

**Analyses**

A priori T-tests planned to test the following hypotheses were not completed because they were not appropriate for the small sample size. Rather, binomial tests were used to test
relations between infant behaviors and stress or readiness cues (Figure 4). The assumptions of this nonparametric test were met. The data were: dichotomous, nominal and were collected from a small sample.

Figure 4. Frequency of behaviors identified as stress vs. readiness cues.

Hypothesis Two (H₂): Specific preterm infant feeding behaviors are more often classified as “stress” cues
Binomial testing revealed that specific preterm infant feeding behaviors are more often classified as “stress” cues by novice observers (see Table 3). It was predicted that the following behaviors were more likely to be classified as stress cues:

Table 3

Summary of Infant Stress Cues

<table>
<thead>
<tr>
<th>Stress Cues</th>
<th>Proportion</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audible Swallow *</td>
<td>79% (29/33)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Breath Holding</td>
<td>100% (2/2)</td>
<td>**</td>
</tr>
<tr>
<td>Excessive Drooling</td>
<td>67% (4/6)</td>
<td>0.234</td>
</tr>
<tr>
<td>Furrowed Brow</td>
<td>42% (5/12)</td>
<td>0.193</td>
</tr>
<tr>
<td>Head Bobbing</td>
<td>100% (21/21)</td>
<td>**</td>
</tr>
<tr>
<td>Uncoordinated SSB</td>
<td>100% (4/4)</td>
<td>**</td>
</tr>
<tr>
<td>Lips pursed</td>
<td>100% (17/17)</td>
<td>**</td>
</tr>
<tr>
<td>Splayed Fingers</td>
<td>100% (3/3)</td>
<td>**</td>
</tr>
<tr>
<td>Stridor</td>
<td>100% (38/38)</td>
<td>**</td>
</tr>
<tr>
<td>Turning head away</td>
<td>100% (24/24)</td>
<td>**</td>
</tr>
<tr>
<td>Cough/Throat clear</td>
<td>100% (23/23)</td>
<td>**</td>
</tr>
<tr>
<td>Vocalization *</td>
<td>81% (26/32)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* Statistically significant
** Behavior was a constant for stress cue

**H**2-1: Altered tone is more likely to be perceived as a stress cue. This sub hypothesis could not be tested because there were no occurrences of altered tone.

**H**2-2: Audible swallow is more likely to be perceived as a stress cue. Audible swallow was more likely to be perceived as a stress cue (p < .001) (see Figure 3). It was coded as a stress cue in 26 of 33 (79%) occurrences.
$H_2.3$: Breath holding is more likely to be perceived as a stress cue. This hypothesis was not tested statistically because breath holding as a stress cue was a constant. Each of the two occurrences (100%) of breath holding were perceived as stress cues.

$H_2.4$: Color change is more likely to be perceived as a stress cue. This sub hypothesis could not be tested because there were no occurrences of color change.

$H_2.5$: Excessive drooling/liquid loss is more likely to be perceived as a stress cue. Excessive drooling/liquid loss was coded as stress in four of six (67%) of occurrences. This hypothesis was rejected. An exact Binomial Test indicated that excessive drooling/liquid loss was not perceived more often as a stress cue ($p = .234$).

$H_2.6$: Furrowed brow is more likely to be perceived as a stress cue. Furrowed brow was coded as stress in five of 12 (42%) of occurrences. This hypothesis was rejected. An exact Binomial Test indicated that furrowed brow was not perceived more often as a stress cue ($p = .193$).

$H_2.7$: Head bobbing is more likely to be perceived as a stress cue. This hypothesis was not tested statistically because head bobbing as a stress cue was a constant. Twenty-one of 21 occurrences (100%) of head bobbing were perceived as stress cues.

$H_2.8$: Uncoordinated suck-swallow-breathe is more likely to be perceived as a stress cue. This hypothesis could not be tested statistically because uncoordinated suck-swallow-breathe as a stress cue was a constant. Each of the four occurrences (100%) of uncoordinated suck-swallow-breathe were perceived as stress cues.

$H_2.9$: Lips pursed is more likely to be perceived as a stress cue. This hypothesis was not tested statistically because lips pursed as a stress cue was a constant. Each of the 17 occurrences (100%) of lips pursed were perceived as stress cues.
H2-10: Splayed fingers or “stop” hands in front of mouth is more likely to be perceived as a stress cue. This hypothesis was not tested statistically because splayed fingers as a stress cue was a constant. Each of the 3 occurrences (100%) of splayed fingers were perceived as stress cues.

H2-11: Stridor is more likely to be perceived as a stress cue. This hypothesis was not tested statistically because stridor as a stress cue was a constant. Each of the 17 occurrences (100%) of stridor were perceived as stress cues.

H2-12: Turning head away is more likely to be perceived as a stress cue. This hypothesis was not tested statistically because turning head away as a stress cue was a constant. Each of the 17 occurrences (100%) of turning head away were perceived as stress cues.

Post hoc Analyses

Due to trends observed in the data, additional feeding behaviors were tested to determine if they were more often classified as “stress” cues. Vocalization, which was hypothesized a priori to be classified as a readiness cue, was perceived more often as a stress cue ($p = .001$) 26 of 32 (81%) occurrences. Notably, coughing/throat clearing was an additional behavior that was coded as a stress cue 100% (23/23) of the time.
Readiness Cues

Hypothesis Three (H₃): Specific preterm infant feeding behaviors are more often classified as “readiness” cues

Exact binomial testing revealed that the specific preterm infant feeding behaviors predicted to be classified as readiness cues were not more often classified as “readiness” cues by novice observers (see Table 4).

