RELATIONSHIP OF ARTICULATION AND

FEEDING SKILLS IN CHILDREN:

A PILOT STUDY

by

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ABSTRACT

Feeding development begins during the embryologic and fetal periods with maturation of the head, face, and neck, the emergence of early oral motor reflexes, and continues well into early childhood. Children learn to eat in a predictable sequence. They transition from nutritional intake of a single consistency (liquid) to complex, multi-textured foods in just two short years. Children continue to refine their feeding skills through elementary age. Simultaneous to feeding development during childhood is speech and language development. One component of speech and language development is articulation. Articulation refers to the establishment of clear and distinct sounds in speech. Speech sounds are developing from birth and should be fully developed by age eight all the while, gaining clarity with repetition and feedback. Articulation and feeding both require intact orofacial structure and adequate oral motor function. Although the relationship between these two developmental processes is implied because of their shared developmental periods and anatomical structures, it has not been fully explored in the literature. This study investigated the relationship between feeding and articulation in children with known articulation deficits. A total of ten participants were recruited from the University of Alabama Speech and Hearing Center (UA SHC), but only three were included in the final analysis. Participants demonstrated overlapping sound errors that corresponded to overlapping feeding skill error. For clinical purposes, the implication of an articulation and/or feeding screener would be beneficial in the evaluation process of either disorder to aid in the success of the child's therapy.

LIST OF ABBREVIATIONS AND SYMBOLS

VFSS	Video Fluoroscopic Swallowing Study
FEES	Fiberoptic Endoscopic Evaluation of Swallowing
GMP	Generalized Motor Program
UA	University of Alabama
SHC	Speech and Hearing Center
GFTA	Goldman Fristoe Test of Articulation
APFSC	Adaptive Pre-Feeding Skills Checklist
OC	Open cup
P	Pureed
C/C	Chewable/Crunchy
n	Number
N/A	Not Apply
Y/N	Yes/No
M	Mean
SD	Standard Deviation
<	Less Than
+/-	Achieved/Unachieved
→	Followed By

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CHAPTER 1
INTRODUCTION

Feeding Skill and Articulation

Feeding competency represents mastery of a hierarchy of developmental skills. Feeding development plots along a predictable course during the first two years of life (Crary & Groher, 2016). In order to achieve safe and adequate oral feeding, the necessary structures must be anatomically intact. During the embryonic period, the oral cavity, pharynx, larynx and esophagus are being formulated. The fetal period is from nine weeks until birth, which is when suck, swallow, and oral sensorimotor functions are developing (Arvedson & Delaney, 2007). During this time, a normal fetus will typically demonstrate the reflex of suckling while in the womb. When the infant is born, they move quickly from reflexive suckling into a mature sucking stage. As the child becomes more acclimated to either bottle or breast, he/she increase their strength and ability to coordinate sucking, swallowing and breathing. The coordination of these three skills is required in order to support safe and adequate oral intake throughout the first year of life (Arvedson & Delaney, 2007). According to Arvedson and Delaney (2007), normal feeding development follows three stages: homeostasis (0-2 months), attachment (3-6 months) and separation/individuation (6-36 months). Within the broad stage of separation/individuation, there are a number of other stages that hone in on the specific feeding development of the infant during the first two years of life. These stages consist of transitional spoon-feeding, self-feeding using a spoon, mature mastication and open cup-drinking, mature self-feeding, and an overall mastery of techniques needed to accept solids, liquids and a number of textures. Articulation of speech sounds develop over the first seven years of life (Poole, 1934). Articulation is the set of motor processes involved in the shaping and production of speech. Difficulty with motor production can lead to failure of correct production of certain speech sounds (Bernthal, Bankson, & Flipsen, 2013). The age of acquisition of sounds develop in each child differently, but begins at birth. Over time, children will bring objects to their mouths, eat, and explore their voices to discover what sounds they can produce. Seemingly, a child is able to clearly produce phonemes beginning at the age of two (Bernthal et al., 2013). Some sounds are easier to make in the oral cavity than others due to their place and manner. Each phoneme can be characterized by manner, place, and voicing in order to describe how they are produced. The earliest sounds to develop are stops (place of articulation) followed by nasals, the fricative sound 'f,' glides and liquids, the remainder of the fricative sounds, and affricatives (Sander, 1972). Some children will acquire their sounds earlier than predicted by researchers and some will acquire them later. When the lag of acquisition of sounds is present, the child may undergo articulation therapy in order for them to become intelligible to an unfamiliar listener.

Much research has been done on the milestones of feeding and articulation development independently. It is widely assumed in research that the two are interrelated based on the anatomy of the oral mechanism. The same actions and articulators required for successful feeding are the same as those used to produce clear, articulated sounds (Poole, 1934). The tongue, lips, cheeks, jaw, and teeth all serve a specific duty in feeding development. A child needs their teeth to masticate solid foods just as they can use them in the production of a lateralized *r*. If a child is unable to be intelligible by a certain age, it poses a problem for their social communication and confidence to speak (Bernthal et al., 2013).

Therefore, it is important to study the relationship between feeding and articulation skills in children to determine if the two theoretically associated topics are in fact related. In chapter 2, a review of the literature related to this study will be discussed. In chapter 3, the methods and procedures of the study are identified; in chapter 4 the results are presented; and finally, in chapter 5, these results are discussed.

Statement of the Problem

Despite a theoretical link between articulation and feeding development, very little research exists that documents the relationship between these two skills. This study aims to explore the relationship between measures of feeding adequacy and articulatory competency.

Specific Aim

The specific aim and *hypothesis* of this project is as follows:

This study will compare specific sound impairments based on place of articulation (bilabial and apical) to specific feeding skill impairments to determine if there is any correlation between these two variables. Specific sound impairments grouped by place of articulation will be related to specific feeding skill impairments grouped by articulatory involvement (i.e. lips, tongue, jaw). A Fisher's exact test was planned to analyze data, but a descriptive analysis was chosen instead due to a small sample size.

CHAPTER 2
LITERATURE REVIEW

To inform this study, the following areas will be discussed: feeding, normal feeding development, language development and articulation, normal articulation development, theories of motor learning, and articulation and feeding development's relationship toward each other.

Feeding

Feeding skills develop in early childhood and allow for the transition from single texture intake (liquid) to a typical diet that includes multiple textures. Logemann (1998) first described feeding as a process that encompasses the following: preventive reactions; obtaining food; placing food in the mouth; managing a bolus, including mastication; and the transfer of the bolus with the tongue into the pharynx. Current descriptions of feeding conceptualize it within the model of the four stages of swallowing that include: the oral preparation stage, the oral transit stage, the pharyngeal phase, and the esophageal phase (Crary & Groher, 2016). For infants and young children, the oral preparatory and oral transit stages include the ability to coordinate sucking, swallowing, and breathing while safely consuming either breastmilk or formula (Wolf & Glass, 1992). As infants and children grow and mature, the oral preparatory phase transitions from strictly a reflexive activity of suckling, to the highly complex and volitional activities of sucking and mastication.

Normal Feeding Development. Typical feeding development follows a predictable sequence with known and previously described stages. The stages of feeding development often overlap as infants and children learn and master specific skills with exposure and practice with foods that demand greater degrees of processing within the oral cavity (Amaizu, Shulam, Schanler, & Lau, 2007). Feeding development coincides with other gross and fine motor development throughout early childhood (Klein & Morris, 2000). Feeding development typically progresses in the following fashion: suckle feeding → suck feeding → spoon-feeding → chewing → biting and chewing → open cup-drinking. The infant transitions from reflexively driven feeding in the first few months of life to learned oral motor patterns by two years of age that will support nutritional intake for the rest of their life.

Newborns need total postural support for feeding. Their diet consists entirely of liquid, breast milk or formula, taken from the breast or bottle (Dodrill, 2014). Suckling is a reflexive response and it characterizes newborn feeding. It is the only means of accepting nutritional intake in early infancy. Infants demonstrate generalized mouthing, which begins in utero and continues into infancy, to increase their awareness of sensations such as firmness, softness, and hardness of substances or objects they come in contact with (Klein & Morris, 2000). Suckling involves the stabilization of a nipple between the tongue and hard palate and integrated anterior to posterior movements of the tongue. The lower jaw and anterior portion of the tongue elevate together, providing positive pressure that allows milk to exit the nipple and enter the mouth. The liquid then moves toward the pharynx and is prepared for swallowing. The tongue moves in a forward-backward stripping motion drawing milk into the mouth. Then, the tongue transitions to an up-forward movement creating suction of the nipple producing negative pressure and change of the volume in the oral cavity allowing the nipple to refill (Wolf & Glass, 1992). The tongue lateralization reflex may also occur as food is placed on the side of the tongue. The middle section of the tongue elevates and moves toward the stimulus within the oral cavity. As this reflex matures, so does the coordination of the swallow in infants. The lips are able to clasp around the nipple preventing loss of liquid (Klein & Morris, 2000). This patterned tongue motion is used to protect the airway from aspiration (Crary & Groher, 2016). Infants are in the suckling stage (one dimensional, reflexive forward-backward tongue motion) when they begin to transition to the sucking stage.

