**School of Psychology**

**Human Communication Science**

# The Relationship between Early Feeding and Communication Development in Preterm and Term Infants: Birth to 12 months.

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**This thesis is presented for the Degree of**
**Doctor of Philosophy**
**of**
**Curtin University of Technology**

**October 2008**

**Declaration**

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: ……………………………………

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# ABSTRACT

The relationship between feeding development and early speech production has received increasing interest over the past 30 years. If a relationship between the motor control systems for feeding and communication is present, it could have implications for the early identification of communication deficits in children. Theoretical support exists for a relationship between the feeding and speech motor systems based on evolutionary theory (Blanchard, 1963), and anatomical similarities in oral motor function (Morris, 1985, 1990, 1991, 1998). However, the existence of a causal relationship between early feeding and communication development remains uncertain due to a lack of empirical research. A model proposed by Carpendale and Lewis (2004) encompasses the triadic interaction between the environment, maternal factors, and infant factors, which can influence both feeding and communication development.

Clinical feeding assessments typically employed by clinicians and researchers are most often carried out with observational checklists. Data reflecting the theoretical foundation, validity, and reliability for these tools are limited. Observation tools assess specific aspects of feeding and oral motor control from a modular perspective, without regard for the infant's total feeding system. Rogers and Arvedson (2005) highlighted the need for a single standardised assessment tool to assess infant feeding descriptively and objectively.

The primary aim of the project was to determine whether the same motor control mechanisms are utilised for oral feeding and communication. The first stage of the study involved the development of a theoretically informed assessment protocols to document systematically the development of feeding skills from birth, the Feeding Assessment Observation (FAO) and the Feeding Assessment Questionnaire (FAQ). The assessment protocol was piloted on 10 term and 10 preterm infants at 1 to 2 weeks, 4, 8 and 12 months corrected age (CA) for preterm infants and chronological age for term infants.

The second stage of the project examined the progression of feeding and communication development in a group of term and preterm infants over a 12 month period. The progression of 8 preterm and 7 term infants was observed at 1-2 weeks, 4, 8 and 12 months CA and chronological age for term infants. The mean gestational age for preterm infants was 30 weeks, 6 days (*SD* = 6.8 days), and term infants was 39 weeks, 5 days (*SD* = 9.4 days). Assessment of the infants' feeding and communication skills, environmental and maternal influences was conducted using the initial questionnaire, Feeding Assessment Observation (FAO), Feeding Assessment Questionnaire (FAQ), Home Screening Questionnaire (HSQ), Receptive Expressive Emergent Language Scale, second edition (REEL-2), and the infant-toddler checklist of the Communication and Symbolic Behavior Scales Developmental Profile (CSBS-DP), to determine the nature and impact of environmental and social factors on feeding and/or communication development.

Preliminary reliability testing of the FAO was conducted. Sixty seven percent (10/15) of observation items achieved greater than 90% inter-observer agreement. There was no significant difference in feeding and communication development between term and preterm infants. The negative linear trend for the development of feeding efficiency on liquids for infants was opposed to the positive linear trend for communication development. Infant feeding efficiency on solids showed parallel positive linear developmental trends with communication development. Comprehensive data were collected on influencing factors from infant, maternal and environmental domains during the initial assessment, and the 4, 8 and 12 month CA developmental reviews. The data revealed significant differences between the term and preterm groups for infant and environmental factors, but no significant differences were found for maternal influences.

The study provided some support for the hypothesis of integrative motor control and co-development of feeding and communication. The prediction that infant, maternal, and environmental factors would significantly influence feeding and communication development was not supported. In addition, there was no difference in the impact of influencing factors for the term and preterm groups. The feeding and communication skills of preterm infants developed at corrected age levels, and were not significantly slower than term infants. Furthermore, predicted delays in feeding development were not associated with concomitant delays in communication development for

term and preterm infants. Further investigation of the subsequent communication development of infants with definitive feeding difficulties and with a larger sample is suggested.

SUMMARY OF CONTENTS

This thesis is comprised of ten chapters. The first chapter is divided into two parts. The first part will provide a theoretical overview of the literature examining the relationship between feeding and communication development. The second section introduces a theoretical framework to outline factors affecting infant development, and discusses the impact of infant, maternal, and environmental factors on infant development.

The second chapter introduces theories of motor control, and proposes two alternative perspectives; the evidence to support related motor control for feeding and communication development, and unrelated motor control systems. The final section of the chapter introduces the aims and hypotheses of the current study.

The third chapter comprises two sections. The first section describes a critical evaluation of existing tools used to assess feeding and communication skills in infants, and highlights the inadequacy of these feeding assessments for this study. The second section describes the development of the theoretical framework to interpret infant feeding, and the subsequent development and preliminary validation of the feeding observation tools. This chapter also addresses inter-observer agreement.

The fourth chapter introduces the methodology and results of the second stage of the project. It outlines the participant details, materials, and procedures for the collection of data. The fifth chapter provides results of comparative analyses between preterm and term infants for influencing infant, maternal and environmental factors. Chapter six provides results for the feeding development, and chapter seven the communication development of term and preterm infants. Chapter eight outlines the results for the relationship between feeding and communication skills in term and preterm infants.

The ninth chapter includes a discussion of the results obtained during this study in light of the current literature. The discussion contains three sections, the first section provides an evaluation of the feeding assessment protocols developed during the study. The second section highlights the impact of prematurity and other factors on the development of feeding and communication skills. The final section presents strengths and limitations of the study and proposes directions for future research. Chapter ten concludes with a summary of the project outcomes.

# LIST OF PUBLICATIONS ARISING FROM THE THESIS

*Publications prior to November 2004 were published under the name Massey, S.*

## Written Publications

Massey, S., Hird, K, & Simmer, K. (2004). Relationship between early feeding and communication development in infants: Birth to 12 months, *Journal of Pediatric Gastroenterology & Nutrition, 39*(2), 227-228.

## Oral Presentations

Smart, S., Hird, K, & Simmer, K. (2005). Relationship between early feeding and communication development in infants, *American Speech-Language-Hearing Association Conference, San Diego, California, United States,* 19th November 2005.

Smart, S., Hird, K, & Simmer, K. (2005). Relationship between early feeding and communication development in preterm and term infants: Birth to 12 months, *The Mark Liveris Health Sciences Student Research Seminar,* Curtin University, Perth, Western Australia, 10th November 2005.

Smart, S., Hird, K, & Simmer, K. (2005). Relationship between early feeding and communication development in preterm and term infants: Birth to 12 months. *Women and Children's Health Service Allied Health Clinical Service Unit.* Subiaco, Perth, Australia, 11th & 18th July 2005.

Massey, S., Hird, K, & Simmer, K. (2004). Relationship between early feeding and communication development in infants: Birth to 12 months, *Curtin University Human Communication Science Mini Conference,* Curtin University, Perth, Western Australia. 6th November 2004.

Massey, S., Hird, K, & Simmer, K. (2004). Relationship between early feeding and communication development in infants: Birth to 12 months, *10th Denis Glencross Memorial Student Conference,* South Perth, Western Australia. 30th August 2004

**Poster Presentations**

Massey, S., Hird, K, & Simmer, K. (2004). Relationship between early feeding and communication development in infants: Birth to 12 months, *26th World Congress of the International Association of Logopedics and Phoniatrics,* Brisbane, Queenland, Australia. 1st September 2004

Massey, S., Hird, K, & Simmer, K. (2002). The relationship between feeding and communication development in pre-term and term infants: birth to 12 months, *The Mark Liveris Health Sciences Student Research Seminar,* Curtin University, Perth, Western Australia. 7th November 2002.

# SCHOLARSHIPS AND AWARDS

## Scholarships

Curtin University Completion Scholarship, 2005, $6,000

Princess Margaret Hospital PhD Scholarship, 2003, $17,000 per annum for 2 years

Speech Pathology Australia Nadia Verrall Scholarship, 2002, $2,000

## Grants

Women and Infants Research Foundation Grant, 2003, $14,735

Princess Margaret Hospital Seeding Grant, 2002, $5,000

## Awards

American Speech Language Hearing Association Student Travel Award, 2005, US$500

Mark Liveris Research Seminar Student Award, 2002, $50

# ACKNOWLEDGEMENTS

I would like to thank and acknowledge the many people who have assisted in the initiation and completion of this thesis.

Firstly, thank you to my supervisor Associate Professor Kathryn Hird, for your guidance and direction at all stages of this thesis. Thank you for your ongoing support, motivation, direction and supervision. Thank you also to co-supervisor Professor Karen Simmer and the thesis Chairperson Associate Professor Jan Piek for your valuable feedback, support and expertise, for your orientation to the neonatal nurseries, and access to participants at King Edward Memorial Hospital. I would also like to acknowledge Dr Neville Hennessey, Janet Beilby, Chantelle Highman, and Dr Suze Leiteo for your constructive feedback and assistance editing and proof-reading the thesis.

Thank you Dr Giselle Mann for igniting my interest in paediatric dysphagia during third year dysphagia lectures. She arranged a clinical placement at the Children's Hospital of Buffalo, in New York State, United States of America working with Dr Joan Arvedson, Speech-Language Pathologist and her staff working with infants and young children with feeding difficulties and dysphagia. These experiences inspired a passion and motivation to work with infants with feeding problems. Thanks also to Professor Sheena Reilly and Janet Beilby for your encouragement to commence postgraduate research investigating the topic of feeding and speech relations in infants.

I would like to thank the infants, parents and siblings for your participation in this project. I am grateful for you making time to see me, and welcoming me into your home every 4 months. Thank you also to Shanni Faulkner from Ward 3, King Edward Memorial Hospital for assisting to find suitable term infants participants, and the staff from the special care and high dependency units at King Edward Memorial Hospital for your cooperation recruiting preterm infants. Thanks also to Priya Karia and the third year students during 2004 for your assistance with inter-rater reliability testing. I would like to thank fellow PhD students and close friends for sharing the journey and for your ongoing morale support.

I would like to thank my parents Steve and Jackie Massey for having faith in me to complete this thesis, with the added motivation of being the first ‘Massey’ to write a doctoral thesis. Finally and most importantly, I would like to thank my husband Michael, for your ongoing support and for delaying much anticipated work and travel plans to enable completion of this thesis.

# 1.0 INTRODUCTION

## 1.1 Feeding and speech

The existence of a causal relationship between early feeding and communication skills has been suggested in the literature (Alexander, 1983; Anderson, 1998; Blanchard, 1963; Broad, 1972a, 1972b; Case-Smith & Humphry, 1996; Davis-McFarland, 2000; Drane & Logemann, 2000; Hiiemae & Palmer, 2003; Lund, 1998; Mathisen, 2001; Morris, 1991, 1998; Rommel et al., 1999; Sjoegreen, Andersson-Norinder, & Jacobsson, 2001; Smith & Gerber, 1993; Starr, 2003; Willett, 1994). However, the presence of separate mechanisms for feeding and speech motor control remains uncertain due to a lack of empirical research. The relationship is important however, as the skills acquired during feeding development are assumed to form a basis for later communication development (Arvedson & Brodsky, 2002). Early identification of developmental speech and language difficulties could be signalled in infants with feeding difficulties at birth. If this were the case, it may be possible to provide very early intervention to reduce the risk of later developing speech and language difficulties.

Feeding problems can be seen in 25 to 35% of normally developing children, and 33 to 88% of developmentally delayed children (Burklow, Phelps, Schultz, McConnell, & Rudolph, 1998). Speech and language disorders occur in 1 to 32% of normal children in the population, and are the most prominent developmental difficulties experienced by 3 to 16 years old children (Busari & Weggelaar, 2004). Twenty six to 92% of children with delayed or disordered communication referred to a Speech Pathology department had a history of feeding difficulties (Treharne, 1980). Mathisen (2001) suggested that infant swallowing and early communication are related, but explained that the relationship was not immediately obvious. Although therapy cannot address speech development in infants, treatment for feeding problems can provide a foundation for speech production in infants (Kumin, Von Hagel, & Bahr, 2001). If a relationship between feeding and communication development is indicated, management to address infant feeding difficulties can be implemented, to ensure the feeding system is operating to optimal efficiency. As a result, the speech motor control system could be enhanced.