Table 4
Summary of Infant Readiness Cues

<table>
<thead>
<tr>
<th>Readiness Cues</th>
<th>Proportion</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooting</td>
<td>100% (2/2)</td>
<td>**</td>
</tr>
<tr>
<td>Smacking lips</td>
<td>80% (4/5)</td>
<td>p = .156</td>
</tr>
<tr>
<td>Hands-to-mouth/Mouthing</td>
<td>67% (4/6)</td>
<td>p = .234</td>
</tr>
</tbody>
</table>

H₃-1: Moving forward toward the nipple is more likely to be perceived as a readiness cue. This sub hypothesis could not be tested as there were no occurrences of moving forward toward the nipple.

H₃-2: Rooting is more likely to be perceived as a readiness cue. This hypothesis was not tested because rooting was classified as a readiness cue in 2/2 (100%) occurrences, signifying it as a constant.
H3.3: Smacking lips is more likely to be perceived as a readiness cue. This hypothesis was rejected. An exact Binomial Test indicated that smacking lips was not perceived significantly more often as a readiness cue. It was classified as a readiness cue on four of five (80%) occurrences ($p = .156$).

H3.4: Vocalization is more likely to be perceived as a readiness cue. This hypothesis was rejected. Vocalization was not more likely to be perceived as a readiness cue. In contrast, vocalization was more likely to be perceived as a stress cue in 26 of 32 (81%) occurrences ($p = .001$) occurrences (Figure 5).

H3.5: Hands-to-mouth/mouthing is more likely to be perceived as a readiness cue. This hypothesis was rejected. It was classified as a readiness cue in 4 of 6 (66%) occurrences. Exact Binomial Test indicated that hands to mouth was not perceived more often as a readiness cue. ($p = .234$).
Figure 5. Vocalization: stress cue.
CHAPTER 5
DISCUSSION

The current study had two main aims. The first was to examine the relationship between preterm infant feeding behaviors and physiological stability, as measured by heart rate (HR), respiratory rate (RR), and oxygen saturation (SPO2). The second aim of this study was to determine if preterm infant feeding behaviors associated with physiological stability or physiological instability were also identified by novice observers as readiness or stress cues.

These questions were important to answer because preterm infants are at risk for chronic feeding difficulties, which may be related to their susceptibility to physiological instability during the neonatal period (Demauro et al., 2011; Dodrill et al., 2008; Start et al., 2008; Thoyre, 2016). Specifically, preterm infants require specialized care to maintain stable HR, RR, and SPO2. Although there is consensus that physiological stability may have a positive impact on oral feeding success in preterm infants, the understanding of what specific feeding behaviors have a direct impact on physiological stability is lacking in the literature. Current cue-based feeding protocols include maintaining physiological stability, along with developing oral feeding skills and engaged feeding (Ludwig & Waitzman, 2007; Ross & Philbin, 2011; Shaker, 2013; Thoyre et al., 2016). They do not, however, utilize an understanding of the association between specific preterm infant feeding behaviors and measures of physiological stability, because the link has not yet been established. By understanding the relationship between specific feeding behaviors and measures of physiological stability, caregivers may be better equipped to
minimize instability, thereby improving feeding outcomes. Preterm infant feeding behaviors, often described as readiness and stress cues have been described in the literature as having a relationship with physiological stability and instability, though the association has not been directly studied (Gennattasio et al., 2015; Hodges et al., 2016; Jones, 2012; Kish, 2013; McGrath & Braescu, 2004; Newland et al., 2013; Ross & Philbin, 2011; Shaker, 2013a; Thoyre et al., 2013; Thoyre & Brown, 2004; Thoyre et al., 2005; Whetten, 2016). Therefore, the current study examined the relation between parameters indicating physiological stability taken from the literature (Table 1) and specific preterm infant feeding behaviors. It was hypothesized that physiological instability, as measured by HR, RR, and SPO2, would be associated with stress cues during feeding in preterm infants.

In addition, little is known about whether feeding behaviors reported in the literature are perceived consistently as stress or readiness cues by novice observers, including parents who, though they are often novice feeders, need to identify behaviors and determine if they indicate readiness to feed or indicate stress. Understanding how novice observers perceive behaviors (stress or readiness) was the second aim of this study.

In order to address the two aims of this study, five preterm infants were videotaped during a feeding with their mother when they were taking at least 90% of prescribed volume. The recordings were then coded by novice observers who identified occurrences of 17 feeding behaviors and categorized them as stress or readiness cues. Heart rate, RR, and SPO2 were also recorded when each feeding behavior occurred.
Infants’ Physiological Stability

It was predicted that measures of physiological instability would be associated with stress cues. Therefore, behaviors that were often classified in the literature as stress cues were tested for relationships with three physiological measures of stability: HR, RR, and SPO2.

Heart Rate

There was a significant association of heart rate with infant feeding behaviors. The mean for heart rate was noted to be elevated (i.e., outside the upper limit of parameters; Table 1) for audible swallow, cough/throat clear, excessive drooling, furrowed brow, hands-to-mouth, head bobbing, smacking lips, splayed fingers, turning head away, and vocalization. Heart rate remained within physiological parameters for lips pursed and stridor. An association between heart rate instability was noted in this study, specifically related to audible swallow, regardless of if the behavior was classified as a stress or readiness cue. Results also revealed an association between heart rate instability and furrowed brow regardless of whether it was classified as stress or readiness.