Sucking involves the containment of the nipple, with greater contribution from the lips (lip seal, positive pressure), and the initiation of negative pressure, with up-down movement of the tongue and jaw. This movement changes the volume of the oral cavity for suction of the fluid from the nipple source (Klein & Morris, 2000). It develops gradually from the negative pressure that arises in the suckle stage. The backward-forward stripping motion of the tongue that characterized the suckling stage has now fully evolved into an up-down movement. During sucking, the lips close more firmly causing less liquid to be lost during bottle or spoon-feeding (Klein & Morris, 2006). The jaw and tongue movements become separated in the sucking stage, unlike in suckling. The tongue paired with the lips/cheeks builds greater closure which allows the jaw movements to decrease in action.

Infants at this stage also demonstrate improved head and neck support and the ability to sit in a semi-upright position with external supports. These new skills allow for oral exploration of infants by the bringing of their hands to their mouths (Dodrill, 2014). Discriminative mouthing permits the child to transition from the sucking stage into spoon-feeding. Many are still only receiving breast or formula milk at this time. Exploring new objects and substances allows children to use their tongue, lips and jaw to discover shapes, size, taste, weight and surface texture (Klein & Morris, 2000). The American Academy of Pediatrics (2017) recommends that parents/caregivers begin spoon-feeding their infant at six months of age when head and neck support is fully developed.

Spoon-feeding of pureed foods beginning around six months of age necessitates use of different oral-motor skills than those used for sucking thin liquid from a bottle. When it is introduced earlier than six months, the suckling patterned movements are being used as the spoon approaches the mouth. The tongue is moving in an up-down motion. The child anticipates the approach of the spoon. The upper lip moves forward, but not downward toward the bowl of the spoon. Once the spoon is in the oral cavity, the child's tongue moves in a forward-backward motion, pushing food out of the oral cavity and on to the lips and chin. The child has not ripened the ability to utilize their top lip to aid in removal of food from the spoon yet. The "put it in and spit it out" routine is used by caregivers to scrape food from the lips and chin and put it back into the child's mouth. The in and out suckle pattern of the tongue still exists and the lips are less active (Klein & Morris, 2000).

To introduce spoon-feeding, caregivers begin by adding cereal or smooth solids to the infant's milk in order to add a substance of greater viscosity to the child's diet. Infants begin by sucking soft solid food from a spoon. They familiarize themselves with the appearance of the spoon and learn to move the body forward to meet the spoon approaching their mouth. Because of previous experience and awareness, infants open their mouths to accept the food from the spoon (Klein & Morris, 2000). First, the jaw stabilizes to allow for opening, and the tongue rest in the oral cavity. Then, the jaw moves in a controlled and graded movement in order to close the mouth once the spoon is inside. The upper lip moves forward and down to scrape food from the spoon and the lower lip draws inward to secure that food does not leave the oral cavity. Once the lips are closed the tongue begins to move within the oral cavity. The tongue no longer moves in the forward-backward suckle motion, but it now moves in concord with the cheeks in the oral cavity to aid in the preparation of the bolus for swallowing (Klein & Morris, 2000). An infant then matures to learning how to clean the spoon by moving their upper lip downward, but not quite inward. Generally, between six to nine months, infants have developed the downward and inward lip motion and are able to effectively remove food from a spoon. Between 12 to 15 months of age, the lower lip is activated and moves inward as the spoon is removed from the oral cavity in preparation for cleaning. The front incisors learn to scrape the spoon and remove food from the lower lip. A mature feeder will have an established pattern for removing soft, solid foods from a spoon, and their tongue will have motility in and outside of the mouth in order to clean food from the lips. The elevation and depression of the tongue is precise in its movements and are independent of the jaw. A child will encompass adult-like feeding patterns, but tongue precision skill will continue to develop until he/she is three years of age (Klein & Morris, 2000).

While spoon-feeding is developed, some children begin to use the spouted cup. Spouted cups are often used before open cup-drinking, but not always. The spouted cup has its advantages and disadvantages of use. The wide, thick spout gives a nice, broad resting place for the lips. The spout conceals the corners of the mouth, preventing leakage of liquids. This cup is a transition for younger infants on the verge of discovering open cup-drinking. The disadvantages for the use of spouted cups are that they offer no room for the infant to develop control of the corners of the lips to prevent spillage. The thick, wide spout could also encourage a wider opening of the jaw and prevent the development of jaw movement control. The lips and mouth are passive in their actions, which does not constitute control of drinking (Klein & Morris, 2000).

Chewing emerges around seven months of age. Within the six to nine-month range, most infants begin to transition to foods that require more sophisticated oral motor patterns. Chewing is characterized by a number of sequenced stages which include; phasic bite, unsustained bite, graded bite, munching with stereotyped vertical chew, munching without stereotyped vertical chew, diagonal rotary chew and circulatory chew. The phasic-bite is the rhythmic bite-release pattern of opening and closing the jaw that is stimulated when a substance touches the teeth or gums. This pattern is usually used early in chewing and the child has no prior experience with chewing. The rooting reflex aids the phasic-bite in that when the cheek is stroked, it allows for opening of the mouth to see if the infant has the phasic-bite ability (Wolf & Glass, 1992). The unsustained bite is the closing of the teeth onto food that is followed by the attempt to bite through food. The graded bite begins where the unsustained bite left off in that the teeth close onto the food and bite through it gradually. Munching with stereotyped vertical chew converts the bites previously discussed into an almost chew state. The jaw is able to move up-and-down rhythmically when stimulated by the teeth and gums. Next, munching with non-stereotyped vertical chew is developed. This stage is an extension of the last, but adds that the jaw can vary in width of opening and timing of movements. The diagonal rotary chew is the last stage of chewing children will develop before the age of two years. The jaw is able to move diagonally allowing the tongue to move from side to side for soft and hard-mechanical foods to be masticated. Circular rotary chew develops somewhere between two and three years of age. This stage incorporates the diagonal rotary chew, with the tongue moving food across midline and the molar teeth grinding the food (Klein & Morris, 2000).

Chewing continues to develop through the stage of independent feeding as timing and coordination improve. The oral motor skills for eating and drinking are becoming more refined in their development and the basic set of patterns for independent feeding are complete (Klein & Morris, 2000). During this stage, a typical infant will be able to grasp a spoon with both hands in order to feed him or herself. They are also able to hold a cup with both hands (Infant & Toddler Forum, 2014). Their food intake ranges from chopped table food, to lumpy consistencies that require chewing techniques and the ability to separate liquid from solid intake. They are able to take liquids from a bottle, cup, or straw without caregiver support (Klein & Morris, 2000) and finger feed without assistance (Crary & Groher, 2016). Children learn to bite hard-mechanical foods and use utensils with more developed dexterity (Crary & Groher, 2016). The internal muscles of the jaw have become balanced around the temporomandibular joint allowing for more external and internal stabilization (Klein & Morris, 2000). Tongue protrusion has been exchanged for tongue-tip elevation and the lips close more effortlessly minimizing loss of food or liquids during feeding (Klein & Morris, 2000).

Open cup-drinking may begin for some infants as early as six months, but typically opportunity for developing this skill occurs between 12 and 14 months of age. Infants approach the open cup with the same skills developed in the suckling and sucking stages. They use the early in-out movement of the tongue with minimal lip closure. Jaw movements are wide and unrehearsed, so the child has to explore those movements in order to establish stability when drinking from a cup (Klein & Morris, 2000). They learn to develop a sucking rhythm with the help of the caregiver tightly holding the cup against the mouth (Crary & Groher, 2016). In bottle feeding, the jaw and tongue movements coordinate together, but now they have developed and a stable position of the jaw constitutes more coordinated tongue and lip motions to occur (Klein & Morris). It is typical for the child to revert back to early patterned movements when presented with more difficult tasks. Beginning around the end of the first year of life, the cup-drinking pattern matures. The jaw and tongue become coordinated causing the child to lose less liquid when drinking. The jaw has gained stability in the open and closed postures, which is needed to develop graded movements and control during drinking. Some children will keep the tongue in the mouth and others will rest their tongue below the cup to achieve the tactile aspects of a nipple. Then they develop the ability to bring the upper lip down to meet the edge of the cup and the tongue no longer rests beneath the cup. By 24 months of age, the jaw muscles work in coordination to provide internal stability at the temporomandibular joint and children are capable of producing three or more sucks from a cup. Lip closure is tightly sealed and loss of liquid is rare. Table 1 includes the position, jaw movement, tongue, lips/cheeks, and teeth's actions and purposes in each stage of feeding development.