Theoretical support for a relationship between the feeding and speech motor systems has emerged from evolutionary theory (Blanchard, 1963), motor control theory (Alexander, 1983, 1987; Broad, 1972b; Fluehr, Cress, & Spilker, 2004; Hiiemae & Palmer, 2003; Iverson & Fagan, 2004; Mathisen, Worrall, O'Callaghan, Wall, & Shepherd, 2000; Palmer & Heyman, 1999), and the shared anatomical structures required for all oral motor functions (Arvedson & Lefton-Greif, 1996; Broad & Duganzich, 1983; Hiiemae & Palmer, 2003; Morris, 1985, 1990, 1991, 1998; Morris & Klein, 1987; Starr, 2003; Wolfe & Glass, 1992). Further evidence to support the relationship has been derived from studies involving specific disordered populations, including children with cerebral palsy (Field, Garland, & Williams, 2003; Morris, 1985), cleft lip and palate (Jocelyn, Penko, & Rode, 1996; Kumin et al., 2001), Down Syndrome (Field et al., 2003; Kumin et al., 2001) and Moebius sequence (Sjoegreen et al., 2001). The importance of additional investigation focussing on infant intervention and later developmental outcomes has been highlighted in a number of studies (Mathisen, 2001; Morris, 1985; Smith & Gerber, 1993).

Whilst the theoretical coherence and anecdotal clinical reports have alluded to the relationship between the development of feeding and speech, only one study has examined and found a correlation between feeding and speech in preterm and term infants (Willett, 1994). The study included two sets of triplets, a preterm group born at 33 weeks gestation, and a second group born at 37 weeks gestation. The children were seen at 3 years 7 months to 3 years 8 months for an oral motor examination, articulation test, and an informal language sample. Retrospective data were collected on the infants' feeding histories. The authors observed that the group of preterm infants who had feeding disorders were significantly less intelligible on their articulation test, and demonstrated significantly more phonological processes than the control group (Smith & Gerber, 1993; Willett, 1994). The study did not account for contributing infant, maternal, or environmental factors, and the author acknowledged large variability within the small sample (Willett, 1994).

### 1.2 Integrated theoretical framework

Historically, neuromaturational frameworks formed the basis of infant development in the 1930s, proposing that motor skills develop at a predetermined time and sequence by volitional movement patterns (Abbott & Habel, 1999). According to this framework, individual aspects of child development operate in isolation from one another. A dichotomy exists to account for the processes or factors that can disrupt the normal development of feeding and communication. Feeding difficulties have sometimes been classified as organic or non-organic in origin, although that dichotomy is now rarely used. Organic difficulties refer to structural abnormalities. neuromuscular, or other physiological reasons. Non-organic feeding disorders were influenced by social and environmental disruptions (Burklow et al., 1998; Rommel, De Meyer, Louw, & Veereman-Wauters, 2003). Burklow et al. (1998), however, found that the majority of feeding disorders cannot be classified into a simple dichotomy, and suggested that feeding disorders typically emerge in response to a combination of organic and non-organic problems. Therefore, feeding disorders can no longer be classified into a simple dichotomy (Locklin, 2005). Thus, a multidimensional view is required in the assessment of feeding difficulties.

The 1980s and 1990s saw the introduction of dynamic systems theories to approach infant development (Fogel & Thelen, 1987; Smith & Thelen, 2003; Thelen, 1992; Thelen, Kelso, & Fogel, 1987; Thelen, Skala, & Klso, 1987; Thelen & Smith, 1994). Dynamic systems theory proposes that a number of factors and subsystems contribute to infant motor development (Abbott & Habel, 1999), and that an infant's experiences and interpretation of the world are influenced by multiple systems interacting in the dynamic system to achieve a functionally orientated motor goal (Thelen & Smith, 1994).

A similar debate is present in literature on speech and language acquisition in infants. One theory suggests that language acquisition in infants is innate, and that infants have a natural genetic predisposition to learn language (Stromswold, 2000). The alternative argument suggests that language can be modified and adapted based on environmental influences (Kuhl, 2004). Some theorists propose that 'critical periods' are present in language acquisition, suggesting skills are more difficult to master once the sensitive period lapses (Kuhl, 2004; Locke, 1997).

Whilst Figure 1 illustrates a developmental timeline of communication skills, and changes in speech perception and production from birth to 12 months, the simultaneous maturation of skills required for feeding could also be included.

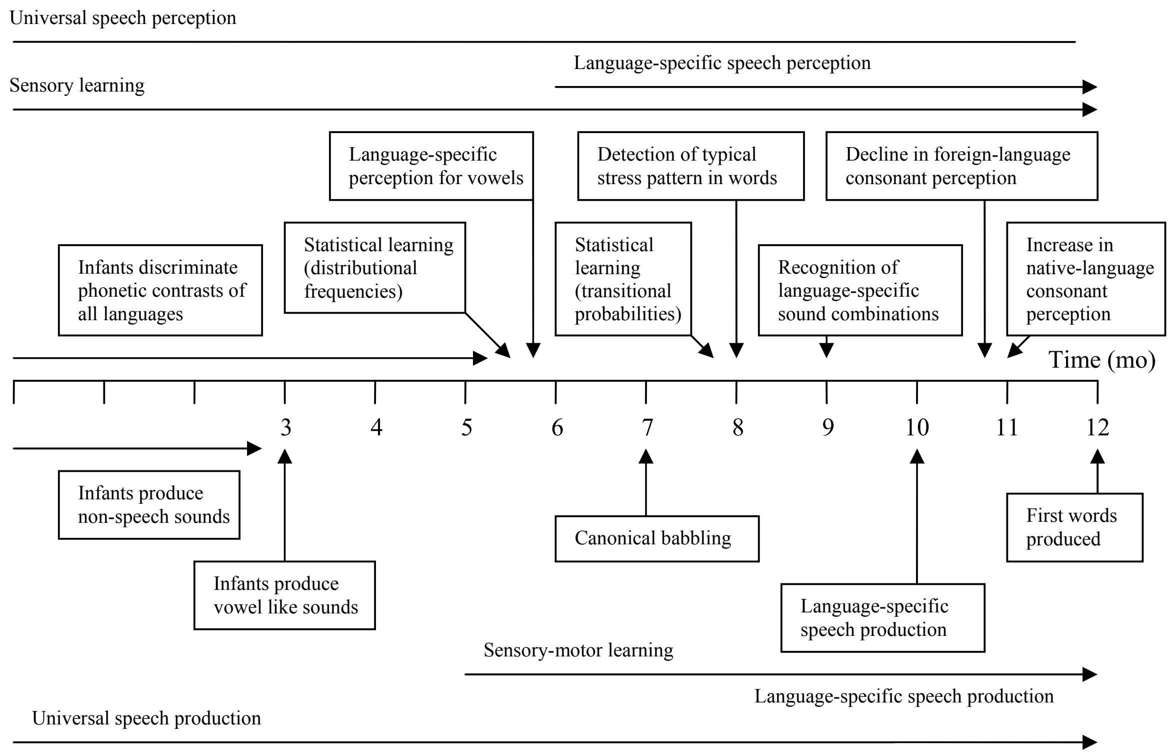


*Figure 1.* Timeline of Speech Perception and Speech Production Development from Birth to 12 months.

*Note.* From 'Early Language Acquisition: Cracking the Speech Code', by P. K. Kuhl, 2004, *Nature Reviews Neuroscience, 5(11),* p. 831-843.

A model proposed by Carpendale and Lewis (2004) encompasses the triadic interaction between the environment, maternal characteristics, and the infant's development. Figure 2 illustrates this triadic interaction model described by Carpendale and Lewis (2004). In practical terms, this theory proposes that when an infant is born, the interaction between the infant and caregiver is dyadic, however, towards the end of the infant's first year of life the interaction becomes triadic between the infant, caregiver and objects in the environment (Carpendale & Lewis, 2004). Although the framework was used to describe the development of theory of mind in children, it can be constructively applied to numerous facets of infant development, including feeding and communication. The model provides theoretical motivation to explore the spectra of factors that impact on the simultaneous development of feeding and speech (Carpendale & Lewis, 2004). They also provide a framework to discern the probable causes and relationships between developmental feeding and speech impairments.

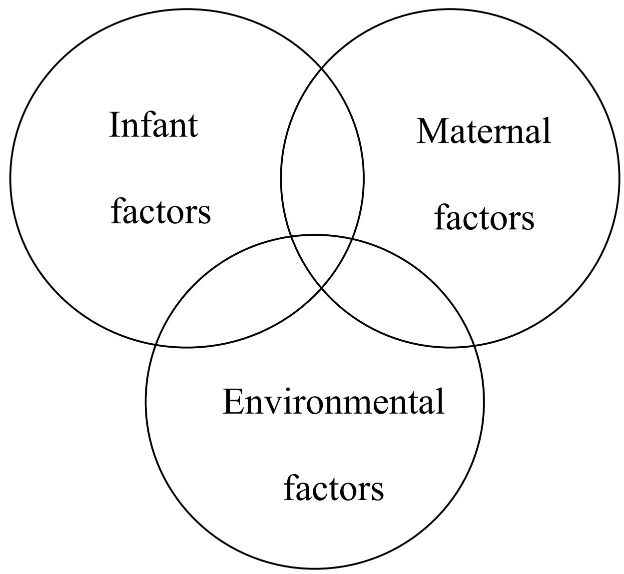


*Figure 2. Triadic Interaction of Infant, Maternal and Environmental Influences.*

*Note.* From 'Constructing an Understanding of Mind: The Development of Children's Social Understanding within Social Interaction', J. I. M. Carpendale and C. Lewis, 2004, *Behavioral and Brain Sciences, 27*, p. 79-150.

The triadic interaction model proposed by Carpendale and Lewis (2004) proposes that a number of complex and indirect factors can have an impact upon an outcome, and that they do not occur as a direct result of a contributory factor (MacKendrick, 2006). MacKendrick (2006) reiterated the consideration of contributory factors, including maternal and environmental factors when investigating the neurodevelopmental outcomes of preterm infants.

A similar triadic model describes the importance of three factors when assessing risk in neonatal development: (a) perinatal risk factors, (b) psychosocial family factors, and (c) environmental factors (Blackburn, 1986). Anderson (2003) also shows the child's general health and wellbeing are dependent on the complex interaction of multiple motor control systems in development. The model is illustrated in Figure 3.

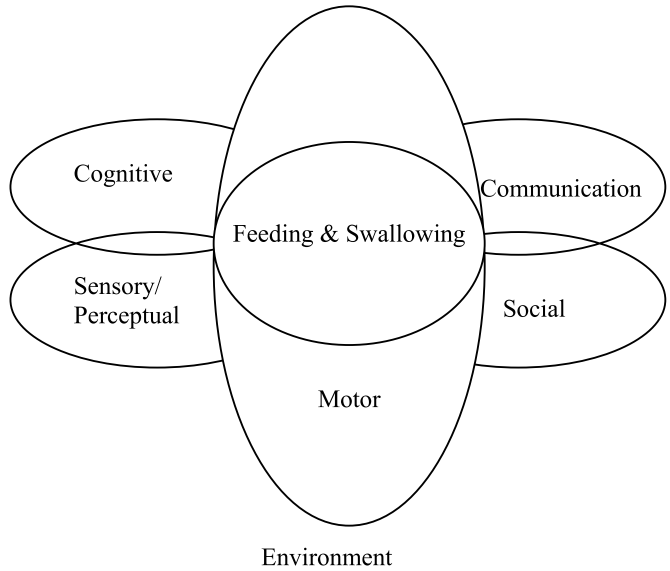


*Figure 3.* Model of General Health and Wellbeing.

*Note.* From 'Feeding Development' by T. Anderson, 2003, Perth, Speech Pathology Australia Professional Development.

The literature outlines a number of factors that have been linked to feeding and communication development in infants. These include gender (Broad & Duganzich, 1983; Rommel et al., 2003), gestational age (MacMullen & Dulski, 2000), weight (MacMullen & Dulski, 2000), medical history (Ramsay, Gisel, McCusker, Bellavance, & Platt, 2002), Apgar scores at 1 and 5 minutes (Juretschke, 2000), and the infant's feeding method at birth (Broad & Duganzich, 1983; Harris, 1986). It is clear that infant development is influenced by factors specific to the infant, carers and the environment. The relative weighting of these factors and their interaction are unknown. Thus, further investigation is required.