Knowing that audible swallow and furrowed brow have a relationship with heart rate stability/instability implies that feeders should pay close attention to these behaviors and if they respond appropriately during the feeding, we may be able to improve physiological stability in that moment. This may also have a residual effect on respiratory stability, as these findings may indicate that heart rate instability is a precursor to respiratory instability which had minimal associations with specific feeding behaviors.
Interestingly, elevated heart rate was also associated with behaviors coders classified as readiness cues. In fact, heart rate has previously been found to be an easily observable and non-invasive measurement of infant stress and physiological demand (Pados et al., 2017; Park et al., 2015). While heart rate has been shown to be a reliable measure of stress, it has not been previously identified as having a relationship with specific feeding behaviors, either those classified as stress or readiness.

This finding, paired with an understanding of the physiological response to stress (positive or negative) may indicate an excitatory response of the autonomic nervous system (ANS) when the infant is stressed or demonstrating readiness. An excitatory response of the autonomic nervous system may result in elevated and/or variable heart rate. This excitatory response may occur, not only with feeding behaviors associated with stress, but also when the infant is overexcited in anticipation of the feeding (Brown, 2007). This may impact caregivers’ ability to distinguish between readiness and stress cues of the infant. In fact, heart rate may be used to predict when specific behaviors might be causing the infant to become physiologically unstable so we can respond to those specific behaviors in ways that could help stabilize the heart rate. For example, giving the infant a break during the feeding. For these reasons it is essential to understand which preterm infant feeding behaviors have the greatest effect on heart rate stability/instability.

In addition, physiological stability is an essential focus and concern of many of the commonly accepted approaches to cue-based feeding, including co-regulated (CoReg) and Infant-Driven Feeding TM (IDF) (Ludwig & Waitzman, 2007; Thoyre et al., 2013). These approaches, however, focus on avoiding physiological instability by attending to the infant behaviors, classified as stress or readiness, during oral feeding. The clinical implications of a
significant association between heart rate and behaviors classified as stress cues point toward a potential use of heart rate as a diagnostic tool during oral feeding. Heart rate instability may, in fact, be a precursor to respiratory instability. Heart rate could have the potential to be used as a diagnostic tool to guide cue-based feeding, thereby minimizing episodes of apnea, tachypnea, and oxygen desaturations.

**Respiratory Rate**

There were no significant relationships between feeding behaviors (stress or readiness) and respiratory stability/instability. Audible swallow and stridor were hypothesized to have an association with increased respiratory rate based upon the literature (Thoyre et al., 2012), but that did not occur in this sample of infants. It is possible that caregivers in the current study responded to audible swallow and stridor when it was combined with heart rate instability by feeding differently and prevented subsequent instability of the respiratory system.

A main goal of many cue-based feeding approaches is physiological stability throughout the feeding (Thoyre et al., 2016). Maintaining stability is often addressed by following the lead of the infant. Preterm infants typically have difficulty maintaining respiratory stability at rest and during feeding, which made the lack of significant findings surprising. Such a finding may be explained by our small sample size. In addition, the specific mothers in the current study may have been well trained with regard to cue-based feeding and minimized any risk of respiratory instability. Nevertheless, a potential clinical implication is that heart rate instability is a precursor to respiratory instability and should be further investigated.
Oxygen Saturation

There were no significant findings related to oxygen saturation levels and specific preterm infant feeding behaviors or significant relations to stress cues analyzed as a whole. A relationship was expected because Thoyre et al. (2012) identified SPO2 as a factor in a study examining the pre-feeding and feeding period of a group of preterm infants with lung disease. Thoyre & Carlson (2003) noted that respiratory instability was often a precursor to SPO2 instability, although they did not investigate associations between SPO2 instability and specific feeding behaviors. Decreased oxygenation is also noted in the literature to be associated with disengagement, stress, and extension behaviors during feeding (Newland et al., 2013; Thoyre et al., 2012). In contrast, Peters (2001) noted flexion behaviors occurred more often in association with increased oxygenation.

The lack of significant findings of oxygen saturation stability related to stress cues may be explained because only five infants participated in the study, feeding behaviors had a small frequency of occurrence and respiratory rates were mostly stable for all five infants. If respiratory rate is stable, then there would be less chance of oxygen saturation instability. Unstable respiratory rates did not occur with enough frequency in the current study to investigate these relations.

Classification of Stress and Readiness Cues

Cue-based approaches to feeding preterm infants are associated with improved feeding outcomes, however there are barriers to their implementation. One obstacle to consistent use of
feeding cues is lack of consensus related to labeling and defining specific preterm infant feeding behaviors (Kish, 2013; Lund-Hrdi & Fannin, 2017; McGrath & Braescu, 2004). Feeding behaviors are the implicit and explicit actions that preterm infants demonstrate during feeding. The literature on cue-based approaches to feeding preterm infants typically classifies behaviors infants produce as readiness (engagement) and stress (disengagement) cues (Gennattasio et al., 2015; Hodges et al., 2016; Jones, 2012; Kish, 2013; McGrath & Braescu, 2004; Newland et al., 2011; Shaker, 2013a; Thoyre et al., 2013; Thoyre & Brown, 2004; Thoyre et al. 2005; Whetten, 2016). Such inconsistencies have a negative impact on implementation and make it difficult to train caregivers.