Table 1

Feeding skill action and purpose

	Position	**Jaw Movement**	**Tongue**	**Lips/cheeks**	**Teeth**
Suckling	Supine with head slightly elevated; Prone on mother's chest; Side lying; Reclining at angle less than 45 degrees	Lower jaw elevates with the help of the tongue onto nipple; Jaw and tongue move together	Elevates; Rhythmic backward-forward stripping movement followed by an Up-forward tongue motion to draw milk out of nipple; Tongue protrusion not beyond borders of the lips; Sides of tongue move upward; Up-down movement	Lips clasp around nipple preventing leakage of milk	N/A
	Position	**Jaw Movement**	**Tongue**	**Lips/cheeks**	**Teeth**
Sucking	Greater variability Breast or bottle	Skillful in opening and closing Less movement	Moves more freely Up-down movement	More firm closure of lips preventing loss of liquid	N/A

		Jaw and tongue move together			
Spoon-Feeding	Fed while in a high chair, infant chair, or special seat at 90-degree angle Held while fed Use of props (towels or pillows) for external support	Controlled, graded movement Stabilizes to accept food Movement depends upon mobility, balance of flexor and extensor movements, and head and shoulder control More refined	Quiets to accept food Moves forward to accept spoon, then remains in the oral cavity to aid in digestion Use simple extraction-retractions movements or tongue protrusion (food still remains in oral cavity)	Upper lip → forward and downward Lower lip → inward to secure feed in the oral cavity	Used for cleaning of the spoon Upper teeth scrape spoon
Chewing	Greater security in sitting Use highchair, without external support	Phasic bite and release pattern Munching (vertical bite) Diagonal rotary	Lateral movement Moves based on the touch of the food In-out movements	Drawing in of upper or lower lip when food is on the lip Lips and cheeks will tighten to keep food in mouth Active with the jaw Upper lips draws down forward during chewing Upper lip moves downward for improved drinking skill Used to help clean food from	Masticate food more efficiently

				upper and lower lip Developed lip closure	
Independent Feeding	Small child's chair and table Junior chair Booster seat Adult chair at table	Enough stability to support skilled and precise movements of tongue and lips Developed jaw muscles for opening and closing	Elevated tongue tip Elevated and depression and accomplished independently of the jaw movement	Upper lip moves downward for improved drinking skill Used to help clean food from upper and lower lip Developed lip closure	Masticate food more efficiently

Note. Adapted from "Ch.12 Typical Feeding and Swallowing Development in Infants and Children," by Pamela Dodrill, 2016, *Dysphagia: Clinical Management in Adults and Children, 2,* p. 262.Copyright 2016 by Elsevier Inc.

Language Development and Articulation

Language development is the ability to understand and learn communication skills in early childhood (Norbury & Paul, 2012). It gives insight into conceptual structures, and how people learn. According to Lois Bloom (1974), understanding and speaking do not develop separately. Both speaking and cognition depend upon the same information, but they are displayed in different forms (Bloom, 1974).

Language has three components: form, content, and use. These three components are then divided into five areas. Form consists of phonology, morphology, and syntax. Content includes semantics and use is characterized by pragmatics. Phonology is the study of phonemes or sounds that are within the English language (Masterson & Apel, 2001). The English language has a total of 18 consonant phonemes (*b, k, d, f, g, h, j, l, m, n, p, r, s, t, v, w, y, z)* and five consonant digraph phonemes (*ng, zh, ch, sh, th* (voiced and voiceless)) (Bernthal et al., 2013). These speech sounds are referred to as phonemes. They are the minimal sound element that represent and distinguish language units. The *k* sound, as in *cat* is the first phoneme or sound in this word. These sounds may be produced with or without other phonemes in order to make words. Phonemes are combined to produce meaningful units called morphemes (words with various endings and differentiating meanings). Morphology is the study of grammar rules that govern language (Bernthal et al., 2013). Roger Brown (1973) has developed a list of 14 morphemes that children should have acquired by the age of four. These rules allow for the acclamation of a number of abilities that allow a child to have adult like speech. A child will need to have intact morphology skills in order to described events that happen at different times. They will use their knowledge of phonology to articulate these sounds. Furthermore, syntax is the study of sentence structure. Once a child has acquired the phonemes for speech and developed correct grammatical morphemes, they begin to use them in appropriate and logical sentences. Syntax describes the way in which sentences need to be formulated in order to achieve clarity (Bernthal et al.). Language for each component can then be further divided into two categories: receptive and expressive. Kipping, Gard, Gilman, and Gorman (2012) attest that within these categories are subsets that influence the following: a child's speech, their understanding of meaning and concepts, their play and movement, their grammar skills, and their interaction and expression.

Articulation is the formation of clear and distinct sounds in speech (Bernthal et al., 2013). Articulation is part of language expression and it is described by the manner in which a sound is made, the place within the oral cavity that the sound is made, and whether or not the sound is produced with vibration of the vocal folds (voicing) (Norbury & Paul, 2012). Children typically acquire all of the unique sounds in the English language by seven years of age (Poole, 1934). However, not everyone will fall within this range of normal development. Templin, among others used the guide for development of sounds to be achieved by eight years of age (Bernthal et al., 2013). Difficulties with articulation development are present in developmental, neurologic, and psychiatric disorders but may also be seen in otherwise typically developing children. A delay in speech and language development is the most common developmental delay in children from ages three to 16. A child's language development, including articulation development, can be modified and adapted with changes to the child's environment **(**Kuhl, 2004**).** Around 60% of children may have a speech and/or language difficulty that will resolve with no formal intervention (Weggelaar & Busari, 2004). Others have delays that persist and will need therapeutic intervention in order to remediate the aberrant articulation.

Normal Articulation Development. Articulation develops from birth until seven years of age. Typical infants are able to absorb what they are hearing, observe their environment (Bernthal et al., 2013), coo, and imitate sounds and facial expressions from birth to three months old (Kipping et al., 2012). They are utilizing and exploring tongue placement and lip movement within the oral cavity to make these sounds. Between three to six months, infants develop the skill of localization and are able to turn their heads and direct their attention towards a voice they hear (Norbury & Paul, 2012). Children babble consonant-vowel-consonant strings, vocalize their likes and dislikes intentionally, and have improved jaw movement that allows them to further their exploration of the oral cavity and articulation skills in order to make sounds that will improve with development (Kipping et al, 2012.).

During the six to nine-month period, sounds like *m, t, d, b, p,* and *j (pronounced 'y')* start to appear in babbling. Children begin to formulate these sounds into babble chains (Kipping et al., 2012). Early developing sounds have acoustic characteristics determined by frequencies of vibration that allow them to be easily perceived. Sounds that develop later are harder to perceive due to their high frequency of vibrations (Poole, 1934). Between seven and 12 months, some children have already begun to speak their first true words. By 18 months, some are using 15 meaningful words (Kipping et al., 2012), and an accurate use of sentence intonation (Norbury & Paul, 2012). During the 18 to 24-month period, a language and vocabulary burst erupt (Norbury & Paul, 2012). Children somehow rapidly develop and acquire a number of articulation skills that also coincide with those of feeding skills. Consonant-vowel-consonant words are present and the child appears to be 25-50% intelligible to an unknown listener (Kipping et al., 2012). Figure 1 displays the developmental processes of feeding and articulation simultaneously.