## 1.3 Normal development

### *1.3.1 Embryologic development*

Development of the embryo occurs from 2 to 8 weeks gestation, and development of the foetus from 9 weeks gestation until birth (Kuo & Urma, 2006). Full term is 40 weeks gestation. The gastrointestinal tract starts to develop during the second to third week of gestation and taste buds start to form from 8 to 15 weeks gestation (Doughty & Krissovich, 2004; Witt & Reutter, 1996). Swallowing has been seen in week 10 to 14 of foetal development, and is one of the first motor functions (Cajal, 1996). The rooting reflex develops between 12 to 16 weeks in utero (Pinelli, Symington, & Ciliska, 2002). This reflex causes infants to turn their heads in search of a nipple or teat before feeding. In week 15, the foetus shows basic facial expressions, such as squinting, frowning, grasping, sucking the thumb, and the foetus can start to feel pain (Anand & Hickey, 1987). The trachea is still filled with fluid rather than air at this stage, and the foetus frequently hiccups. During week 17, the foetus starts to inhale and exhale amniotic fluid through the lungs. In week 20, the foetus swallows amniotic fluid for the first time and the senses start to develop, including taste, smell, hearing, sight and touch. In week 21 the foetus continues to swallow amniotic fluid. During week 22 the foetus can hear conversations, talking, reading and singing. Sucking responses can be elicited at around 24 weeks gestation in utero (Harris, 1986). At 28 weeks gestation the infants start to coordinate sucking and swallowing , and efficient coordination of suck, swallowing and breathing is achieved at 32 to 34 weeks gestation for some preterm infants, although some may take up to 37 weeks gestation (Pinelli & Symington, 2005). The development of efficient coordination has implications for late preterm or 'near-term' infants – classified as 34+0 weeks to 36+7 weeks gestation – who may demonstrate immature feeding behaviours due to immature muscle tone, state regulation and sucking, swallowing and breathing in-coordination (Bakewell-Sachs, 2007; Ludwig, 2007).

### *1.3.2 Birth to 6 months*

There are a number of primitive oral reflexes present when an infant is born, including the sucking, rooting, lateral tongue, biting, and snout/pout reflexes (Schott & Rossor, 2003; Sheppard, 1984). The rooting reflex can be observed when the infant's cheek is stroked (tactile rooting) or when an object is seen in the infant's field of view (visual rooting). Gentle pressure on the lips or the nasal philtrum will result in the lips pouting or the snout reflex (Schott & Rossor, 2003). The rooting and snout reflexes disappear by 4 to 6 months of age (Sheppard, 1984).

The sucking reflex is a rhythmic motor activity which diminishes at 6 to 12 months of age (Harris, 1986). The terms sucking, suckle feeding and suckling are used interchangeably in the literature, and the primitive oral reflex will be referred to as 'sucking' during this paper (Schott & Rossor, 2003). Sucking occurs in the median or middle part of the infant's mouth and tongue. Effective sucking is measured by coordination of the infant's tongue, lips, and muscles in the infant's cheeks and the hyoid. An infant's sucking skills can vary depending on the type of nipple or teat provided, the presence or absence of fluids, and the viscosity of fluids (Harris, 1986).

The nasal passage, mouth and pharynx provide a channel for the transmission of air to the lungs and food or liquid to the stomach. In the newborn infant, structures within the mouth, including the lips, tongue, hard and soft palate and cheeks are involved in mouth breathing, early vocalisation, and feeding (Wolfe & Glass, 1992).

An infant is required to coordinate sucking, swallowing and breathing effectively in order to feed successfully. Similarly, effective vocalization is achieved when respiration, phonation, and articulation are coordinated. The interaction between these parameters is complex and constitutes the earliest form of oral motor control (Bosma, 1997; Case-Smith & Humphry, 1996). The anatomic structures for sucking, swallowing and respiration are located in close proximity to one another, and their functions and neural control are also closely interrelated (Wolfe & Glass, 1992). The development of rhythmic sucking, and suck and swallowing coordination changes significantly between 32 and 34 weeks gestation (Gewolb, Vice, Schwietzer-Kenney, Taciak, & Bosma, 2001). Table 1 highlights the development of sucking, and suck and swallow coordination in preterm infants by gestational age. MacMullen and Dulski (2000) investigated the impact of a range of maternal, environmental and infant factors on sucking skills in healthy newborn infants from. The study found that an infant's weight, state and gestational age were most correlated with sucking abilities in term newborn infants.

Table 1. *Development of Sucking, and Suck and Swallow Coordination in Preterm Infants*

| | *32-34 weeks* | *33 weeks* | *34 weeks* |
|---|---|---|---|
| Sucking | Rapid, low amplitude | Irregular deflection 2-3/second | 1 suck/second |
| Suck/swallow | Poor coordination | Poor coordination | Suck/swallow dyad |

*Note.* From 'Developmental Patterns of Rhythmic Suck and Swallow in Preterm Infants', by I. H. Gewolb, F. L. Vice, E. L. Schwietzer-Kenney, V. L. Taciak, J. F. Bosma, 2001, *Developmental Medicine and Child Neurology*, *43*, 22-27.

Two forms of sucking are frequently discussed: nutritive and non-nutritive. They have different rhythms, rates and suck to swallow ratios, pressures and flow rates for nutritive sucking. Nutritive sucking occurs when fluids are ingested during sucking. Non-nutritive sucking occurs when the infant sucks on an object and no fluid is extracted, such as sucking a finger or pacifier (Hafstrom & Kjellman, 2000, 2001; Johnston, 1999; Medoff Cooper & Ray, 1995; Meza, Powell, & Covington, 1998; Pickler & Reyna, 2004; Pinelli & Symington, 2001; Pollard, Fleming, Young, Sawczenko, & Blair, 1999; Standley, 2000; Webster, 1999).

The passage of breathing is from the nose or mouth, through the upper airway (pharynx, larynx and trachea) to the lower airway (bronchi and bronchioles) to alveoli in the lungs. Respiration is an integral component with the coordination of sucking and swallowing, and also during phonation and articulation for speech. Adequate functioning of the respiratory system is imperative for an infant to maintain oxygen and carbon dioxide levels in the bloodstream (Wolfe & Glass, 1992). Breast fed infants breathe more frequently during sucking than orthodontic teat bottle-fed infants, and have fewer episodes of oxygen desaturation (Dowling, 1999).

Feeding skills develop from reflexive movements during infancy to more complex adult like patterns when the child reaches around 3 years of age or equivalent developmental skill levels. Similarly, language and speech skills develop significantly during the first few years of life. The infant's engagement in socialisation and early communication is described as 'preintentional' from birth until around 8 months of age (Owens, 1995; Paul, 1995). Young infants can recognise faces and imitate gross gestures a few weeks after birth, can imitate pitch and duration of speech sounds at around 1 month, and learn simple discriminations at around 2 months of age (Bourgeouis et al., 2000; Owens, 1995). The positive interaction between the infant and caregiver encourages communication development. These interactions include turn-taking, imitation, and joint attention (Delgado et al., 2002; Flom & Pick, 2003; Francis, 1981; Kuhl & Meltzoff, 1996;

Reissland & Stephenson, 1999). Turn-taking starts to develop with games like 'peek-a-boo' at 3 to 4 months. A study by Reissland and Stephenson (1999) measured vocalisations and turn-taking in term and preterm infants, at discharge from hospital and at 2 month follow up. No significant difference was found between frequency of vocalisations between preterm and term infants, in hospital and at home (Reissland & Stephenson, 1999). Mothers of preterm infants engaged in turn-taking with child directed utterances significantly more than mothers of term infants. However, term infants engaged in significantly more turn-taking vocalisations than preterm infants when communicating with their mothers (Reissland & Stephenson, 1999). Infant vocalisations represent a greater range of emotions of anger and happiness at around 5 months of age, than in younger infants. At 6 months, interactions change from dyadic between the infant and caregiver, to a triadic between the infant, mother and objects in the environment (Carpendale & Lewis, 2004; Owens, 1995).

The infant's gross motor and other skills also develop significantly during the first 6 months of life. Carruth and Skinner (2002) conducted a longitudinal study to monitor the gross, fine, and oral motor skills of normally developing infants from 2 to 24 months. They found that infants would lift their head when on their stomach at an average of 1.45 months, bring toys to mouth at 3.29 months, and sit without support at 5.54 months (Carruth & Skinner, 2002). Social milestones that develop before 6 months also include smiling to a stimulus like a face at 3 to 6 weeks and laughing at 16 weeks (Owens, 1995; Paul, 1995).

### *1.3.3 6 to 12 months*

The World Health Organisation (WHO) recommends exclusive breastfeeding until 6 months of age, with the introduction of solids at 6 months of age (World Health Organisation, 2003). The nutritional recommendations were implemented to ensure that infants are developmentally and physiologically ready for solids, in order to provide optimal development, health and growth (Schmitz & McNeish, 1987) (World Health Organisation, 2003). When smooth purees are introduced at 6 months, a suckling pattern is observed to draw the food from the spoon. The infant will try to imitate the suck and swallowing action used during bottle or breast feeding, when smooth purees are introduced by spoon. As neither the teat nor nipple is in the mouth to provide stability on the tongue and lower lip, the tongue protrudes, resulting in an anterior-posterior tongue motion to suckle the food (Reilly, Skuse, Mathisen, & Wolke, 1995; Starr, 2003). This pattern alters gradually as the infant develops increased vertical tongue movements to munch food against the hard palate during the next few weeks and months. Infants will open their mouth when the lips are touched, or the spoon approaches at around 4 months of age (Carruth & Skinner, 2002). At 6 months of age, liquids can be offered from a spout or open cup. Significant anatomic changes occur during the first 6 months of life, when the larynx and hyoid bone descend in the pharyngeal region. As the larynx descends, it enables air to flow through the larynx, pharynx and oral cavity for the production of speech (German & Palmer, 2006).

Illingworth and Lister (1964) suggested that a sensitive period exists at 6 to 7 months of age with infants for the introduction of solids. Infants are reported to be at increased risk of oral motor deficit and of food refusal behaviours if solids are not introduced within this sensitive period. These finding were supported by Northstone and colleagues (2001) who found a significant difference between infants introduced to lumpy purees at 6 to 9 months of age compared to infants greater than 10 months, and their feeding preferences and variety of solids at 15 months of age. They also found that infants were more likely to experience feeding difficulties when lumpy purees were introduced after 10 months of age.

At 9 to 10 months of age, mashed and lumpy purees are usually introduced, and chewing skills start to develop. Chewing differs from sucking and munching, and involves the use of the lateral structures in the mouth, including the lateral gums or molars. Chewing development usually commences when the infant is introduced to more lumpy purees or soft and dissolvable finger foods. The tongue, buccal muscles, gums and teeth, lips, and palate play important roles in the chewing process. The tongue is perhaps the most important muscle in the chewing process, and the ability to move the tongue from side to side, or 'tongue lateralization' is an important precursor for effective chewing. Lumpy purees are introduced at around 8 months of age, and infants are reported to cope with small lumps without gagging at an average of 8.70 months (Carruth & Skinner, 2002). For example, an infant is given a solid meal consisting of soft pasta lumps in a smooth vegetable puree from a spoon. The infant is required to separate the lump from the smooth puree, and to swallow a bolus of smooth puree. The infant is then required to move the subsequent bolus with the tongue to the side gums or teeth to masticate it a few times before returning the bolus to the medial part of the tongue in preparation for swallowing. Tongue lateralisation skills continue to be refined when soft and hard finger foods are introduced. Infants start to finger feed themselves at this time, and a fork can be used to feed mashed and puree foods. Carruth and Skinner (2002) reported that chewing soft foods develop at 9.42 months and firmer foods at 10.53 months of age.

Infants initiate a biting action around the same time that teeth emerge. Biting is different from chewing and refers to the closure of the lips and teeth over food or an object. The upper teeth are referred to as the maxillary teeth, and the lower teeth are mandibular teeth. The lower central incisor teeth emerge at 6 to 10 months, and the upper central incisors between 8 and 11 months. Carruth and Skinner (2002) sampled the development of 98 infants, and the average age of eruption of lower central incisors was at 7.1 months, and upper central incisors at 9.5 months. Similarly, the upper lateral incisors develop between 10 and 13 months, and lower lateral incisors between 10 and 14 months of age (Carruth & Skinner, 2002). Basic chewing patterns develop at around 12 months of age (Green et al., 1997). More efficient rotary chewing develops between 12 and 20 months of age and depends when the infant's molar teeth erupt. Bosma (1997) reported that 60% percent of chewing is on the right side at 2 years and 60% is on the left side for chewing at 4 years of age. Gisel (1988) found that normally developing children from 2 to 8 years of age have a preference for which side food is placed in the oral cavity. This was investigated further by McDonell, Hector and Hannigan (2004) who studied chewing found that 23% of children aged 6 to 8 years had a consistent preferred chewing side, and 69% of children were observed to have a chewing side preference.