Common behaviors reported in the literature as stress (disengagement) include: audible swallow, stridor, head bobbing, excessive drooling, uncoordinated suck-swallow-breathe, crying, furrowed brow/worried face, change in tone, splayed fingers, hands in “stop” position, color change, and turning away from the nipple (Newland et al., 2013; Thoyre et al., 2012). As expected, several specific preterm infant feeding behaviors are more often classified as “stress” cues by novice observers (see Table 3).

This was not the case for “readiness” cues, which were not predictably classified by novice observers (See Table 4). Readiness cues couldn’t be clearly classified, likely due to small sample size and lack of occurrences. Behaviors typically reported in the literature as readiness (engagement) cues included: hands-to-mouth, mouthing, rooting, moving toward the nipple, vocalizations, smacking lips, and good tone (Ludwig & Waitzman, 2007; Newland, et al., 2013; Ross & Philbin, 2011; Thoyre, et al., 2010). Rooting was the only behavior consistently
classified as a readiness cue in 100% (2/2) occurrences. Moving toward the nipple could not be tested, as there were no occurrences of the behavior in the small sample.

Vocalization was hypothesized a priori to be classified as a readiness cue, when in fact it is more often perceived as a stress cue. This finding reveals the need for additional study to identify different functions of vocalization and operationalize the types of vocalization in order to help caregivers identify vocalizations as stress or readiness. This may be related the difficulty caregivers and novice observers have interpreting behaviors as stress or readiness. Vocalization may be a behavior that is more likely to be misinterpreted. Thoyre et al. (2012) described a stress cue related to dysregulation that resulted in audible grunt during prolonged exhalation. The vocalization in this behavior may be difficult to differentiate from vocalizing to indicate feeding readiness. In addition, Watson & McGuire (2016) note that missing readiness cues can in fact increase preterm infant stress. Missing or misinterpreting an infant’s readiness cues likely increased their stress response. This may account for the surprising finding that vocalization was more often perceived as a stress cue by novice observers. It is clear that there are many types and functions to vocalization. Types of vocalization may need to be assessed to determine if there are in fact different meanings or constructs behind each type of vocalization that result in difficulty identifying stress or readiness for oral feeding. Behaviors, when identified accurately as stress or readiness may serve as warning signs for pending physiological instability.

Limitations

There are clear limitations to this study. Shortly after beginning data collection, COVID-19 was identified as a global pandemic by the World Health Organization. The result was
lockdown across much of the United States, including the state of Wisconsin where data collection was happening. Data collection was halted as a result, which negatively impacted sample size, the diversity of participants, collection of all physiological data, and the number of feeding behaviors that occurred. In addition to these limitations, the design of the study included behaviors that are visual or audible so they could be coded from video recordings of preterm infants being fed by their mother. It did not include feeding behaviors that one can only feel such as the infant pushing the nipple out with their tongue. Although this can be conceived as a limitation, it can also be considered a strength because it focused on salient and observable behaviors caregivers can easily identify. It is difficult to describe and train caregivers and/or novice feeders on behaviors that are not observable or audible.

The small sample size, which also lacked diversity, made it difficult to generalize findings from the current study to larger groups. Small sample size also resulted in a lack of power in the statistical analysis. There were findings that appeared to be an overwhelming percentage of occurrences, but there was no statistical significance. For example, smacking lips was hypothesized to be perceived as a readiness cue. Although it was classified as a readiness cue in four of five (80%) occurrences, there was not statistical significance ($p = .156$). This is likely related to the limited number of occurrences, which negatively impacted statistical power.

With a decreased sample size, hypothesis testing was modified to use appropriate non-parametric statistics rather than the t-tests that were originally proposed. Frequency of occurrence of preterm infant feeding behaviors was utilized as the unit of measurement in all analyses. However, given the small sample size ($N = 5$), there were some behaviors that did not occur during the feedings we recorded. This resulted in the inability to test any hypotheses that included the following feeding behaviors: decreased coordination of suck-swallow-breathe,
altered tone, color change, and moving forward toward the nipple. There were also several behaviors that occurred with limited frequency, including: hands-to-mouth, head bobbing, and splayed fingers. The use of non-parametric statistics, such as Fisher’s Exact Test and exact Binomial Test, allowed for hypothesis testing when there were frequencies of occurrence of behaviors that were less than 5. Therefore, as restrictions related to COVID-19 ease and access to the NICU resumes, it is recommended that additional participants be added to the study and analyses be redone.

Future Directions

Further investigation into the association of elevated heart rate and/or heart rate variability and their association with specific feeding behaviors is an important future direction. Perhaps heart rate can be used as an early indicator of stress during feeding, ultimately minimizing the impact on the respiratory system and the likelihood of oxygen desaturation and/or apnea. Because preterm infant feeding difficulties often result in chronic Pediatric Feeding Disorder (PFD) (Goday et al., 2018), a greater understanding of the relationship between heart rate instability and oral feeding stress is important to improving outcomes. Heart rate instability could be a viable diagnostic tool in the NICU (McCain, Fuller, & Gartside, 2005; Pados et al., 2009; Pados et al., 2017; Park et al., 2015). In addition, if specific feeding behaviors are identified to have a direct impact on heart rate instability, caregivers can be trained to identify and respond before heart rate is affected. Ultimately, this may have a positive impact on overall stability and decrease the stress for both the preterm infant and their caregiver.
Lastly, an interesting direction to pursue is to further investigate heart rate elevation in those behaviors typically identified as readiness cues. Increased heart rate was not expected to co-occur with readiness cues. Increased heart rate may be an excitatory response of the autonomic nervous system as an infant moves from early to late stages of feeding readiness. This investigation may support improved timing of initiation of feedings with preterm infants.