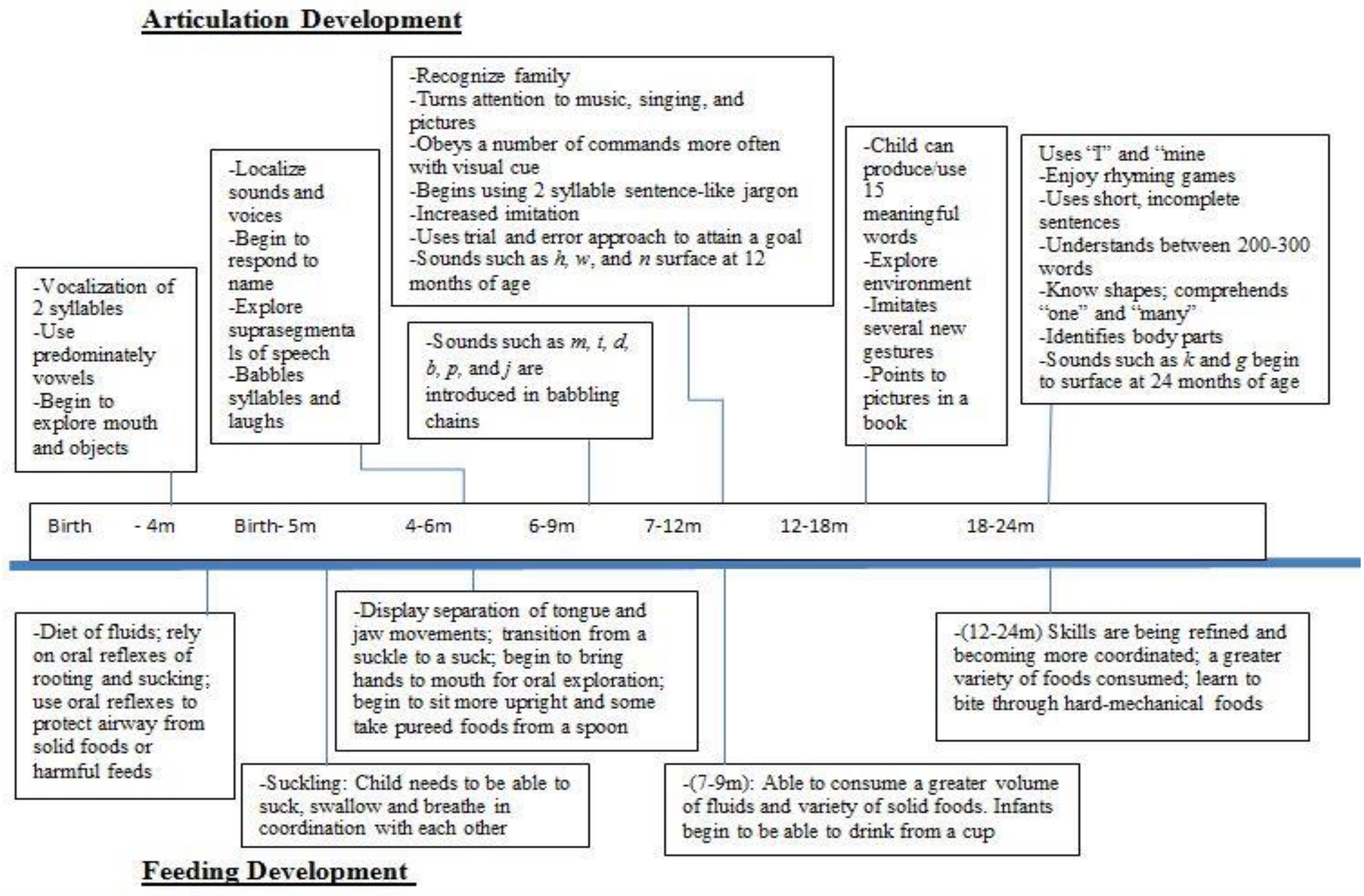

Figure 1. Articulation and Feeding Development
Sources: Dodrill, 2014; *Infant and Young Child Feeding*, 2009; Crary & Groher, 2016

There is a body of evidence that establishes when speech sounds are developed. This can be controversial, but most researchers agree with the range in which sounds are developed. Lawrence Shriberg suggests (1993) that there are three stages of phoneme acquisition which are: early eight: *m*, *b*, *'y'*, *n*, *w*, *d*, *p*, *h*, middle eight: *t, ng, k, g, f, v, 'ch','dz'* and the late eight: *'sh', 'th' (voiceless), s, z, 'th' (voiced), l, r, 'zh'*. These sounds can be categorized into their place and manner in order to better understand when they are typically developed.

After two years of age, the true production of phonemes becomes apparent and intelligible. Stops are the first sounds to be achieved. First, the bilabial stops *p, b* followed by the bilabial glide *w*, the fricative glottal *h* and the nasal alveolar *n* are all acquired by the age of three and a half (Poole, 1934). *W* and *h* are not classified as stops, but they are easy sounds to produce because of their place within the oral cavity (Bernthal et al., 2013). This is why they are produced earlier than other sounds. According the Sander (1972), *n* is developed by three and a half although it does not fall into the bilabial category. Then, the alveolar stops and velar stops *t*, *d* and *k*, *g* develops shortly later by the age of four. Kipping et al. (2012) agreed that sounds such as *k, g, d, t, ng*, *f,* and *'y'* will be acquired by four years of age and children will be 75-90% intelligible to an unfamiliar listener. Next, is the velar nasal sound *'ng'*. According to Schmidt (2003), it can begin developing as early as two years of age but according to Sander, it is not mastered by 90% of children until the age of seven (See Appendix A, 2003). Relatively, glides are produced before fricatives with the exception of *f.* This labiodental fricative should be mastered by age three and a half, but does not surface until the end of age two. Palatal glide '*y*' surfaces its production during the same time as *f,* followed by *r* and *l.* These glides and liquids can differ in which are acquired first and last, but according to Sander, *r* is the last of the glides to be mastered by age seven (see figure 2). Next in line are the fricative sounds. With *f* already mastered, the palatal fricative *'sh'* is achieved by age six, alveolar fricatives *s* and z are achieved by six years, labiodental *v* is achieved by five years of age, and last '*th'*, voiced and voiceless, are achieved around age seven (See Appendix A, 2003). The affricatives are the last to be acquired with *'ch'* and *'dz'* and both being mastered around age seven. Kipping and colleagues (2012) and Sander (1972) have confidence that by seven years of age, a child will be 100% intelligible to an unfamiliar listener and have acquired the late eight speech sounds and a number of blends. Research does agree that by age seven, a child will have acquired the sounds to possess adult-like speech.

Theories of Motor Learning

Motor learning, like what is required for feeding and articulation development is believed to be the consequence of neuromotor maturation (Gesell & Thompson, 1929). In the early 1930s, research was aimed at advancing development as a whole system, no matter whether the outcomes were exhibited in different areas (Iverson, 2010). Developmental milestones of feeding and articulation would be seen as developing simultaneously and not looked upon separately.

The evolutionary theory included a biological complex that centered its focus on the dual purpose of the organs within the human body. In short, Irene Blanchard (1963) states that the appropriate and efficient use of eating should lead to the more appropriate and efficient patterns of speech exhibiting a strong relationship between articulation and feeding.

The schema theory of motor learning supposes that learning is a result of evolving and refining representations of actions (Schmidt, 1975). The main concepts that aid in the schema theory are Generalized Motor Programs (GMP) and parameters. GMP possess an abstract code that relates timing, and force behind how events are produced. Parameters supply the details within the GMP (Knock, Ballard, Robin, & Schmidt, 2000). Feeding development and articulation both have aspects of their development that could be explained by this theory. The generalization that occurs when a child articulates a word correctly, and they are praised for it, allows a child the ability to continue to say that word in that specific way in order to get a response.

The dynamic systems theory is the idea that more general theories govern pattern formation in complex physical and biological systems (Thelen, 2005). Not one particular system gives direction, but the whole system achieves order over time by the influence of a number of subsystems to achieve a motor target (Smith & Thelen, 1998). The dynamic systems theory rejects the cognitively based assumptions of the schema theory (Schmidt, 2003), but it does target the many aspects of feeding and articulation development down to the biological and physical complexity.

Research suggests that the development of feeding skills mature at different times and/or rates (Amaizu et al., 2007). It has also shown us that language dysfunction and oral motor dysfunction often occur together (Alcock, 2006). The theories that have been used to describe motor learning all can be applied to feeding and articulation motor learning skills.

Articulation and Feeding Development

It is known that the relationship between feeding and communication is multifaceted and in need of extensive research (Arvedson & Delaney, 2007). Alcock (2006) states that there is a large amount of research dealing with limb motor control, and a small portion dedicated to oral motor control. Research has taken its focus to the feeding skills of children with disabilities, but placed little emphasis on the oral motor control in typically developing children. Oral motor control would need to be established in typically developing children, before it could effectively be challenged in children with disabilities.