Infants demonstrate obvious intentionality to communicate after 6 to 7 months of age. At 7 months, infants can make simple gestures, such as waving goodbye. Turn-taking was observed between infants and caregivers at 8 to 12 months (Owens, 1995). Babbling represents one of the earliest forms of speech motor control in infant development (Kent, 2000). At 7 to 8 months, reduplicated babbling or repetition of the same syllable develops, for example *baba, mama, dada*, and variegated babbling, with different vowels and consonants, *bada, dadi,* at 10 to 12 months (Bleile, 1995; Carrol, 1994).

A number of gross and fine motor developmental milestones are achieved between 6 and 12 months of age, with 95% of infants able to roll from front to back, and back to front at 7 to 8 months of age. Also, 91% of 7 to 8 month old infants can sit alone without support, 88% of 9 to 11 months old infants can crawl when placed on their stomach, and 85% can pull to a standing position without help at 9 to 11 months of age (Carruth, Ziegler, Gordon, & Hendricks, 2004). Infants are able to track maternal pointing and can reach and point at objects at 9 months of age (Owens, 1995).

Accurate reporting of the infant's health during the neonatal period and during the first few years of development is important to determine potential impacts for the infant's feeding and communication development. Conway (1989) investigated the feeding skills in a group of 16 term bottle-fed infants when ill with a respiratory illness and when well. The infants demonstrated a more coordinated suck, swallow, and breathe cycle when well, compared to an uncoordinated, erratic suck-pause pattern and poor lip seal around the nipple or teat when they were ill. They also showed increased respiratory distress and irregular respiratory patterns whilst unwell (Conway, 1989). Therefore, the extent of respiratory difficulties reported during the neonatal period, and frequency and duration of respiratory illnesses during the infant's first year of life, may impact on the infant's feeding ability.

The language skills of male infants are reported to develop slower than females (Jennische & Sedin, 2003; Largo, Molinari, Comenale Pinto, Weber, & Duc, 1986). Females score lower in speech motor skills and interaction, motivation, but clearer articulation skills. In contrast, males demonstrate higher auditory memory skills, but below average speech motor and spontaneous speech (Largo et al., 1986).

## 1.4 Prematurity

Prematurity is defined as the birth of an infant before 37 weeks gestation (Brust, 1987; Moutquin, 2003). Eighty five percent of preterm births occur between 32 and 36 weeks gestation, and the World Health Organisation classifies the 10% of preterm infants born between 28 and 31 weeks gestation as ‘very preterm’, infants born below 28 weeks gestation are considered ‘extremely preterm’ (Moutquin, 2003). Term infants are defined as being born between 37 week and 42 weeks gestation (Mittendorf, Williams, Berkey, & Cotter, 1990).

During this thesis, gestational age (GA) refers to the number of weeks since the mother’s last menstrual period. Postconceptional age (PCA) will refer to the time since the infant was conceived. Chronologic age or post natal age (PNA) refers to the time since the infant’s birth. Corrected age (CA) is based on the age the child would be if the pregnancy had actually gone to term. For example, an infant born at 30 weeks gestation and is currently 11 weeks old, the infant has a GA of 30 weeks, the PNA is 11 weeks, PCA is 39 weeks and CA is 1 week.

Prematurity can also be classified by birth weight. Infants born over 2,500 grams are considered average weight, infants born between 1,500 and 2,500 grams as low birth weight (LBW), 1,000 to 1,500 are very low birth weight (VLBW), and infants born below 1,000 grams are identified as extremely low birth weight (ELBW) (Hunter, 2003). Small for gestational age (SGA) babies are defined as those whose weight is 2 times the average less than expected for their gestational age; this includes preterm, term and post-term infants (Karlberg & Albertsson-Wikland, 1996).

### *1.4.1 Feeding*

Different neuromotor behaviours can be observed in preterm infants compared to term infants (Bartlett & Piper, 1993). Infants born prematurely are more likely to have feeding disorders (Rommel et al., 2003). Enteral feeding is usually delayed in preterm infants until their respiratory and cardiac systems are stable (Harris, 1986). Orogastric or nasogastric feeding tubes may be inserted to provide adequate nutrition and nourishment for the infant. Tube feeds are typically a transitional process until adequate oral intake is achieved. Rommel et al. (2003) found that infants who had a nasogastric tube had significant oral motor and oral sensory feeding difficulties. A significant correlation was also found between infants with a history of ventilation and aspiration during the first 6 months of life and oral sensory feeding difficulties (Rommel et al., 2003).

Gaebler and Hanzlik (1996) found preterm infants to have better sucking skills if oral motor stimulation was provided in the Special Care Unit after birth. They studied 9 experimental and 9 control infants. Parents and nursing staff of experimental group participants had 10 minutes of verbal instruction, demonstration, and practice, with written notes and diagrams also provided. Parents and nursing staff were advised to carry out the program 3 times a day, 5 days a week. The protocol included perioral and oral motor stimulation, with firm rubbing on the side and around the mouth, and rubbing the upper, lower and side gums, and hard palate. Infants who had received the oral motor stimulation had a higher sucking score on the Neonatal Oral-Motor Assessment Scale (NOMAS) assessment, fewer non-oral feedings, increased weight gain and decreased hospital stay (Gaebler & Hanzlik, 1996; Palmer, Crawley, & Blanco, 1993). Hill and colleagues (2000) found that infants without oral support paused more frequently and for a longer duration during feeding. Similarly infants who received oral, cheek and jaw support demonstrated better sucking efficiency, with greater volume intake. The thumb and index finger were used to provide cheek support, and support with the middle finger was placed under the protuberance of the mandible (Einarsson-Backes, Deitz, Price, Glass, & Hays, 1994; Hill et al., 2000).

There are a number of oral readiness indicators to consider before introducing a preterm infant to oral feeds. Daley and Kennedy (2000) conducted a meta-analysis to determine what interventions positively influence feeding efficiency and performance. They suggested that the infant's post conceptional age (PCA) and development outcomes should be considered, and the length of time of tube feedings should be minimised. They also suggested that oral stimulation and support should be provided as proposed by Einarsson-Backes et al. (1994). The presence of complicating medical factors, such as digestive, respiratory, and cardiac complications, has been significantly correlated with longer transition time to oral feeding in preterm infants (Bazyk, 1990). In contrast, Lemons (2001) suggested that an infant's gestational age is the main indicator of readiness for oral feeding. He reported that time taken for transition to full oral feeds is reduced in older infants. He therefore proposed that oral feeds should be introduced at a later gestational age to reduce unnecessary stress on the infant's fragile system in order to shorten the transition period to full oral feeds (Lemons, 2001).

Overall, preterm infants are reported to have less developed sucking and rooting reflexes and demonstrate less crying than their term counterparts (Bartlett & Piper, 1993; Conway, 1989; Daley & Kennedy, 2000; Howard, Parmalee, Kopp, & Littman, 1976). They demonstrate less variation in weaker motor skills throughout the first year, and attain motor milestones later than the term infants (Bartlett & Piper, 1993; Magill-Evans, Harrison, Van der Zalm, & Holdgrafer, 2002).

### *1.4.2 Communication*

Conflicting results have been reported whether preterm infants experience delays in cognitive and language development. A sample of preterm infants without significant health problems scored significantly lower receptive and expressive language skills and performance intelligence quotient (IQ) at 10 years of age compared to term infants (Crnic, Ragozin, Greenburg, Robinson, & Bashham, 1983). A longitudinal investigation of 79 mother-infant pairs, 37 preterm infants, (birth weight less than 1801g, born less than 38 weeks gestation), and 42 term infants, (birth weight greater than 2,500g, born at 39 to 42 weeks gestation) was conducted at 1, 4, 8 and 12 months CA (Crnic et al., 1983). The Receptive Expressive Emergent Language scale (REEL) was measured at 1 and 8 months CA, and the Bayley Scales of Infant Development, mental development index (MDI) scale scores at 4 and 12 months CA. The study found that preterm infants smiled less and avoided eye gaze significantly more than term infants. The results highlighted no significant difference between cognitive skills of term infants and preterm infants at 4 and 12 months CA (1999). These results were supported by Wolke & Meyer (1999). However, a number of studies report that preterm infants experience cognitive and language delays (Burns, O'Callaghan, McDonnell, & Rogers, 2004; Magill-Evans et al., 2002). Preterm infants are reported to develop appropriate receptive language and vocabulary skills, however they often experience more difficulty with verbal reasoning, syntax, and abstract language skills (Aylward, 2002)

The birth weight and gestational age of preterm infants was correlated with language delays until five years of age (Aylward, 2002; Mathews & MacDorman, 2006).

### *1.4.3 Developmental outcomes*

The developmental outcome of preterm infants depends largely on the infants' gestational age and weight at birth (Wood et al., 2003). Infants born less than 25 weeks gestational age often experience longer oxygen dependency, higher incidence of severe motor disabilities, and many of these infants fail to catch up to the growth trajectory of their term counterparts (Brown, Bendersky, & Chapman, 1986; Colvin, McGuire, & Fowlie, 2004; Gaebler & Hanzlik, 1996; Gregoire, Lefebvre, & Glorieux, 1998; Mathews & MacDorman, 2006; Medoff Cooper & Gennaro, 1996). Infants born less than 28 weeks gestation accounted for only 0.7% of live births in the United States in 2003. In addition, preterm infants born at less than 32 weeks gestation demonstrate a mortality rate 78 times higher than term infants. Infants born greater than 32 weeks gestation are likely to demonstrate similar neurodevelopmental outcomes to term infants, and demonstrate better feeding and language outcomes than more at-risk and medically fragile infants (Allen, 2002).

Significant medical advancements have been implemented since the 1980s. Although the rates of long-term disability, special education, and behavioural difficulties are still high, they have decreased for preterm infants (Piekkala, Kero, Sillanpaa, & Erkkola, 1988). Preterm infants continue to present with medical complications and higher rates of motor and social delays. The psychosocial and motor development of a cohort of 351 preterm infants revealed higher rates of fine motor delays at 3 months PCA and deviant psychosocial scores at 2 years PCA compared to a low-risk term sample. However, the study found that healthy preterm infants developed close to the term infant control group (Wood et al., 2003). The EPICure study found that 50% of participants had disabilities, 25% of these were severe disabilities, in addition to feeding problems and respiratory illnesses (Colvin et al., 2004). Infants born at a shorter gestational age demonstrated a higher risk of cerebral palsy (Aylward, 2002; Aylward, Pfeiffer, Wright, & Verhulst, 1989; Colvin et al., 2004). It is important to consider other factors that can impact on motor development. Piper and colleagues (1989) suggested variability in the neuromotor development of preterm infants may be influenced by the extra uterine and environmental experiences (Piper, Darrah, & Byrne, 1989).

Outcome studies have investigated the impact of prematurity on the infant's intellectual and motor development. The intelligence quotient (IQ) of preterm infants are between 3 to 10 points lower than term infants (Aylward, 2002). Prematurity has been found to have long term implications for the child's cognitive, language, and motor development at school age. It is suggested that up to 50% of infants born less than 28 weeks gestation, and a much larger proportion of extremely low birth weight infants, require educational support and special education (Kilbride, Thorstad, & Daily, 2004). Studies of extremely low birth weight infants (classified as weighing less than 801 grams) and born between 24 and 27 weeks gestation, have shown evidence of lower measures on cognitive, language and psychomotor assessments when re-assessed at preschool age. The participants demonstrated a range of medical difficulties associated with prematurity as infants, including chronic lung disease and intra-ventricular haemorrhage (Bhutta, Cleves, Casey, & Cradock, 2002).

Preterm infants demonstrate a range of cognitive and behavioural or social delays compared to term infants. A meta-analysis was conducted to determine the long term impact of prematurity on cognitive and behavioural outcomes after five years of age (Bhutta et al., 2002; Hediger, Overpeck, Ruan, & Troendle, 2002; Saigal, 2000). Preterm infants scored significantly lower on cognitive, motor and social development than control term infants (Bhutta et al., 2002). In addition, cognitive scores were correlated with infant birth weight and gestational age at birth. Preterm infants also showed more behavioural difficulties and had twice the incidence of attention deficit hyperactivity disorder at school age than term infants (Aylward, 2002). A greater proportion of preterm males are reported to exhibit behavioural problems at school age (Colvin et al., 2004).