Additional work is needed to fully understand the complex relationships between preterm infant feeding behaviors, physiological stability/instability during feeding, and classification of behaviors as stress or readiness cues. A truer understanding may support feeding skill development in these fragile infants. Based on the current study, clinicians should explicitly include heart rate stability/instability as part of their intervention strategy, in addition to attending to respiratory rate and oxygen saturations.
REFERENCES


APPENDIX A

NIPPLE FEEDING PROTOCOL
TITLE: Nipple Feeding Guideline

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DEFINITIONS
• **Nipple feeding**: Feedings administered by breast and/or bottle.
• **Contingent caregiving**: Providing care when the infant indicates readiness to receive care.
• **PCA**: Post Conceptual Age
• **Self regulatory feeding**: The infant is fed based on awake and readiness behavior cues, with oral feedings progressing and concluding according to the infant’s ability to tolerate them without fatigue or distress.
• **Major stress cues**: Compelling, adverse overt events; suggesting a high level of concern for swallowing safety and airway protection.
• **SLP**: Speech Language Pathologist
• **NNS**: Non-Nutritive Sucking

GUIDELINES
Nipple feeding is an activity that seems especially amenable to contingent caregiving. Research supports the use of “demand” or “self regulatory” behaviors as indicators for nipple feeding. Therefore, once Behavioral/Developmental Indicators are met, infants may be offered a nipple feeding anytime Oral Feeding Readiness Cues are observed. Any remainder of a bottle feeding is to be delivered via feeding tube (gravity or pump). (see Naso-Oral Gastric Tube Feeding TIP SHEET)

BEHAVIORAL/DEVELOPMENTAL INDICATORS FOR NIPPLE FEEDING
Nipple feeding readiness for any specific bottle feeding is based on:
- neurologic maturation
- severity of illness
- pre-feeding autonomic, motor and behavioral state organization

When determining the infants’ readiness to nipple feed, the infant must meet the following criteria:

1. **PCA**
   The premature infant at any PCA may or may not have the skills necessary for safe and efficient nipple feeding, but for initiating nipple feeding the infant should be at least 32 weeks PCA. Preterm infants even as young as 28 weeks GA may be able to successfully breastfeed. This is much earlier than bottle fed infants who shouldn’t attempt nipple feeding until 32 weeks GA.

2. **Gastrointestinal Function**
   Tolerating enteral feedings with minimal residuals, emesis or abdominal distention.

3. **Airway**
   The airway should be stable and maintained without obstruction. There should be no stridor or an abnormal ENT exam.

4. **Breathing Regulation and Work of Breathing (WOB)**
   - Infant should be comfortable at rest.
   - Minimal signs of respiratory distress or increased WOB should be seen during non-nutritive sucking.
   - The respiratory rate is ideally less than 60 breaths per minute.
   - The otherwise healthy term or post term infant may begin nipple feeding with a respiratory rate of <70 breaths per minute, if there are no other signs of distress. Criteria may need to be modified for infants with BPD or CLD.

5. **State Regulation/Modulation**
   The infant should be waking for feedings on his/her own and be able to sustain a quiet alert state.

6. **Postural/Sensory-Motor Control**
   The airway needs to make dynamic adjustments during nipple feeding. Emerging active head/neck control, contribute to the muscular/structural supports for these adjustments and therefore support the swallow mechanism and maintain the airway during nipple feeding.

7. **Non-nutritive Sucking and Swallowing**
   The non-nutritive suck is typically present before 30 weeks PCA. The infant should demonstrate rhythmical non-nutritive sucking with adequate strength on a pacifier, your finger or their hand. The infant should swallow saliva and secretions. Non-nutritive sucking is not predictive of successful bottle feeding.

**ORAL FEEDING READINESS CUES**
- Demonstrates energy for feeding – maintains muscle tone and body flexion
• Ability to remain engaged in the feeding
• Ability to organize oral/motor functioning – open mouth when lips stroked, rooting
• Ability to safely swallow and breath – able to engage in long sucking burst without behavioral stress signs or an adverse negative cardio-respiratory response. Once feeding is underway maintain a smooth, rhythmic pattern of sucking.
• Ability to maintain physiologic stability – stable oxygen saturation and behavioral stress cues are absent. Infant pauses to breath before stress cues appear. Clear breath sounds.

SELF REGULATORY FEEDING OF THE NICU INFANT
The major goal is for caregivers to assist sick and premature infants to develop safe and effective early oral feeding skills, and improve breast feeding outcomes.
• The caregiver may offer the infant a nipple feeding based on the behavioral indicators of the infant at the time of the feeding.
• Every feeding time offer the infant the ability to non-nutritive suck with a pacifier, gloved finger or the infants’ hands. Non-nutritive sucking promotes awake behavior for feeding. After 5-10 minutes of non-nutritive sucking assess and evaluate the infant’s behavioral state to determine readiness for nipple feeding. Optimal behavioral states for a successful feeding: awake, fussy, crying.

Behavioral State Assessment
(adapted from Anderson Behavioral State Scale)

SLEEP: eyes closed, regular or irregular respirations, slight movement of face or limbs.

DROWSY: eyes opening and closing, slight movement of face or limbs.

AWAKE: eyes open, no movement to full body movement.