Poole's (1934) research correlated the relationship between feeding and articulation. Her longitudinal study documented the feeding and articulation development of 140 pre-school aged children over the course of three years. Informal measures of articulation were collected in four-month intervals over the course of three years. Words were expressed in isolation in response to pictures, objects, and questions. The study concluded that the skill of feeding gives musculature exercise to the tongue which develops the tongue's ability to generalize certain positions that later produce intelligible speech sounds (Poole, 1934). Measures of feeding were not noted in the article, but the results of the articulation portion of this study led to the conclusion that the muscle generalization that is required to produce the earliest speech sounds like *b, p, m, h, w, d, n, ng, k,* and *'y'* were identical with the muscle movements required for feeding. The need for the sides of the tongue to lie on the molar teeth in order to produce lingual consonants sounds is not an accident in development, but strategically ordered for efficient production (Poole, 1934). No further research has evaluated the link between articulation and feeding in typical developing children.

CHAPTER 3
METHODS AND PROCEDURES

Participants

In this study, individual recruited for participation were between two and 18 years old who were diagnosed with an isolated articulation disorder. Isolated articulation disorder indicates that participants in this study did not have concomitant diagnoses with articulation disorder such as craniofacial defects, significant cognitive impairment, and/or neuromuscular impairment from congenital or acquired conditions. Only English speaking, monolingual participants were enrolled. Participants were recruited from the University of Alabama Speech and Hearing Center (UA SHC) through advertisement in the clinic with printed flyers that were distributed to supervisors. Participants did not have documented oral phase dysphagia with laryngeal penetration and/or aspiration from instrumental assessment (Video Fluoroscopic Swallowing Study (VFSS) or Fiberoptic Endoscopic Evaluation of Swallowing (FEES)) and did not consume all of their nutrition by mouth (participants excluded if partially or fully dependent on gastrostomy tube for nutritional intake). Interested participants were screened before enrollment to the study to rule out any concomitant diagnoses by completion of the UA SHC's intake form. When the participant met inclusion criteria, they completed the assent documentation and parental consent documentation was also completed prior to any assessment.

While ten participants were recruited, only three were included in the final analysis. Two recruited participants cancelled and we unable to be rescheduled, three obtained Goldman Fristoe Articulation-III scores that were above the criteria for this study, one participant's video data was lost, and one participant was unable to receive a score on the Goldman Fristoe Test of Articulation because of the lack of his responses during the administration of the test. Our three participants that were included were Caucasian, one female and two males, all between the ages of four years zero months and six years eight months of age.

Procedures

Potential participants were self-referred to the study by calling the UA SHC and speaking with the principal investigator (Lacey Dent) or her research mentor (Dr. Memorie M. Gosa) for screening and documentation of qualification for inclusion. Upon successful qualification for this study, a mutually convenient time for assessment at UA SHC was established. At the time of presentation to UA SHC, the participant assented to inclusion in the study and the parent provided consent for inclusion in the study and for videotaping of the assessment. The participant and a parent/caregiver then completed the following measures as indicated. The participant was recorded during completion of study parameters to allow for reliable scoring.

Assessments and Measures

This study explored the relationships between oral competency and articulation ability. Oral competency was documented with the Adapted Pre-Feeding Skills Checklist (Dodrill & Marshall, 2016). Articulation ability was determined with a standardized articulation measure, the Goldman Fristoe Test of Articulation-III (Goldman & Fristoe, 2015).

Oral-Competency

The measure of the oral-competency was the Adapted Pre-Feeding Skills Checklist (APFSC; Dodrill &Marshall, 2016). APFSC was first described by Marshall, Hill, Ware, Ziviani, and Dodrill (2014). The APFSC is adapted from an existing clinical resource (Klein & Morris, 2000). It assesses oral feeding competency across three main skill areas (spoon-feeding, drinking, and chewing) from observations made during participant intake of three different nutritional textures (puree, chewable/crunchy food, and a thin fluid drink). In Marshall, Hill, Ware, Ziviani, and Dodrill's study, two groups were being compared: those with Autism Spectrum Disorder and those with a non-medically complex history. APFSC was used because a suitable standardized tool for classifying oral motor skills in children was not available. They needed a scale to assess children at specific ages and severity levels (Marshall et al., 2014).

Severity levels are assigned based on the presence of multiple areas of difficulty from the hierarchical expectation of feeding skill mastery. Participants with documented dysphagia, that includes aspiration and/or laryngeal penetration, were excluded. Participants were presented with a puree, chewable/crunchy food, and a thin fluid drink and their consumption of the test items were recorded for assessment. Assessment included rating drinking subskills (3 subskills), spoon subskills (3), and chewing subskills (4) as either pass or fail by two seasoned speech-language pathologists with experience diagnosing oral phase feeding impairment. If there was disagreement between the two, seasoned speech-language pathologists, a third experienced speech-language pathologist reviewed and rated the assessments. Each judgement of failure on a subskill received a score of zero and each judgement of pass on a subskill received a score of one. Impairment in each area is determined by the following:

Table 2

Adaptive Pre-Feeding Skills Checklist scoring

Feeding Skill	Scoring
Drinking	Participant earns score of < 2
Spoon	Participant earns score of < 2
Chewing	Participant earns score of < 3

A total score of zero areas (drinking, spoon-feeding, and chewing) failed are within normal limits, one area failed is classified a mild delay/impairment, two areas failed is classified as moderate delay/impairment, and three areas failed is classified as severe delay/impairment. It took 15 minutes or less for each participant to complete this assessment.

Table 3

Delay/impairment scale

Skills failed	Delay/impairment
Fail 1 section (skill)	Mild feeding delay/impairment
Failure of 2 sections (skills)	Moderate feeding delay/impairment
Failure of 3 sections (skills)	Severe feeding delay/impairment

Articulation

Articulation ability was assessed with the standardized articulation measure, the Goldman Fristoe Test of Articulation III (GFTA-III, 2015). The Goldman Fristoe Test of Articulation (2015) assesses an individual's articulation of all of the consonant sounds in Standard American English. The test is appropriate for participants aged two - 21 years and takes five - 15 minutes to administer depending on age of the participant. It provides age-based standard scores (M = 100, *SD* = 15), percentiles, and test-age equivalents and does not require reading or writing on the part of the examinee (Goldman & Fristoe, 2015). If the participant had completed the GFTA-III in the last three months from the date of enrollment in the study, those scores from that assessment were used for the study. If the participant had never completed the assessment or if the test was completed more than three months prior to enrollment in the study, the test was administered during the visit to the UA SHC by the principal investigator under the direct supervision of a certified speech-language pathologist. Sounds from the GFTA-III can be grouped into bilabial and apical sounds. These sounds are directly related to feeding skills addressed in the APFSC. The bilabial sounds involve lip closure and the apical sounds involve the tongue tip coming in contact with the palate, alveolar ridge, or teeth for production, which is also needed for adequate feeding skills. Table 4 lists the bilabial and apical sounds that were analyzed in this study.

Table 4

Bilabial and apical sounds related to feeding skill

Bilabial	Apical
p	*t*
b	*d*
m	*n*
w	*l*
	s
	z
	th (v)
	th (vl)
	Ch
	dz
	sh

Data Analysis

To address the specific aim, a Fisher's Exact Test was planned, but due to a small sample size, a descriptive analysis was completed. First, demographics of the participants were reported. Each participant's scores from the GFTA-III and APFSC were calculated. The GFTA-III errors were categorized into bilabial and apical sounds for each participant. Percent correct for bilabial and apical sounds were calculated. Percent correct for each position was also reported. The APFSC skills related to the production of these sounds were analyzed for each participant using +/- for achieved and unachieved skills during feeding. Participants demonstrated more difficulty with apical sounds. These sounds were then broken down into the position in words they were missed by each participant. Ultimately, specific sounds incorrect on the GFTA-III were compared to feeding skills failed on the APFSC.

CHAPTER 4
RESULTS

Ten participants were initially recruited for this study. All of the recruited participants were receiving services for articulation delay/disorder with no concerns for feeding/swallowing disorders and none of the participants had any secondary diagnoses. Two of the ten participants did not complete evaluations due to cancellation without rescheduling. The remaining eight participants underwent evaluation. Five of the eight participants that completed the evaluation were not included in data analysis due to the following: loss of video data (n=1), articulation scores that did not qualify participant for inclusion (n=2), and inability to complete scoring because of lack of responses on articulation testing (n=3). Thus, a total of three participants were included in the final data analysis. The Goldman Fristoe Test of Articulation-III (GFTA-III) scores for all participants that completed assessment are listed in Table 5. Standard scores range from 85-115. Scores below 85 indicate significant articulation errors.