In summary, preterm infants have shown to demonstrate more language problems, visual perception difficulties, learning disorders, neuromotor difficulties, hyperactivity, and behavioural problems than term infants. Therefore, children with medical complications at birth, including comorbidities typically associated with prematurity, are at risk for developmental problems. However, long term studies have shown no significant differences between the quality of life during adolescence of ex-preterm and term infants (Brust, 1987). It is important to consider that studies of preterm infants include participants of varying gestational ages with differing birth weights. As such, it is difficult to provide conclusive generalisations on specific infants of a particular gestational age or birth weight, due to variable methods for patient selection of individual studies.

### *1.4.4 Maternal factors*

Barnard (1978) outlined a dyadic model to describe the interactions between parents and their infants. The model assumes that both members of the dyad (the infant and parent) are able to recognise cues and respond accordingly. Brust (1987) suggested that the dyadic interaction matures over time, and across situations. She adapted the Barnard Model to include environmental and situational factors that can influence the interaction between a parent and a preterm infant (Blackburn, 1986). The model is illustrated in Figure 4.

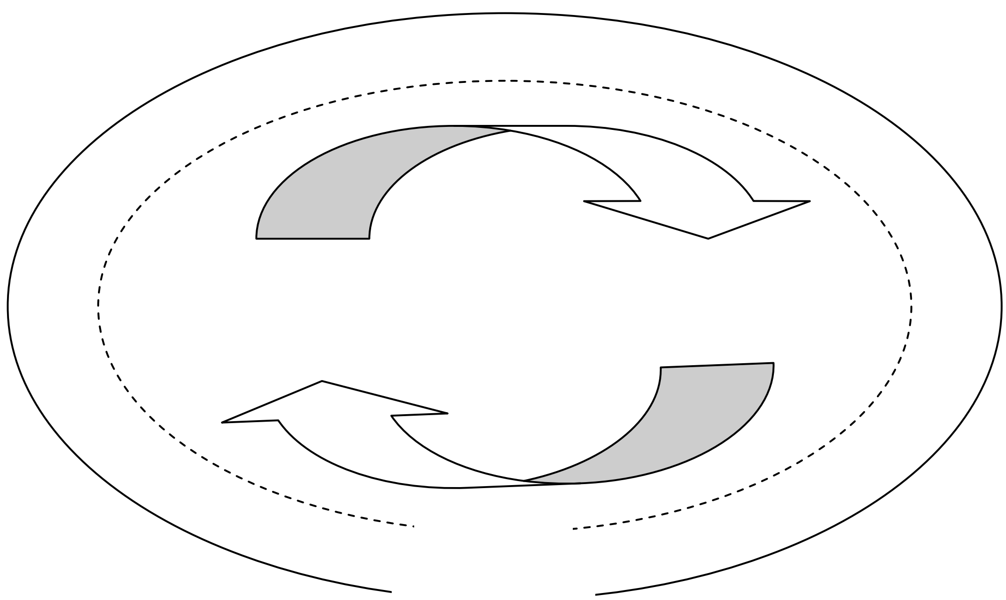

*Figure 4.* Barnard Model Representing the Dyadic Interaction of the Mother and Infant.

*Note.* From 'Characteristics of Mother-Preterm Infant Interaction during Feeding Situation', by D. J. Brust, 1987, *Masters Thesis*, Ann Arbor: Ohio State University, p. 10.

The birth of a child can be a stressful time for parents with changing family dynamics, which can be further heightened with the birth of a preterm infant

(Blackburn, 1986). The parents can experience emotional stress, fatigue and grief. These stressful situations can influence the parents' ability to bond and attach with their infant, particularly if the infant is in special or intensive care, and separated from the parents (Blackburn, 1986).

Infant feeding difficulties are often secondary to medical conditions, including respiratory and cardiac problems. Often infants with complex medical problems are admitted to hospital for medical monitoring and management. In this situation, the opportunity for the mother and infants to develop a mother-infant relationship is reduced. A range of other maternal factors are reported to have positive and negative implications for infant development, including the mother-infant interaction (Bakeman & Brown, 1980; Feldman, Keren, Gross-Rozval, & Tyano, 2004), parental expectations and attitude (Abbott & Habel, 1999; Scott, Shaker, & Reid, 2004), parent's socioeconomic background (Abbott & Bartlett, 1999; Broad & Duganzich, 1983), maternal employment (Huston & Rosenkrantz Aronson, 2005; Pessanha & Bairrao, 2003) marital status (Pessanha & Bairrao, 2003), maternal health (Cheng, Chou, Tsou, Fang, & Tsao, 2004), and parental ages (Magill-Evans et al., 2002),. Petrova and colleagues (2003) investigated the impact of paternal race and ethnicity of 1006 preterm infants born between 22 and 32 weeks gestation. Of the participants, 54.3% were classified as white, 21.7% black, 13.7% Hispanic, and 10.3% were classified as other. The study revealed no significant impact of paternal ethnicity or race on the gestational age, birth weight, morbidity or mortality of preterm infants (Petrova et al., 2003).

The impact of postnatal events on the mother-infant interaction was investigated by Brachfield, Goldberg and Sloman (1980) in 8 and 12 month preterm and term infants. They found that ill infants at 8 months played less than term infants and fussed more, even though the parents of preterm sick infants provided more play demonstration and physical contact. No significant differences were reported between the two groups at 12 months (Brachfeld et al., 1980).

### *1.4.5 Environmental influences*

The neonatal intensive care unit (NICU) environment is physically and socially very different to the environment in utero and in the home. The environment usually provides an overload of sensory stimulation for the infant, with bright lights, loud noises and fluctuating temperatures, which can increase the infant's heart rate and stress levels. In addition, infants are also exposed to many different staff members providing immediate care during this period (Blackburn, 1986; Frank, Maurer, & Shepherd, 1991; Morrison, Haas, Shaffner, Garrett, & Fackler, 2003; Perlman, 2001).. The environment and individual care provided to preterm infants during hospitalisation can impact on their neuromotor development. Harris (1986) suggests the earlier intervention is provided in the nursery, the better the outcome for the infant. A recent study by Arnon and colleagues (2006) revealed live music to be beneficial for preterm infants within the neonatal unit. The study included 31 stable preterm infants greater than 32 weeks gestational age, comparing the benefits of live music, pre-recorded music and no music when performed for 30 minutes over 3 consecutive days. The provision of live music reduced the heart rate and a deeper sleep for preterm infants (Arnon et al., 2006).

The NICU environment is reported to have negative implications on the infant's growth, development and health (Blackburn, 1986), language skills (Duffy, Als, & McAnulty, 1990; Magill-Evans et al., 2002; Mathisen, 2001), and intellectual development (Bee et al., 1982; Bradley & Caldwell, 1976; Price et al., 2000).

## 1.5 Summary

Consideration must be given to the multiple factors that can influence an infant's developing control processes. Literature supports that infant, maternal, and environmental factors can have implications for infant's feeding and communication development. Special consideration must be given to the added maternal and environmental influences along with the normal variation in the preterm infant's developmental sequelae.

# 2.0 RELATED AND UNRELATED MOTOR CONTROL SYSTEMS FOR FEEDING AND SPEECH DEVELOPMENT

Considerations of the relationship between motor control processes for feeding and communication development are important. The question of shared or separate control processes for communication and feeding is important for the development of assessment and management strategies for infants with difficulties in either or both domains.

## 2.1 Related motor control systems

Oral feeding is a dynamic, multifaceted and highly integrated system (Rommel et al., 2003). Ziegler (2003a) described two models to explain motor control, 'task independent' and 'task dependent' hypotheses. The 'task independent' model assumes that the motor control is independent of the particular motor task. He also explained and advocated for the 'task dependent' hypothesis, proposing that motor control is dependent on the purpose of the motor activity (Ziegler, 2003a). There are limited theoretical models described in the literature discussing the processes specific to the motor control for feeding in the infant and paediatric population. Figure 5 illustrates the 'task independent' model (Ziegler, 2003a).

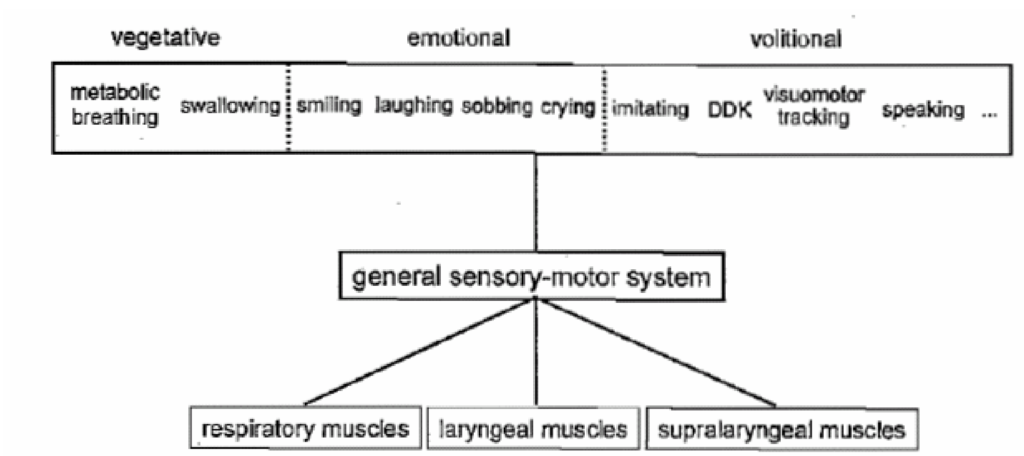


*Figure 5.* Task Independent Model of Oral Motor Control.

*Note.* From 'Speech Motor Control is Task Specific: Evidence from Dysarthria and Apraxia of Speech', by W. Ziegler, 2003, *Aphasiology*, 17(1), p. 5.

In response to Ziegler (2003a), Ballard, Robin and Folkins (2003) proposed an 'integrative model' of motor control. The integrative model assumes that some non-speech motor tasks share principles with speech and some do not, thus supporting an overlap between the speech and volitional sensory motor systems. Ballard and colleages (2003) argue that the use of speech and non-speech tasks is important when assessing motor speech control and provides neural, evolutionary, and behavioural evidence to support an integrative model.

### *2.1.1 Evolutionary theory*

Blanchard (1963) provided an early evolutionary account to describe the relationship between infant feeding and speech development. It was suggested that oral movements for sucking, masticating, and swallowing involve automatic control in response to sensory stimulation, such as taste, sight, and smell. The ability to coordinate muscles for respiration, swallowing, and sucking or chewing for eating and drinking, have enabled people to implement changes in respiration and phonation patterns to produce a range of sounds and vocal patterns. Over time, coordination has been refined within a highly flexible control system to form language systems, including vowels and consonants, words, phrases, and sentences (Blanchard, 1963; Lund, 1998). Blanchard (1963) suggested that the same oral structures are utilised during eating and talking. He provided suggestions to facilitate the development of early feeding, which should then aid the development of improved speech patterns.

Evolutionary research has also studied the developmental anatomy between humans and other mammals. Significant differences have been observed in the pharyngeal development, specifically the larger supralaryngeal region in the human system. It is suggested that this difference permits humans to produce speech and other sounds specific to the human population (Laitman & Reidenberg, 1993).

### *2.1.2 Anatomical relations for feeding and speech production*

The same oral mechanisms, including sensory and motor control, are involved for speaking and eating functions (Blanchard, 1963; Starr, 2003). Iverson and Fagan (2004) proposed that although the motor systems for eating and vocalising are 'anatomically' separate, they suggest an overlap between vocal and motor activity for eating production in early human development.

Many parallels exist between the oral movement and processes for feeding and communication development in utero and from birth to 6 months. In utero, the foetus has basic facial expressions, including squinting and frowning by 15 weeks gestation at the same time that thumb sucking starts. At 4 to 6 weeks after birth, the tongue thrust pattern reverses and cooing emerges at 2 to 3 months of age, highlighting greater tongue control (Bleile, 1995; Owens, 1995; Starr, 2003; Treharne, 1980). At 2 to 3 months, an infant can drink fluids successfully. Cooing merges into early babble with increased non-vegetative sounds. When solids are introduced at 6 months of age, the infant gains greater lip and tongue control. Babbling of alveolar and bilabial sounds, for example, *d, b,* and *m* emerge (Starr, 2003). Anatomically, at around 6 months of age, the larynx begins to descend and an oropharyngeal region becomes evident. Due to this developmental maturation, the infant is more capable of oral respiration, allowing airflow through the larynx, pharynx and oral cavity in addition to nasal breathing, which is crucial for infants to commence sounds and vocalisations (Fitch, 2000; German & Palmer, 2006).