FUSSY/CRYING: eyes open or closed, audible whimper to cry, normal color to red color, limb movement and or body tenseness.

• If the infant continues to sleep or is too drowsy to feed allow the infant to sleep an additional 15 minutes, while continuing cares. Reevaluate the infants’ behavior state if the infant continues to sleep or is too drowsy to feed then gavage the feeding.
• If the infant is alert/awake or restless offer a nipple feeding every 3 hours.
• If the infant tolerates the nipple feeding, but does not nipple feed the volume prescribed, then gavage the remaining volume.
• If the infant tolerates the total prescribed volume of nipple feeding and continues to breast/ nipple feed the total volume prescribed for all feedings within a 24 hour period, remove the indwelling feeding tube and advance to full oral feeds.

DEVELOPMENTAL FEEDING SUPPORT
Oral feeding within a developmental framework involves:
• Assessing individual physiologic, motor and state behaviors during feeding. 
• Individualizing the feeding plan based on specific infant cues.
• Fostering parental skill and confidence with feeding.
1. **Environment**
   Provide a calm quiet area, dim lighting and no distractions. Ensure a restful environment between feedings.

2. **Direct Care**
   - Avoid oral feedings after stressful procedures.
   - Choose appropriate nipple type or breast shield for infant.
   - Gently arouse to alert state.
   - Swaddle infant in your arms or semi upright in your lap with the upper body and head at a 45 degree angle to the buttocks; or feed the infant side lying, head higher than hips. If side-lying have infant face you so caregiver can observe for signs of stress.
   - Facilitate neutral head - neck flexion, chin slightly tilted down, excessive head flexion can compromise airway maintenance.
   - Keep infants head midline, not to one side, arms should be slightly flexed and midline with hands towards the face.
   - Continuously observe physiologic, behavioral, and oral motor functioning and respond contingently in ways that promote self regulation.
   - Begin feeding by eliciting the rooting response, this promotes the infants active engagement in feeding. Place the nipple in the infant’s mouth only in response to his cues of readiness.
   - Provide adequate breathing and rest periods for infants who cannot pace themselves by gently removing the nipple, or if that is too stressful, tipping the bottle downward to drain the milk from the nipple.
   - Provide firm but gentle jaw and cheek support for problems latching onto the nipple, weak seal or loss of milk bolus.
   - Institute developmental burping, with postural support, and gentle back rubbing, in an upward motion to stimulate burp.
   - Recognize the infants limits, and when to stop feeding.
   - Gavage the remainder of the feeding as indicated.
   - Allow undisturbed rest between feedings.

**DETERMINATION OF A SUCCESSFUL FEEDING**
Success implies the ability to take all of the prescribed volume by mouth within an allotted time and maintain a sustained pattern of weight gain. However, successful feeding of an infant should NOT be determined by completion of prescribed volume alone. Rather, did the infant nipple safely and have a positive experience during the portion which they completed. The infant should be able to maintain autonomic, motor, and behavioral state organization during nipple feeding. As well as show minimal to no “Major Stress Cues” as described on the Nipple Feeding Profile (Form #80699).

**INFANT STRESS CUES DURING FEEDING**

1. **State Organization and Endurance**
   - decreased arousal
   - awake but no energy
   - irritable
   - fatigues quickly within the first 5 minutes of feeding

2. **Physiologic**
• tachypnea
• nasal flaring
• retractions
• increased work of breathing
• decreased oxygen saturations
• apnea and/or bradycardia
• color change (dusky, pale)

3. Oral/Motor
• unable to control fluid bolus
• high pitched sounds
• gulping
• coughing, choking
• multiple swallows without pausing for a breath

FAMILY SUPPORT AND EDUCATION
Educate parents on infant cues and how to measure feeding success.

Provide opportunities for feeding:

1. Breast Feeding Infant
   • All NICU infants who will be breast fed and their mothers should have a lactation consult.
   • Carefully evaluate the preterm infant for readiness to breast feed. Include behavioral state assessment, ability to maintain body temperature, respiratory status, and readiness to suckle at breast.
   • Supplementary bottle feeding is inefficient. If the infant nursed well as evidenced by active sucking and swallowing for a period of 20-30 minutes there is no need to supplement the feeding. The best approach is to allow the infant to nurse while providing the prescribed volume of feeding via the feeding tube on a pump. If a supplement is indicated after breast feeding, consult with the provider for orders.

2. Bottle Feeding Infant
   Once the infant is able to successfully complete the prescribed volume 3 times in a 24 hour period, and the parent has observed 3 successful feeding attempts, the parent may begin to bottle feed their infant under the supervision of the registered nurse or SLP. As the infant progresses with successful nipple feedings the parent may independently feed their infant.

SPEECH LANGUAGE PATHOLOGIST (SLP)
Consider a SLP consultation to provide developmental support for the following infants:
• Infants who are unable to satisfactorily progress in nipple feeding attempts.
• Infants who have an absent or unreliable swallow requiring frequent suctioning of secretions.
• Infants who have an absent or weak gag reflex.
• Infants who have been diagnosed by an ENT as having vocal cord paralysis or paresis, subglottic stenosis, laryngomalasia, or other concerns.
- Infants who have developed oral aversions, such as refusing pacifier or gagging with pleasant oral stimuli.
- Infants with cleft lip and/or palate.

**NIPPLE TYPES**

In the NICU we use 2 types of bottle nipples:

- Standard Flow
- Slow Flow (green nipple or yellow nipple)

**NOTE:**
- Breast feeding mothers can obtain breast shields from lactation.
- Specialty nipples and/or feeders should be discussed with and obtained with the knowledge of a SLP.