Table 5

Evaluated participants GFTA-III scores

Participant ID	GFTA-III score	Included in Study (Y/N)	Reason for Exclusion
5	76	Y	N/A
13	67	Y	N/A
15	40	Y	N/A
12	46	N	1
7	110	N	2
10	94	N	2
17	86	N	2
16	N/A	N	3

Note. *1 = loss of video data, 2 = articulation scores did not qualify participant for inclusion, 3 = inability to complete scoring because of lack of responses during articulation testing.

A descriptive analysis was chosen for this research because of the small sample size. Demographic information for each participant can be found in Table 6.

Table 6

Demographics

Participant	Age in years; months	Male/Female	Race
5	4;0	Male	Caucasian
13	5;4	Male	Caucasian
15	6;8	Female	Caucasian

The participant's results on the Adaptive Pre-Feeding Skills Checklist are below. Each child failed at least one area on the checklist (drinking, pureed, or chewable/crunchy). One participant failed two areas and the third participant failed three areas. GFTA-III scores for each participant are compared to their Adaptive Pre-Feeding Skills Checklist scores. Each participant's GFTA-III results caused them to be significantly unintelligible to an unfamiliar listener.

Table 7

Adaptive Pre-Feeding Skills Checklist and GFTA-III *results*

Participant IDs	APFSC	GFTA-III scores
5	7/10	76
13	9/10	67
15	7/10	40

Analysis of the APFSC scores for skills that correspond specifically to the articulation of bilabial and apical sounds are noted in Table 8. Participants 5 and 15 had evidence of tongue protrusion during the consumption of pureed and crunchy/chewable foods. This was also evident during speech. Participants 13 and 15 failed the open cup (drinking) task indicating bilabial difficulty, but neither demonstrated this in their articulation errors. Bilabial skills were open cup skills, no liquid loss (straw), no loss of food (P) and independent tongue and lip movements.

Apical skills were no tongue protrusion (P and C/C). + indicates the skill was mastered while – indicates the skill was failed.

Table 8

Feeding skills errored

Category of Feeding Skill	Feeding Skill	5	13	15
Drinking	Liquid loss (OC)	+	+	+
	Consecutive sips (OC)	+	-	-
	Biting for stabilization (OC)	+	+	+
	No liquid loss (straw)	-	+	+
Pureed	Tongue protrusion	-	+	-
	No Loss of food	+	+	+
	Independent tongue and lip movements	+	+	+
Crunchy/Chewable	Tongue Protrusion	-	+	-
	No Loss of food	+	+	+

The GFTA-III has two sections: Sounds-in-Words and Sounds-in-Sentences. Participants were administered the Sounds-in-Words portion in order to calculate their production of each sound in each position of words. These sounds were then categorized based on relevance to feeding skill by the placement of the articulators. Sounds that were not relevant were excluded. Bilabial (*p*, *b*, *m*, *w*) and apical (*t, d, n, l, s, z, 'th'* (vl), *'th'* (v), *'ch', 'sh', 'dz'*) sounds were used. Table 9 shows the percent correct for each participant for bilabial and apical sounds overall and in each position of words (initial, medial, and final).

Table 9

Bilabial and apical sounds percent correct

Sound placement/position	Participant 5	Participant 13	Participant 15
Bilabial overall	83%	100%	100%
Initial	67%	100%	100%
Medial	83%	100%	100%
Final	100%	100%	100%
Apical overall	57%	42%	51%
Initial	76%	43%	33%
Medial	36%	36%	33%
Final	60%	46%	86%

Table 10 lists each participant's production of apical sounds in all positions of words. +/- indicate sounds produced correctly and incorrectly in each position of words at least once during testing.

Table 10

Apical sound production for each participant

Apical	5			13			15		
sounds	I	M	F	I	M	F	I	M	F
t	+	-	-	+	+	+	+	-	+
d	+	-	+	+	+	+	+	+	+
s	-	+	-	-	-	-	-	-	+
**z*	-	-	-	-	-	-	-	-	-
'th' (vl)	-	N/A	+	-	N/A	+	-	N/A	+
'th' (v)	+	-	N/A	-	-	N/A	-	-	N/A
'ch'	+	-	-	-	-	-	-	-	-
**'dz'*	-	-	N/A	-	-	N/A	-	-	N/A
'sh'	+	+	-	+	-	-	-	-	+
n	+	+	+	+	+	+	+	+	+
l	-	-	+	+	-	+	+	-	+

Note. N/A refers to the placement in words that were not assessed nor administered in these positions on the assessment.
*Represents the sounds (*z*, *'dz'*) that were produced incorrectly by all three participants in all positions of words.

Table 11 displays each participant's feeding skill errors as compared to their sound production errors in all position of words taken from the GFTA-III. Table 12 displays the shared apical errors of participants 5 and 15 (a continuation of Table 11).

Table 11

Deficient skills and overlapping sound errors

Deficient skills	Participants	Sound errors
Bilabial errors		
Consecutive sips (OC)	13, 15	N/A
No liquid loss (straw)	5	*m, p*
Apical errors		
No tongue protrusion (P and C/C)	5, 15	Multiple errors (refer to Table 12)

Table 12

Shared apical errors for participants 5 and 15

Initial	Medial	Final
th (vl)		
	th (v)	
s		
z	*z*	*z*
dz	*dz*	
	ch	*ch*
	l	

Note. Errored sounds were linguadental's, alveolar's, or palatal apical sounds. In other words, they all involved the tongue tip or blade to make contact with these places in the oral cavity for production. Furthermore, these two participants have incorrect manner for half of the fricatives (*'th'*(vl), *'th'* (v), s, z), affricates (*'ch'*, *'dz'*), and one liquid consonant (l).

CHAPTER 5
DISCUSSION

As a reminder of the development process, below is a figure that is derived from Figure 1 (in the literature review) that illustrates the simultaneous development of articulation and feeding from birth to two years of life. In Figure 2, the major milestones at each stage in articulation and feeding development are compared to each other (side by side) in months.

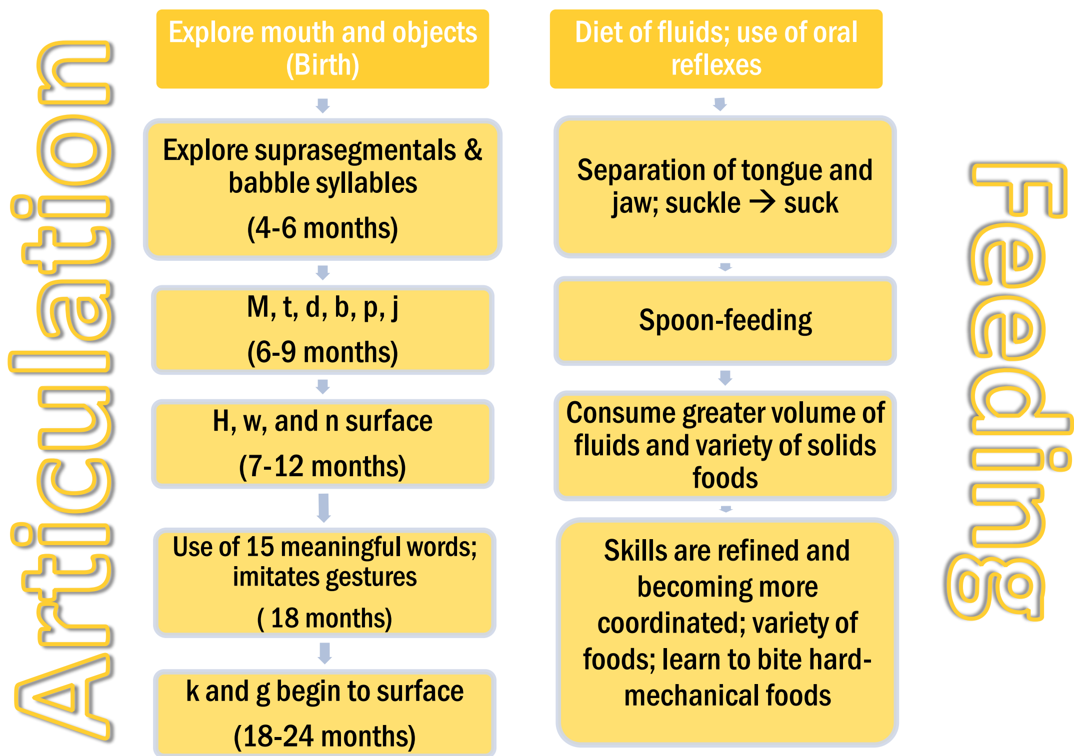

Figure 2. Major milestones of articulation and feeding development
Sources: Dodrill, 2014; Infant and Young Child Feeding, 2009; Crary & Groher, 2016

Overall, bilabial sound impairment was related to impaired feeding skill for one participant. Participant five demonstrated errors on the bilabial sounds *m* and *p* and also demonstrated loss of liquid (inadequate lip closure) when drinking from the straw (a bilabial feeding skill). Participants 13 and 15 also failed the bilabial skill of drinking consecutive sips from the open cup; however, they did not demonstrate errors in bilabial phoneme production.