Parallels can be seen in the motor control development of feeding and communication development of infants from 6 to 12 months of age. At 7 to 8 months, thicker purees are introduced by spoon. Infants can bring the top lip down to remove food from the spoon at 7.73 months, and an early munching pattern can be seen (Carruth & Skinner, 2002). Similarly, at 6 to 9 months, reduplicated babbling commences. Reduplicated babbling occurs when an infant repeats the same consonant vowel sequence of syllables, such as *baba*, *dada*. When more textured solids and liquids are introduced, there is increased contact between the tongue tip and alveolar ridge. At this stage, alveolar consonants like *d* and *n* increase in production (Morris, 1985, 1990; Treharne, 1980).

When children begin solid foods that require chewing, the lips help to hold food and liquid in the oral cavity during chewing. Lip seal starts to develop in the first few days of life during drinking from the bottle or teat, and lip closure when solids are introduced. Bilabial or lip sounds, such as *m*, *p*, and *b* are a few of the first consonants produced (Bleile, 1995). Given the development of simultaneous functions of the lips for eating and speaking, it could be predicted that infants with inadequate lip function for feeding will have delayed production of bilabial sounds in speech development than their non-feeding impaired counterparts?

During feeding, the seal created by the elevation and retraction of the soft palate with the anterior protrusion of the posterior pharyngeal wall functions to separate the oral and nasal space, to prevent regurgitation (Morris & Klein, 1987). Similarly during speech production, this separation or velopharyngeal closure prevents air and sound from moving through the nose. Therefore, if infants have poor soft palate function for swallowing are they likely to experience difficulties with velopharyngeal motility in speech development.

The tongue has an important role during feeding to create areas of positive and negative pressure in the oral cavity when forming the bolus. A central groove is formed to channel the bolus before swallowing in 'normal' situations. Similarities in tongue shapes during feeding and speaking are reported (Arvedson & Lefton-Greif, 1996). During infant feeding, the tongue moves in relation to the jaw and the palate. This is likely due to the large size of the tongue in relation to the oral cavity in infants where the tongue fills the mouth (Hiiemae & Palmer, 2003). During speech, coordination of the tongue becomes more precise and complicated, and tongue movements become independent of jaw movements (Green, Moore, & Reilly, 2002; Wolfe & Glass, 1992).

Perlstein and Shere (1946) stated that 'eating and speaking movements have a common origin, and progress in the former ensures progress in the latter', p.389. Indirect evidence to support integrative motor control systems is described in literature investigating the development of infant vocal and motor coordination (Broad, 1972a). The study explained that the motor control systems for vocal and feeding motor development are interrelated, even though separate anatomical structures are utilised (Broad, 1972a). Morris (1998) suggested that the same motor organs are involved in sucking and speech. She proposed that motor control for feeding and speech are partially related and partially unrelated. She suggested that a common motor control system is utilised during the initial stages of feeding and early speech development. However, the speech motor control needs increase beyond those required for feeding and then diverge into two separate systems at this point, thus supporting an integrative system of motor control (Morris, 1998).

The coordination of laryngeal, respiratory, and articulatory musculature is important in motor control of speech and feeding in infants (Alexander, 1987; Lund, 1998). The effective use of speech depends on the ability to successfully integrate processes involved in feeding, language, cognition, and fine and gross motor development. An infant who experiences a difficulty in any of these areas has the potential for speech production difficulties (Alexander, 1987). For example, an infant experiencing abnormal motor patterns in feeding and speech production may be compensating for abnormal postural tone (Alexander, 1987). Similar views were expressed by Fluehr and colleagues (2004) namely that low muscle tone and difficulty coordinating movements will have an impact for both swallowing and speech coordination in infants.

Mathisen and colleages (2000) compared term infants at 6 months chronological age and extremely low birth weight (ELBW) infants at 6 months corrected age. They found that the ELBW infants had less vocalisations and socialisation for communicative purposes. They also had inconsistent oral motor development. In addition, they were not as ready for solid food and demonstrated less biting and self feeding skills (Mathisen et al., 2000). Similarly, Palmer and Heyman (1999) studied the relationship between infant feeding skills during the neonatal period and developmental outcomes at 24 to 36 months of age. Sucking ability was measured using the Neonatal Oral Motor Assessment Scale (NOMAS). A perfect correlation (100%) was found between infant's normal or disordered sucking skills as a neonate and developmental outcome as a toddler. All infants with developmental delay at 24 months experiences sucking difficulties during infancy (Palmer & Heyman, 1999).

A number of studies have examined the sound production of infants who are breast and bottle-fed infants with conflicting conclusions. Some reports suggest that breast-fed infants have more developed phonological repertoire than their bottle-fed counterparts (Broad, 1972a, 1972b). Broad (1972a) reported less speech difficulties in breast-fed children when assessed at 5 years of age. In addition, he found that breast-feeding has a more positive impact on the development of speech in male infants (Broad, 1972a).

There is much overlap in the neural control of sucking, swallowing, and breathing. Of the 12 cranial nerves, half of them are involved in the sensory and/or motor innervation during sucking, swallowing and breathing. Figure 6 illustrates the overlapping functioning of sucking, swallowing and breathing.

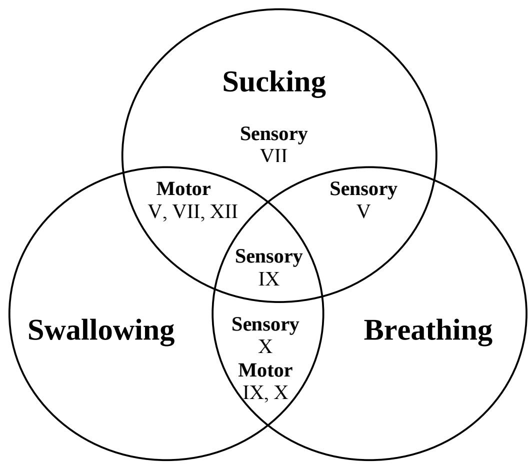


*Figure 6.* Cranial Nerves Involved in Sucking, Swallowing and Breathing.

*Note.* From 'Feeding and Swallowing Disorders in Infancy: Assessment and Management, by L. S. Wolfe and R. Glass, 1992, San Antonio, Texas: Therapy Skill Builders.

The glossopharyngeal nerve (IX) provides extensive sensory innervation to the pharynx during swallowing and respiration, and taste to the posterior 1/3 of the tongue. The facial nerve (VII) also provides taste sensory innervation to the anterior 2/3 of the tongue. The trigeminal (V), facial (VII), vagus (X), glossophayngeal (IX) and hypoglossal (XII) nerves also provide a range of overlapping innervation during sucking, swallowing and breathing. The trigeminal (V) nerve provides motor control to the muscles of mastication during sucking, munching and chewing; to the lower jaw; and to elevate the palate during sucking and swallowing. The sensory branch provides sensory feedback to the face, tongue, palate, nose and teeth (if present). The facial (VII) nerve provides motor control to the buccinator and stylohyoid muscles; and the hypoglossal (XII) nerve supplies motor function to the muscles in the tongue. The glossopharyngeal (IX) and vagus (X) nerves also provide important motor control to the pharynx, larynx and esophagus during swallowing and respiration. The sensory branch of the vagus nerve supply sensory innervation to the pharynx and larynx (Arvedson & Brodsky, 2002; Arvedson & Rogers, 1993; Derkay & Schechter, 1998; Rogers & Arvedson, 2005).

### *2.1.3 Neurologically impaired populations*

A number of sources have suggested a relationship between feeding and communication skills in children with structural and neurological impairments, including, but not limited to, cleft lip and palate (Chapman, Hardin-Jones, Schulte, & Halter, 2001; Glenny et al., 2004; Jaffe, 1989; Jocelyn et al., 1996; Lee, Nunn, & Wright, 1997; Treharne, 1980), Down syndrome (Field et al., 2003; Jaffe, 1989; Kumin et al., 2001), Smith–Magenis Syndrome and Moebius sequence, (Rosenfeld-Johnson, 1999; Sjoegreen et al., 2001).

Studies show that a large proportion of infants with cleft palate (with or without cleft lip) experience early multiple and prolonged feeding difficulties, and may experience subsequent growth and weight problems (Glenny et al., 2004; Jocelyn et al., 1996). 16 children with cleft lip and palate and a control group of 16 non-cleft children control were investigated. No participants had congenital abnormalities or neurodevelopmental difficulties. Children with cleft lip and palate experienced significantly lower receptive and expressive language, and cognitive scores at 12 and 24 months of age compared to non-cleft control children (Jocelyn et al., 1996).

Oral motor delays are present in up to 80% of children with Down Syndrome (Field et al., 2003). Children with Down Syndrome often experience low muscle tone, including oral muscle weakness, which can impact on feeding and speech abilities (Field et al., 2003; Kumin et al., 2001). Kumin et al. (2001) developed a treatment program for 4 children with Down Syndrome. 2 male and 2 female participants aged 20 to 27 months had a mean age of 22.75 months. Each participant's oral motor skills for feeding and speech were assessed pre and post treatment. Treatment consisted of a 2 hour parent education session with follow up consultation. The study found that after the treatment period, the participants that received a consistent home program had normal muscle function as opposed to moderate muscle dysfunction with 2 control participants. The 2 participants who received consistent treatment at home had better oral motor scores for eating and greater speech output than the 2 subjects with an inconsistent home program (Kumin et al., 2001).

75% of children diagnosed with Smith–Magenis Syndrome are reported to have feeding, swallowing, and speech-language disorders, including a weak suck, difficulty progressing with more textured solids, and failure to thrive requiring non-oral feeds. Children with Smith-Magenis Syndrome are also reported to have poor expressive language skills and poor intelligibility in conversational speech (Gropman, Duncan, & Smith, 2006; Shaw et al., 2003).

The development of feeding and speech, and their interrelationship, are described for children with Moebius sequence or syndrome (Sjoegreen et al., 2001). Moebius sequence is a rare congenital disorder involving unilateral or bilateral paralysis of the abducens (VI) and facial (VII) cranial nerves. Hypoglossus (XII) and glossopharyngeus (IX) cranial nerves may be involved for some children. A Swedish multidisciplinary study observed the orofacial functions of 25 participants (aged 2 months to 55 years) with Moebius sequence. 16 respondents reported feeding problems, ranging from 'slight problems with breast or bottle-feeding' to 'tube-feeding' during infancy, and 14 reported eating difficulties. Similarly, 17 respondents experienced orofacial dysfunction for speech, ranging in severity from a 'slight articulation disorder' to 'no speech'. Although this study did not specifically investigate the relationship between orofacial dysfunction for feeding during infancy and speech production, the results suggest that 13 participants experienced dysfunction for both infant feeding and speech production (Sjoegreen et al., 2001). Similarly, Rosenfeld-Johnson (1999) suggested that an oral motor treatment program to facilitate lip closure and rounding during drinking assisted in development of speech clarity and phoneme production in children with Moebius sequence (Rosenfeld-Johnson, 1999).

Children with cerebral palsy can exhibit abnormal muscle tone to include the oral musculature resulting in a negative impact for feeding and speech development (Kumin et al., 2001). Field and colleagues (2003) found that 68% of children with cerebral palsy had oral motor delays, 32% had dysphagia and 30% had food refusal. Arvedson and colleages (2004) reported on a child with Klippel-Feil Syndrome

(KFS) who demonstrated multiple cranial nerve deficits that had a negative impact on motor control for swallowing and speech.

In summary, theoretical and clinical support exists for the presence of common sensory motor control for oral feeding and communication development. The next sections will provide conflicting evidence for unrelated motor control systems.

### 2.2 Unrelated motor control systems or 'task dependent' hypothesis

In contrast to the 'related motor systems' theory where it is assumed that feeding and speech are controlled by the same motor control system, Ziegler (2003a) explained and advocated for the 'task dependent' hypothesis to describe motor control mechanisms associated with eating and speaking. He proposed that oral motor structures (tongue, lip, larynx) are controlled differently depending on the purpose of the motor activity. Ziegler (2003a) argued against the examination of non-speech tasks when assessing motor control for speech. According to the task dependent hypothesis, speech and non-speech functions are controlled by different sensory-motor systems, speech by the speech motor control centre, and non-speech by the volitional motor control centre. Similarly, the vegetative sensory motor system involves a range of muscle groups involved in vegetative functions such as swallowing, and the speech sensory-motor system for speech (Ziegler, 2003a). A diagram of the task dependent hypothesis is illustrated in Figure 7.