Most infants should transition over to a standard nipple prior to discharge if possible. If the infant is still in need of the slow flow nipple as discharge to home is near, transition the infant to a commercially available slow flow nipple.

**NOTE:** Hospital issued nipples are one time use only, and should never be sent home with parents.

**NOURISH AND NURTURE**

**GOAL:** To foster the advancement of enteral nutrition and the decrease of parenteral nutrition while also promoting the establishment of nipple feedings without losing the personal patient contact and nurturing care environment. The following is a list of suggestions to maintain developmental care and nurturing during the feeding process:

- Observe, understand, and appropriately respond to infant cues.
- Offer non-nutritive sucking on a pacifier during gavage feedings. This supports the maturation of the sucking reflex, facilitates more rapid transition to oral feedings and is pleasurable and soothing.
- Hold stable convalescing infants during feeding to promote face to face contact and interaction.
- Allow breastfed infants to suckle at breast during gavage infusion.
- Offer facial expression, affect.
- Initiate nipple feeding per guidelines using tube to supplement.
REFERENCES


**Date Updated:** July 2009, October 2011, February 2014
APPENDIX B

INTAKE FORM
Appendix B

Intake Form

Date of initial contact: ____________________ Date Consent signed: ____________________

Child’s name: ___________________________________________________________________

DOB: __________________________ Due Date: _________________________________________

Corrected age: ___________________ Gender: _______ male _______ female

Ethnicity: ______African American ______Asian ______Caucasian

_____Hispanic/Latino _____Native American _____Pacific Islander Other: _________

Parents’/Caregivers’ name(s): _____________________________________________________

Address: ______________________________________________________________________

______________________________________________________________________________

Phone: (cell) __________________________ (home) __________________________________

E-mail: _______________________________________________________________________

Referred by: ___________________________________________________________________

Mother’s Marital Status: _____married _____separated _____divorced

_____single _____widowed _____ other: _____________

Father’s Marital Status: _____married _____separated _____divorced

_____single _____widowed _____ other: _____________

People living in the household:

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
Maternal Education Level: _____Grade completed     _____GED     _____High School
_____Associate Degree       _____BS/BA  _____MS/MA/MBA  _____PhD/EdD
_____Clinical Doctorate _____MD _____Law  _____Other: _________________________

Paternal Education Level: _____Grade completed     _____GED     _____High School
_____Associate Degree       _____BS/BA  _____MS/MA/MBA  _____PhD/EdD
_____Clinical Doctorate _____MD _____Law  _____Other: _________________________

**Family History:** Please check all that apply and identify the relationship
_____ Prematurity ______________________________________________________________
_____ Autism _________________________________________________________________
_____ Developmental Delays ____________________________________________________
_____ Feeding/swallowing problems _____________________________________________
_____ Hearing problems ________________________________________________________
_____ Visual problems _________________________________________________________
_____ Speech/Language delays _________________________________________________
_____ Reading/Literacy difficulties _____________________________________________
_____ Seizures ________________________________________________________________
_____ Respiratory difficulties __________________________________________________
_____ Other: __________________________________________________________________

**Pregnancy Information:**
Number of pregnancies: ____________________ Number of live births: _________________
When did prenatal care begin: ________________
Medications during pregnancy: ____________________________________________________
______________________________________________________________________________
Complications: __________________________________________________________________
Birth Information:
NSVD: _______ Planned C-Section: _______ Emergent C-Section: _______ Induced:______
Gestational age at birth: ________________
Birth weight: _________ Length: _________ Head circumference: __________
APGAR: ________ Respiratory status: ____________ Respiratory support:
____________________
Other: ________________________________________________________________________

Neonatal Period:

<table>
<thead>
<tr>
<th>Respiratory support</th>
<th>Date on:</th>
<th>Date off:</th>
<th>Date on:</th>
<th>Date off:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscillator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPAP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heated Wire NC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Flow Nasal Cannula</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal Cannula</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comment:

Diagnoses:

<table>
<thead>
<tr>
<th></th>
<th>Check if applicable</th>
<th>Specialist seen</th>
<th>Evaluations</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>EoE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stridor/Sterter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocal Fold dysfunction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GI/feeding intolerance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Other

| Other | | | |

Other Specialists Involved:

SLP involved:

OT involved:

PT involved:

**Feeding History:**

Breast Milk / Formula: Formula type: ________________________________

Previous Formula tried: ________________________________

Feeding Intolerance: ________________________________________________

First test nipple: _____________________ Second test nipple: ________________

Number of bottle feedings: ________________________________

Dry breast: ______________________________ Breast Feeding: ____________________

Feeding position: ______________________________________

Bottle system / nipple used: ____________________________________________

Pacing needed: _________

Comments/Notes:
APPENDIX C

CODING MANUAL
Appendix C

Coding Manual

Coder 1

1. Open videos to code for participant
   a. open the mother and infant videos only
      i. Video of monitor is reserved for coder 2
   b. Coding of video session should begin when the mother is seated with infant and takes
      the bottle in hand.