Apical sound impairment was related to impaired feeding skill for all three participants. All three participants consistently missed many of the same sounds in the same position of words (see Table 11). Examples of participant five's errors in words were: production of 'shoap' for the word 'soap', 'pushul' for the word 'puzzle' and the omission of sounds *ch* and *z* in the final position of words. Participants five and 15 demonstrated tongue thrusting during the APFSC and tongue thrusting during the production of apical sounds. A few of participant 15's errors in words were: production of the word dumb' for 'thumb', 'puddle' for 'puzzle' and 'wash' for watch' in the final position of words. She also demonstrated the use of tongue thrust during conversational speech saying words like 'erath' for 'erase' and 'crunthy' for 'crunchy'. Her apical errors can be related to her failed apical related feeding skills of tongue protrusion from the spoon and when chewing. Although participant 13 did not demonstrate apical related feeding skill errors, he produced apical sound errors. A few of his errors in words were: production of the word 'theven' for 'seven', 'teather' for 'teacher', and the omission of the final sound in the word 'watch' (produced 'wat'). All three participants produced overlapping sound errors that are noted in Table 10.

After reviewing the error patterns of the three participants, there is evidence of a relationship between feeding skills and articulation in this initial pilot investigation. The three participants included in this study had overlapping errors in bilabial and lingual feeding skills and in lingual (apical) articulatory placements. This work supports the findings of Poole, 1934, who also found a relationship between articulation and feeding skills. When Poole completed her research, her measures of articulation and feeding were informal. The articulation and feeding assessments used in this study provided more of a formal evaluation of skills that has transpired since 1934. This allowed for more exploration into this topic given the measures that are readily available. This study also confirms the theoretical basis of this study which relates the overlapping movements of the lips and tongue for feeding and articulatory competency. Specifically, bilabial closure is needed for the production of *p, b, m, w* phonemes and to swallow food and liquid without anterior loss. Further, tongue tip or tongue blade to alveolar ridge, palate, and teeth is required for the production of *t, d, s, z ‘th’(vl), ‘th’ (v), ‘ch’, ‘dz’, ‘sh’, n, l* phonemes and to initiate posterior movement of a liquid or food bolus to trigger a swallow.

The theories of motor learning (discussed in the literature review) provide a basis for how we explore the development of feeding and articulation simultaneously and not separate them from each other. Theories mentioned were the evolutionary theory, schema theory, and dynamic systems theory. In the evolutionary theory, dual organs within the body lead to more appropriate and efficient patterns of speech. The schema theory believed in the generalization of motor programs. The last theory discussed was the dynamic systems theory, which explores how the whole system achieves order over time by influence of subtypes involved to achieve motor learning. All of these theories could be used when explaining the simultaneous development for articulation and feeding skills.

The use of non-speech oral motor exercises for treatment of articulation is an area of research that has been explored immensely. Researchers state that the use of these exercises give way to the generalization of development for speech. This study did not explore non-speech oral motor exercises for treatment of articulation due to the fact that none of our participants have engaged in the use of non-speech oral motor exercises. These exercises have been widely used with adults who suffer from a stroke and/or neurological diseases in order to restore oral motor strength in and also promote accurate articulation.

The results of this study and the work of Poole support the screening of feeding skills as part of a comprehensive articulation evaluation. Additionally, those that seek evaluation for feeding and swallowing difficulties might also benefit from articulatory screening. Although, we were only able to assess trends within this small case series, there were consistencies between articulatory and feeding errors across participants and this subject would benefit from further investigation.

Future Studies

Future studies should focus on increasing recruitment to further analyze the relationship between articulatory and feeding errors. This will provide more substantial evidence to support Poole's research and this small case series to demonstrate more of a relationship between articulatory and feeding errors. This would also allow more support for the implementation of an articulatory screener for those who present with feeding difficulties and a feeding screener for those who present with articulatory difficulties in speech. Children with a diagnosis of childhood apraxia of speech could also be included to understand the relationship of motor planning disorders as a result of feeding and swallowing skills. Gender differences would also be a focus area for future studies. We were only able to have one female participant, and gender is said to play a role in the development and acquisition of sounds. This study could also be continued into the elderly population to see if those who demonstrated articulation difficulties at a young age demonstrate related feeding skill deficits in old age. Future participants who may have different neurological make-ups should also be considered to determine if this is a factor in participants abilities to motor plan, articulate sounds and feed properly.

Limitations

Limitations of this study included: small sample size, limited numbers of children with articulation disorder, stages of therapy, and single errors. Ten participants were initially recruited for inclusion, but due to cancellations, loss of video data, disqualifying articulation test scores, and lack of responses on articulation test, the final number of participants was only three. Small sample size limited statistical analysis and applicability of results. Many of the children receiving articulation therapy at UA SHC scored within the mean for their age and gender on the Goldman Fristoe Test of Articulation-III. Their score disqualified them from inclusion in data analysis because it confirmed presence of isolated articulation issues (one or two sounds) and not a true articulation disorder. Our participants were also at different stages in their therapy. Participant five has been in therapy for one year. Participant 13 had just begun therapy a month prior to the completion of the study, and participant 15 has been in therapy for over three years. This plays a factor into each participant's errors, but also the types of errors they are producing and the types of error that they have already began to overcome.

Conclusion

Findings from this small case series suggest a relationship between articulation and feeding skills. Although there was a small sample size, there was evidence of shared speech errors and shared feeding deficits. This supports the findings of Poole's (1934) research that suggested motoric development during feeding impacts articulation skills (1934). With the exception of participants 13 and 15 for bilabial production, the participants demonstrated deficits in both areas when one area (articulation or feeding) was deficient. Participants in this study consistently missed many of the same sounds in the same positions of words. Age was not a factor in these results because sounds that were appropriate for an older child (six years) were still not achieved in all three participants (ages ranging from four to six years). There is limited generalizability of these results; however, sufficient evidence is provided to warrant further investigation.