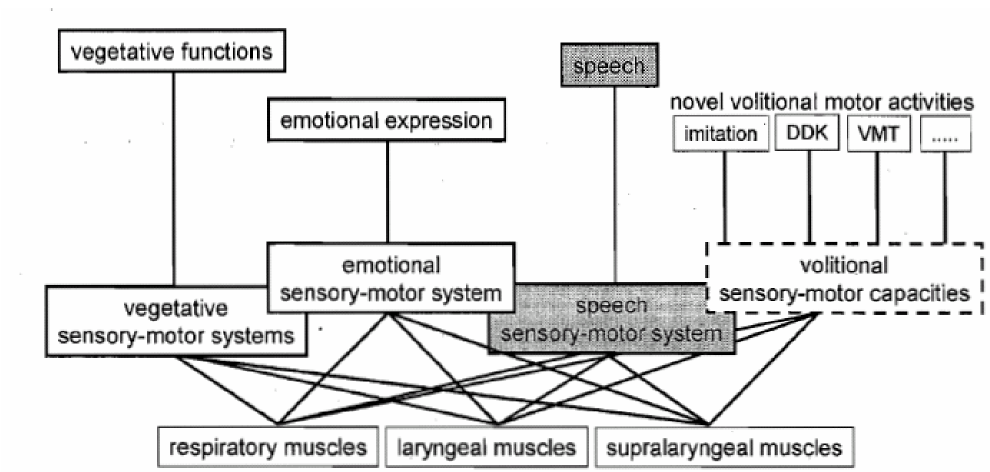

*Figure 7.* Task Dependent Model of Oral Motor Control.

*Note.* From 'Speech Motor Control is Task Specific: Evidence from Dysarthria and Apraxia of Speech', by W. Ziegler, 2003, *Aphasiology*, 17(1), p. 5.

Within the task dependent account of motor control, there is some evidence of co-occurrence between disorders. Moore and Ruark (1996) suggested that mandibular coordination and strength during speech and sucking and chewing during feeding are controlled by different motor systems. Seven 15 month-old participants were observed during sucking, chewing, babbling, and talking spontaneously. Moore and colleagues (1996) used electromyographic (EMG) recording to measure the lip and jaw movements during eating and talking. Mandibular muscle movements required for reduplicative babbling and chewing were similar. However, different movements were observed for variegated babbling and more sophisticated speech acts. Therefore, it was concluded that common neural control could exist during early development, but that later motor control of speech was not derived from earlier non-speech motor activity (Moore & Ruark, 1996; Ruark & Moore, 1997).

Relationships between breast-feeding and speech development have been refuted by some researchers. Taylor and Wadsworth (1984) conducted a retrospective study examining the influence of breast feeding on various aspects of development at 5 years of age in 13,135 children. The participants' language was assessed using the English Picture Vocabulary Test (English PVT). Maternal, behaviour, and visual motor coordination scores were collected, using the Malaise inventory of maternal psychological state, a child behavioural screening, and a copying design measure of visual motor coordination. They found no statistically significant difference among vocabulary, visuomotor coordination, and behaviour. In addition, they found that breastfeeding had no effect on speech production during the child's first 5 years. Similarly, Smith and Gerber (1993) failed to discover an association between infants who were exclusively or partially breastfed as infants and their later phonological or sound development. They examined 29 children aged 36 to 48 months. Information on the participants' feeding history, the duration of exclusive breastfeeding, and the phonological development measured by an assessment of Percentage of Consonants Correct (PCC) and parent ratings of speech and communication was collected. The study supported the findings of Taylor and Wandsworth (1984) of no association between breastfeeding and phonologic development.

### *2.2.1 Non-oral feeding*

Most infants initiate oral feeding without incident during the first experience of sucking from a nipple or teat. Other infants born preterm with neurological or structural abnormalities may require non-oral feeding by nasogastric or orogastric tube to ensure that nutritional and hydration needs are met. The establishment of early oral feeding is documented to facilitate growth and development (McPherson, 1993; Yu, 1999). If oral feeding and communication development are related, the assumption would be that children receiving non-oral feeds may be at risk of delayed or disordered communication development. However, there are a number of children fed by non-oral methods from birth who later develop age appropriate speech and language skills.

### *2.2.2 Nutritive and non-nutritive sucking*

If a single motor control system is responsible for oral feeding and speech production, then non-nutritive sucking training to promote the infants' sucking skills should facilitate improved feeding skills and speech production. Use of a pacifier or dummy to facilitate non-nutritive sucking was found to modulate the infant's behaviour state (Engebretson & Wardell, 1997; Gill, Behnke, Conlon, & Anderson, 1992; Pickler, Frankel, Walsh, & Thompson, 1996), to reduce the time to transition from tube to oral feeds (Pinelli & Symington, 2001), to reduce distress (Shiao, Chang, Lannon, & Yarandi, 1997), to reduce length of hospital stay (Johnston, 1999; Pinelli & Symington, 2001), and to appease pain (Pinelli et al., 2002). A systematic review of non-nutritive suck training of preterm infants in the neonatal nursery found that it did not significantly improve energy intake, weight gain, or corrected age when full oral feeds were achieved (Johnston, 1999). Non-nutritive sucking did not decrease the duration or number of breastfeeds during the night (Pollard et al., 1999). The communication skills of infants who received neonatal non-nutritive suck training were not examined by Pollard and colleagues.

## 2.3 Summary

The majority of literature reviewed supports the interrelationship of the motor control systems during feeding and communication development. The current practice of isolated assessment of feeding and communication skills appears to be based on the assumption of separate and distinct motor control systems for these two functions. This practice is not supported by the literature which suggests some integration between motor control mechanisms for feeding and communication.

At the tertiary paediatric children's hospital in Perth, Western Australia, clinical caseloads are separated into teams, that include the Feeding Service, Communication Difficulties Team, Neurology Rehabilitation Team and Cleft, Lip and Palate team. Therefore, specialty clinical teams are segregated by separate motor control systems. The current assessment of an infant's feeding skills is usually conducted by a Speech Pathologist, in collaboration with other relevant clinicians, including a Dietician, Occupational Therapist, and Physiotherapist. The assessment by the Speech Pathologist involves an observation of the infant feeding to evaluate the infant's oral readiness, oral sensory and motor skills and coordination during feeding. There are a number of checklists developed by different institutions to record such observations. A separate team with a different Speech Pathologist assesses the infants' comprehension, pre-speech, and expressive language development using a combination of informal assessment protocols, formal parent questionnaires, and observation protocols. The integrative approach proposed by Ballard and colleagues (2003) would support the use of a theoretically driven assessment protocol to address the multiple skills utilised by an infant during oral feeding.

## 2.4 Project aims and hypotheses

The aim of this project is to gather evidence to support or refute the following positions; (a) specialist and separate control mechanisms develop for vegetative (swallowing) and motor speech control, or (b) an integrative system for speech and swallowing motor control mechanisms. The study also aims to determine whether factors influencing the feeding situation or specific feeding difficulties may predict communication delay in both term and preterm infants. The study will analyse the influence of infant, environmental and maternal factors on term and preterm infants feeding and communication development. The findings of these objectives will be interpreted in light of the theoretical positions proposed by Ziegler (2003a; 2003b), Ballard et al. (2003), and Carpendale and Lewis (2004).

The following hypotheses were tested:

1. Integrative motor control is utilised during communication and feeding development, see Figure 8.

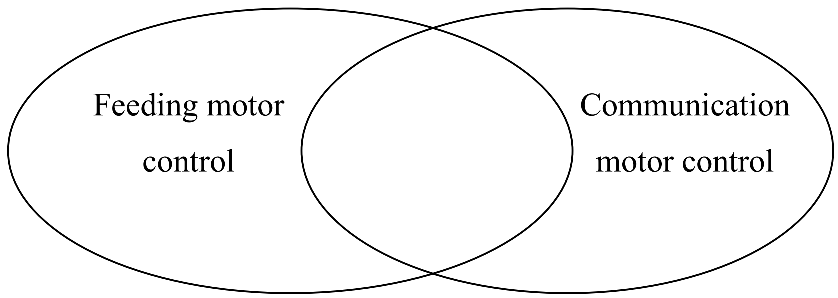


*Figure 8.* Integrative Motor Control for Feeding and Communication.

2. The development of feeding and communication will be significantly influenced by infant, environmental, and maternal factors. The impact of these factors on the development of feeding and communication will be higher for preterm infants than for term infants. This hypothesis is shown in Figure 9.

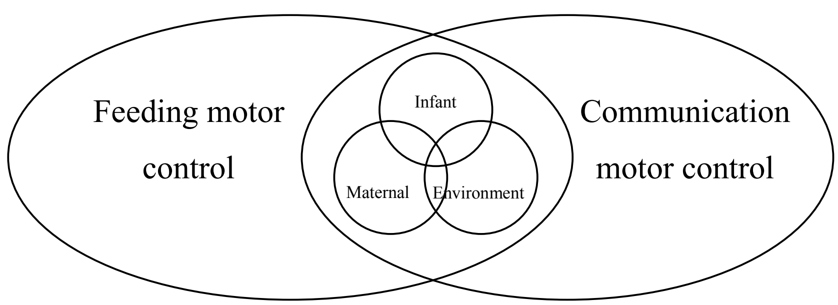


*Figure 9.* Integrative Motor Control and Contributing Infant, Maternal, and Environmental Factors.

3. Feeding and speech control will develop significantly slower for preterm compared to term infants.
4. Delayed feeding development will be associated with delay in the development of communication skills.

# 3.0 DEVELOPMENT OF FEEDING ASSESSMENTS

## 3.1 Background

The first stage of the study involved the development of a theoretical framework to evaluate the feeding skills in infants. The second stage involved the development of an observation feeding protocol and questionnaire based on the theoretical model. Preliminary reliability testing was conducted for the feeding assessment observation.

### *3.1.1 Evaluation of existing assessment tools*

#### *3.1.1.1 Feeding assessments*

There are few published observation tools for assessing oral and pharyngeal swallowing in children (Morris, 1982; Morris & Klein, 1987). Checklists and observation protocols have been developed by individual hospitals, organisations and health services in Western Australia, Australia, and the rest of the world. However, no consistent theoretically motivated, standardised, reliable and valid assessment tool exists to measure infant feeding skills. The Schedule of Oral Motor Assessment (SOMA) (Reilly, Skuse, & Wolke, 2000), and the Neonatal Oral-Motor Assessment Scale (NOMAS) (Braun & Palmer, 1984) contain validation data, and will be discussed further in this thesis. Table 2 also provides a summary of other paediatric oral motor clinical and instrumental assessments of feeding skills that can be used with infants and children.