2. Listen for audible cues with coding manual open and in view

3. Record audible cues

4. Focus on visual cues with coding manual open and in view

5. Record visual and other cues

6. Review all cues and identify if behaviors are stress or readiness and code as such

Coder 2

1. Following the completion of Coder 1 recording behaviors and cues, Coder 2 will review for
   physiological stability.

2. Coder 2 reviews video of monitor
   a. Each time a behavior has been coded (by Coder 1), the heart rate, respiratory rate, and
      oxygen saturations are recorded
   b. Indicate if physiological measure is stable or unstable according to the parameters
Table C.1

<table>
<thead>
<tr>
<th>Physiologic Measure</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Rate</td>
<td>120 bpm</td>
<td>160 bpm</td>
<td>Yamamoto, Prade, Berwig, Weinmann, &amp; Keske-Soares, 2015</td>
</tr>
<tr>
<td>Respiratory Rate</td>
<td>40 breaths per minute</td>
<td>70 breaths per minute</td>
<td>Groh-Wargo &amp; Sapsford, 2009; Lau, 2006;</td>
</tr>
<tr>
<td>Oxygen Saturation Levels</td>
<td>90%</td>
<td>100%</td>
<td>Manja, Saugstad, Lakshminrusimha, 2017; Poets, Stebbens, Alexander, Arrowsmith, Salfield, &amp; Southhall, 1991; Shiao, Booker, &amp; DiFiore, 1996; Yamamotor, Prade, Bolzan, Weinmann, &amp; Keske-Soares, 2017</td>
</tr>
</tbody>
</table>

Figure C.1. Coding flow chart.
**Table C.2**

*Coding Scheme*

<table>
<thead>
<tr>
<th>Infant Behaviors</th>
<th>Operational Definition</th>
<th>Picture</th>
<th>Noldus Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altered tone</td>
<td>Extreme increase or extreme decrease in muscle tone</td>
<td></td>
<td>a</td>
</tr>
<tr>
<td>Audible swallow</td>
<td>Gulping sound during the swallow</td>
<td></td>
<td>u</td>
</tr>
<tr>
<td>Breath holding</td>
<td>Interruption of a rhythmical breathing pattern with breath hold.</td>
<td>Add Video Example</td>
<td>b</td>
</tr>
<tr>
<td>Color change</td>
<td>Increased redness, paleness, or circumoral cyanosis (blue color around lips) for greater than 2 seconds</td>
<td></td>
<td>c</td>
</tr>
<tr>
<td>Coughing/Throat clear</td>
<td>Coughing or throat clear in response to the swallow. Can occur during or after the swallow.</td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>Crying</td>
<td></td>
<td></td>
<td>r</td>
</tr>
<tr>
<td>Excessive Drooling/Liquid Loss</td>
<td>Large volume of liquid loss orally during feeding</td>
<td></td>
<td>e</td>
</tr>
<tr>
<td>Furrowed Brow or Raised eyebrows</td>
<td>Elevation and/or medial rotation of the eyebrows for greater than 1 second</td>
<td>f</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Hands to mouth/ Mouthing</td>
<td>Elbow and wrist flexion toward own mouth; may or may not enter the oral cavity but attempt is made. Attempting to suck on fingers; palm facing in, licking lips, sticking tongue out</td>
<td>h</td>
<td></td>
</tr>
<tr>
<td>Head bobbing</td>
<td>Rhythmical anterior/posterior movement of the neck for greater than 1 time back and forth</td>
<td>d</td>
<td></td>
</tr>
<tr>
<td>Lips pursed</td>
<td>Tight lip closure observed upon presentation of the nipple blocking potential entry of the nipple</td>
<td>l (lower case L)</td>
<td></td>
</tr>
<tr>
<td>Move forward toward nipple</td>
<td>Cervical or thoracic flexion toward the nipple and/or feeder</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>Rooting</td>
<td>Head turns in the direction of stimulus to lips/mouth</td>
<td>t</td>
<td></td>
</tr>
<tr>
<td>Behavior Cue</td>
<td>Operational Definition</td>
<td>Code</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td><strong>Smacking Lips</strong></td>
<td>Pulls lips together tight with intraoral air pressure then blows them apart</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td><strong>Splayed fingers or “stop” hands in front of mouth</strong></td>
<td>Not trying to suck. Using fingers/hands to block mouth with palm facing outward. Fingers stiff and spread apart</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td><strong>Stridor</strong></td>
<td>Upper airway sound upon inspiration</td>
<td>i</td>
<td></td>
</tr>
<tr>
<td><strong>Turn head away</strong></td>
<td>Pulling head away in any direction in anticipation of the bottle; not associated with burping</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td><strong>Uncoordinated suck-swallow-breathe coordination</strong></td>
<td>Uncoupling of Suck-Swallow-Breathe synchrony, altered ratio of 1:1:1</td>
<td>k</td>
<td></td>
</tr>
<tr>
<td><strong>Vocalization</strong></td>
<td>Intentional phonation during feeding that are not associated with crying</td>
<td>v</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Behavior Cue</th>
<th>Operational Definition</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Readiness</strong></td>
<td>Infant behavior is demonstrating desire to start and/or continue nipple feeding</td>
<td>R</td>
</tr>
<tr>
<td><strong>Stress</strong></td>
<td>Infant behavior is demonstrating stressful responses and attempting to indicate desire or need to stop feeding and/or take a break</td>
<td>S</td>
</tr>
<tr>
<td>Physiological Measures</td>
<td>Operational Definition</td>
<td>Code</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Stable</td>
<td>Within parameters on Table 1</td>
<td>T</td>
</tr>
<tr>
<td>Unstable</td>
<td>Outside of parameters on Table 1</td>
<td>U</td>
</tr>
</tbody>
</table>