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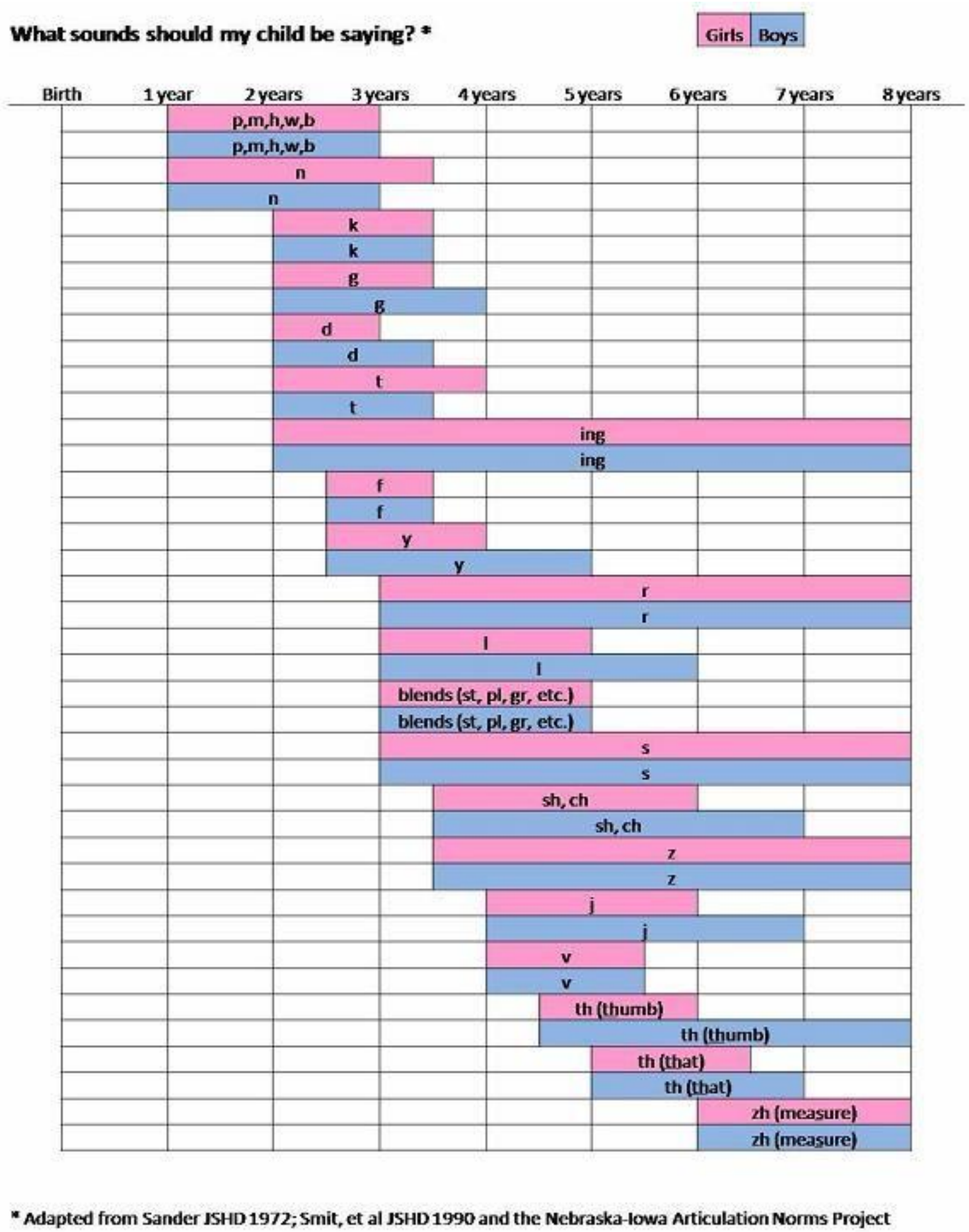
APPENDIX A


What sounds should my child be saying? *
Girls
Boys
Birth
1 year
2 years
3 years
4 years
5 years
6 years
7 years
8 years
p,m,h,w,b
p,m,h,w,b
n
n
k
k
g
g
d
d
t
t
ing
ing
f
f
y
y
r
r
l
l
blends (st, pl, gr, etc.)
blends (st, pl, gr, etc.)
s
s
sh, ch
sh, ch
z
z
j
j
v
v
th (thumb)
th (thumb)
th (that)
th (that)
zh (measure)
zh (measure)
* Adapted from Sander JSHD 1972; Smit, et al JSHD 1990 and the Nebraska-Iowa Articulation Norms Project

APPENDIX B

Goldman Fristoe Test of Articulation-3 Sounds-in-Words

Sounds-in-Words (Ages 2:0–21:11)

Item	Target Word	IPA Transcription	Response	Initial	Medial	Final
1	house	haus		h		s
2	door	dɔr		d		r
3	pig	pɪg		p		g
4	cup	kʌp		k		p
5	boy	bɔɪ		b		
6	apple	æpəl			p	l
7	go	go		g		
8	duck	dʌk		d		k
9	quack	kwæk		kw		k
10	table	tebəl		t	b	l
11	monkey	mʌŋki		m	ŋ k	
12	hammer	hæmɚ		h	m	ɚ
13	fish	fɪʃ		f		ʃ
14	watch	wɑtʃ		w		tʃ
15	spider	spaɪdɚ		sp	d	ɚ
16	web	wɛb		w		b
17	drum	drʌm		dr		m
18	plate	plet		pl		t
19	knife	naɪf		n		f
20	shoe	ʃu		ʃ		
21	slide	slaɪd		sl		d
22	swing	swɪŋ		sw		ŋ
23	guitar	gətɑr		g	t	r
24	lion	laɪən		l		n
25	chair	tʃɛr		tʃ		r
26	soap	sop		s		p
27	glasses	glæsɪz		gl	s	z
28	tiger	taɪgɚ		t	g	ɚ
29	puzzle	pʌzəl		p	z	l
		Items 1–29 Subtotals				
30	finger	fɪŋgɚ		f	ŋ g	ɚ
31	ring	rɪŋ		r		ŋ
32	thumb	θʌm		θ		m
33	elephant	ɛləfənt			l f	nt
34	vacuum	vækjum		v	k j	m
35	shovel	ʃʌvəl		ʃ	v	l
36	teacher	titʃɚ		t	tʃ	ɚ
37	zebra	zibrə		z	br	
38	giraffe	dʒəræf		dʒ	r	f
39	vegetable	vɛdʒtəbəl		v	dʒ t b	l
40	brushing	brʌʃɪŋ		br	ʃ	ŋ
41	blue	blu		bl		
42	yellow	jɛlo		j	l	
43	brother	brʌðɚ		br	ð	ɚ
44	frog	frɔg		fr		g
45	green	grin		gr		n
46	that	ðæt		ð		t
47	leaf	lif		l		f
48	cookie	kuki		k	k	
49	cheese	tʃiz		tʃ		z
50	pajamas	pədʒɑməz		p	dʒ m	z
51	teeth	tiθ		t		θ
52	princess	prɪnsɛs		pr	n s	s
53	crown	kraun		kr		n
54	truck	trʌk		tr		k
55	red	rɛd		r		d
56	juice	dʒus		dʒ		s
57	zoo	zu		z		
58	star	stɑr		st		r
59	five	faɪv		f		v
60	seven	sɛvən		s	v	n
		Items 30–60 Subtotals				
		Transfer Items 1–29 Subtotals here				
		Total Raw Score				

Note. Misarticulation or omission of one or more phonemes in a cluster counts as one error. Distortions are counted as errors.

Adapted Pre Feeding Skills Checklist

Oral Motor Skills Checklist

For oral skills consolidated >24 months

Food/skill area	Skill	Skill met? Y/N
1. Open cup drinking	No **liquid loss** during drinking or when cup is removed from the lips	
	Uses up-down jaw pattern with cup held between the lips for **consecutive sips** (score 0 if no consecutive sips)	
	Not biting on cup for stabilization	
OR	**Total** (≤2=FAIL)	/3
1. Pop-top bottle/straw drinking	Sequences **3 suck-swallows** without pause	
	Swallowing follows sucking with no pause, and **no coughing/choking** is observed	
	No liquid is lost during sucking	
	Total (≤2=FAIL)	/3
2. Pureed food	**No tongue protrusion** beyond incisors during swallowing	
	No loss of food observed	
	Tongue and lip movement are independent of jaw movement when clearing the spoon (score 0 if not actively using upper lip to clear, if biting on spoon, or if spoon needs to be flipped to clear)	
	Total (≤2=FAIL)	/3
3. Chewable/ crunchy food	**No tongue protrusion** beyond incisors during swallowing	
	Tongue lateralization observed for chewing (score 0 if using fingers to assist)	
	Minimal loss of food/no mess observed	
	Takes an **adequately sized bite** without associated head/hand movement and with **appropriate jaw grading** for chosen food (score 0 if 'munching' or overstuffing mouth)	
	Total (≤3=FAIL)	/4
	Overall Total (cup drinking OR pop-top scores)	/10
0 areas failed=WNL; 1 area failed=mild delay; ≥2 areas failed=moderate delay		

Adapted from Morris, S. E. & Klein, M. D. (2000) *Pre-Feeding Skills: A Comprehensive Resource for Mealtime Development,* Therapy Skill Builders, United States of America.

Dodrill and Marshall (2016)

IRB CERTIFICATION

THE UNIVERSITY OF ALABAMA® | Office of the Vice President for Research & Economic Development
Office for Research Compliance

January 22, 2018

Memorie Gosa, Ph.D.
Assistant Professor
Department of Communicative Disorders
College of Arts & Sciences
The University of Alabama
Box 870242

Re: IRB # 17-OR-238-B "Swallowing and Feeding Development and Disorders Research Database"

Dear Dr. Gosa:

The University of Alabama Institutional Review Board has reviewed the revision to your previously approved expedited protocol. The board has approved the change in your protocol.

Please remember that your protocol will expire on July 18, 2018.

Should you need to submit any further correspondence regarding this proposal, please include the assigned IRB application number. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants.

Good luck with your research.

Sincerely,

Carpantato T. Myles, MSM, CIM, CIP
Director & Research Compliance Officer
Office for Research Compliance

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