Table 2. *Summary of Feeding Assessments (clinical and instrumental)*

| Assessment | Description |
|---|---|
| Schedule for Oral Motor Assessment (SOMA) (Reilly et al., 2000) | Assessment of oral motor skills separated into four sections; 1) oral motor challenge, 2) functional areas, 3) functional units and 4) oral motor behaviours. |
| Neonatal Oral-Motor Assessment Scale (NOMAS®) (Braun & Palmer, 1984). | Objective measure of nutritive and non-nutritive sucking in infants, by measuring normal, disorganised, and dysfunctional oral motor |

| | |
|---|---|
| | patterns in infants. |
| Infant Breastfeeding Assessment Tool (IBFAT) (Riordan, 1997) | Measures the infant's breastfeeding skills, including readiness to feed, rooting, suckling and fixing |
| Mother Baby Assessment Tool (MBA) (Riordan, 1997) | Measures five steps during breastfeeding, 1) signalling, 2) positioning, 3) fixing, 4) milk transfer, and 5) ending. |
| LATCH (Riordan, 1997) | Measures breastfeeding skills, including: L, latches to the breast; A, audible swallow observed; T, type of the mothers nipple; C, comfort level of the mother; and H, help required by the mother to hold the infant. |
| Dysphagia Disorders Survey (DDS) and The Dysphagia Management Staging Scale (DMSS) (Sheppard & Pressman, 2003) | The DDS is a standardised screening test for swallowing and feeding disorders in the people with developmental and lifelong disabilities. The DMSS is a rating scale of feeding involvement on a five-level severity scale. |
| Videofluoroscopic Swallow Study (VFSS) | Lateral and anterior-posterior (for selected patients) assessment of swallowing, with a dynamic X-ray view. |
| Cervical Auscultation (CA) | Audio signals are recorded from the front of the cricoid cartilage in the pharyngeal region through a stethoscope or acoustic detector unit |
| Fiberoptic Endoscopy for Examination Swallowing (FEES) | A fiberoptic endoscope passed through the nose, providing visual examination of the soft palate, pharyngeal and laryngeal regions. |
| Great Ormond Street Measurement of Infant Feeding (GOSMIF) | A transducer objectively measures respiration patterns, swallow sounds, and intra-oral pressure during sucking. |

The SOMA was developed to assess the oral motor skills in infants and children aged 8 to 24 months (Reilly et al., 2000). The tool provides a structured assessment of oral motor skills separated into four sections: (a) oral motor challenge, (b) functional areas, (c) functional units, and (d) oral motor behaviours. The oral motor challenge refers to the texture of liquids and solids offered. The functional area refers to the muscle groups or structures involved, such as the jaw and lips, and the functional unit would be biting. The oral motor behaviour is the single oral motor movement to achieve the functional unit, such as controlled sustained bite and graded jaw opening. Individual functional units and oral motor behaviours are rated for each oral motor category, and a cut off score is achieved indicating whether an oral motor dysfunction is present (Reilly et al., 2000). The SOMA assesses infant's oral motor skills during bottle, cup or spout cup drinking, and on a range of solid consistencies, but does not include assessment of the infant breastfeeding. Therefore, it can not be used to measure the oral motor skills of breast-fed infants. The SOMA was validated on 127 infants aged 8 to 24 months, and achieved predictive validity between 78% and 100% for solids, and 96% to 100% on liquids (Skuse, Stevenson, Reilly, & Mathisen, 1995). Reliability testing of the SOMA obtained 69% interrater reliability and 85% agreement for test-retest reliability (Reilly et al., 1995). The SOMA measures oral motor function during feeding from a modular perspective, as opposed to dynamic systems theory of multiple subsystems interacting to achieve a functionally orientated motor goal. It would appear difficult for a clinician to conduct online scoring of the SOMA whilst feeding the infant. This assessment could not be utilised in the proposed study as it does not assess infant feeding from birth to 8 months.

The Neonatal Oral-Motor Assessment Scale (NOMAS®) was developed in 1983 to assess nutritive and non-nutritive sucking objectively in infants, by measuring normal, disorganised, and dysfunctional oral motor patterns (Braun & Palmer, 1984). The examiner is required to attend a certification course for administration and scoring the NOMAS in the United States (Palmer, 2005). Original validation of the revised NOMAS assessment found it accurately distinguished between two groups of efficient and inefficient feeders (Case-Smith, Cooper, & Scala, 1989). Additional inter-rater reliability testing achieved greater than 80% agreement among 3 scorers on 17 out of 26 items on the NOMAS (Palmer et al., 1993). The NOMAS was also used to measure the oral motor function of infants with feeding difficulties and colic. Colic was defined by the modified Wessel "rule of three", for infants who cry for more than 3 hours per day, for at least 3 days of the week, for at least 3 weeks. The study found a greater number of infants with colic demonstrated disorganised feeding patterns with less rhythmic nutritive and non-nutritive sucking on the NOMAS than a comparison groups of non-colic infants (Miller-Loncar, Bigsby, High, Wallach, & Lester, 2004). The assessment measures oral motor function by individual anatomic structures. For example, jaw and tongue movements are scored separately during a nutritive sucking observation (Palmer et al., 1993).

Three clinical assessments of breastfeeding have been described (Table 2). The Infant Breastfeeding Assessment Tool (IBFAT), the Mother Baby Assessment Tool (MBA), and the LATCH assessment were evaluated for validity, interrater reliability, and test-retest reliability (Riordan, 1997). The IBFAT measures the infant's breastfeeding skills, including readiness to feed, rooting, suckling, and fixing with a score from 0 to 3 for each item for a total score out of 12. The MBA measures 5 steps during breastfeeding, (a) signalling, (b) positioning, (c) fixing, (d) milk transfer, and (e) ending. The infant and mother each receive a score out of a maximum of 5, for a total of 10. The LATCH measures: L, latches to the breast (infant); A, audible swallow observed (infant); T, type of the mother's nipple ; C, comfort level of the mother; and H, help required by the mother to hold the infant. Each item is scored from 0 to 2, out of a total of 10. 3 raters scored 23 infants on a videotaped breastfeed with each of the 3 breastfeeding assessments. Poor interrater reliability was attained for the IBFAT, MBA, and LATCH breastfeeding assessments. Test retest reliability was variable with 37% to 97% consistency (Riordan, 1997).

The DDS and DMSS developed by Sheppard and Pressman (2003) provide a quick screening of developmental eating delays. It can be administered in as little as 10 minutes. However, to administer the DDS and DMSS, the clinician is required to attend a certification course, and the clinician must renew certification on an annual basis (Sheppard & Pressman, 2003). All empirical studies that have utilised the DSS and DMSS as an assessment tool have focussed on the outcomes in physically disabled adults. Few studies have involved infants and young children (Sheppard, 1991, 1997, 2002; Veugelers et al., 2005).

There are multiple instrumental feeding assessments to assess the oral and pharyngeal phases of swallowing. The videofluoroscopic swallow study (VFSS), also known as a coordination swallow study or modified barium swallow, provides a lateral assessment of swallowing with a dynamic X-ray view. The anterior-posterior view is also used in selected circumstances, for example, to evaluate unilateral vocal fold paralysis or unilateral hemiparesis. The radiographic technique can demonstrate aspiration and penetration before, during, or after swallowing. Scoring protocols have been developed to record VFSS observations (Arvedson & Lefton-Greif, 1998). Videofluoroscopic studies are being utilised as part of standard clinical practice in many paediatric hospitals and for research in paediatric dysphagia (Hormann et al., 2002; Morton, Bonas, Fourie, & Minford, 1993).

Cervical auscultation is a technique whereby audio signals are recorded from the front of the cricoid cartilage in the pharyngeal region (Eicher, Manno, Fox, & Kerwin, 1994; Lefton-Greif, 1996; Lowery, 2001). The three parts of the swallowing cycle can be heard through a stethoscope or acoustic detector unit; pre-swallow, swallow, and post-swallow signals (Cichero, 2000). Various acoustic devises have successfully recorded swallowing signals, including an accelerometer and an acoustic detector unit with a microphone attached (Cichero & Murdoch, 2002). Eicher and colleagues (1994) tested the accuracy of cervical auscultation with 56 children, aged 1 to 312 months referred for a modified barium swallow study. Twenty nine participants were seen for a clinical evaluation and feeding observation with cervical auscultation, followed by a modified barium swallow study, and the other 27 participants were not assessed by cervical auscultation. Of the participants who had CA, the predicted presence of aspiration and penetration matched the cervical auscultation results 86% of the time, and positively predicted aspiration and penetration in 81% of participants. The results of the study suggest cervical auscultation as a supplementary assessment of dysphagia in infants and children (Eicher et al., 1994).

Fiberoptic endoscopy for examination of swallowing (FEES) has been described as an affordable alternative or supplement to the videofluoroscopic swallow study (Migliore, 1999). The technique involves a fiberoptic endoscope being passed through the nose, providing visual examination of the soft palate, pharyngeal and laryngeal regions. Two benefits of FEES are the cost, at under half the cost of VFSS, and the lack of radiation exposure to the child (Aviv et al., 1998; Migliore, 1999).

The FEES procedure has been allowed for the provision of specific feeding recommendations to reduce aspiration risk for infants and children aged 11 days to 20 years (Leder & Karas, 2000), and is currently used by a number of institutions as a standard instrumental assessment for assessing dysphagia for infants and children (Lowery, 2001).

A recently developed assessment is the Great Ormond Street Measurement of Infant Feeding (GOSMIF). The GOSMIF uses a transducer to measure the length of sucking bursts, the rate of sucking, length of sucks, and suck to swallow ratio. The assessment is conducted with simultaneous video recording of the infant feeding. Software has been developed to analyse and display data from the transducer (Masarei, Veness, Sell, Wade, & Reilly, 2001; Masarei, Wade, Mars, Sommerlad, & Sell, 2007).

#### *3.1.1.2 Communication assessments*

There are a number of assessments of language, including receptive and expressive language skills from birth to 12 months. Many assessments of speech and language functions in the first 12 months are parent questionnaires, and many lack standardisation, and adequate reliability and validity data. Table 3 provides a summary of communication assessments.

Table 3. *Summary of Communication Assessments*

| Assessment | Description |
|---|---|
| Receptive-Expressive Emergent Language Scale, second edition (REEL-2) (Bzoch & League, 1991) | Measure of receptive and expressive language skills from birth to 3 years of age. Provides a Receptive Language Age (RLA), Expressive Language Age (ELA) and a Combined Language Age (CLA). |
| Communication and Symbolic Behavior Scales Developmental Profile (CSBS DP) (Wetherby & Prizant, 2003) | Infant-Toddler checklist from 6 to 24 months of age. Contains seven prelinguistic skills or clusters; emotion and use of eye gaze, use of communication, use of gestures, use of sounds, understanding of words, use of words and use of objects. |

| | |
|---|---|
| Rossetti Infant-Toddler Language Scale (Rossetti, 1990) | Measures preverbal and language skills from birth to 3 years, with a parent questionnaire and clinical observation of developmental areas. |
| MacArthur Communicative Developmental Inventory (CDI) (Fenson et al., 1993) | Questionnaire to measure verbal and non-verbal communication in infants and children. The first questionnaire ‘words and gesture’ for children aged 8 to 16 months, and ‘words and sentences’ for children from 8 to 30 months. |
| The Capute Scales (Accardo et al., 2003) | The Capute Scales contains two parts: 1) Cognitive Adaptive Test (CAT) measures the child’s visual-motor skills, and 2) Clinical Linguistic and Auditory Milestone Scale (CLAMS) measures the child’s receptive and expressive language skills from 1 to 36 months of age. |

The Receptive-Expressive Emergent Language Scale, second edition (REEL-2) is a measure of receptive and expressive language skills in children from birth to 3 years of age (Bzoch & League, 1991) (see Appendix A). The assessment contains 132 items in 4 stages of development. Stage I is the phonemic level development that refers to infants from birth to 3 months, and Stage II refers to the morphemic level development from 3 to 9 months. Stage III refers to infants from 9 to 18 months at the syntactic level, and Stage IV represents the semantic development level for toddlers aged 18 to 36 months. Each stage is separated into age period skills, with monthly age periods for the first 12 months, 2 month age periods from 12 to 24 months, and 3 month age periods from 24 to 36 months of age. Each age period contains 3 receptive and 3 expressive language skills observations. Items are marked ‘+’ for typical, ‘–’ for not observed or ‘±’ if the skill is emerging and variable. The child receives a Receptive Language Age (RLA), Expressive Language Age (ELA) and a Combined Language Age (CLA), which is based on the ceiling age period of skills. A Receptive Quotient (RQ), Expressive Quotient (EQ), and a Language Quotient (LQ), can be derived from the child’s chronological or corrected age (Bachman, 1995; Bzoch & League, 1991; MacDonald, 1979).

The reliability and validity of the REEL-2 have been expanded from the original version, which contained no validity data (Bachman, 1995; MacDonald, 1979). The revised assessment contains information on test retest reliability, inter-examiner agreement and standard error of measurement. The internal consistency of the assessment is over 0.92 (Bachman, 1995).

Reviewers of the REEL-2 assessment describe it as an easy assessment to administer and score. The instructions for the assessment are clear for the interviewer (Bachman, 1995). However, the model on which the assessment is based is considered to be outdated as it does not include areas of language, such as pragmatics. Another disadvantage is that the normative and standardised data are not included in the assessment manual, and the standardised population trialled with the assessment is small and limited (Bachman, 1995; MacDonald, 1979). The first and second editions of the REEL have been used in a number of research studies to evaluate the neurodevelopmental, cognitive, and communication outcomes of term, preterm, and infants with a range of disabilities during infancy and early childhood (Baker, Kummer, Schultz, Ho, & delRey, 1996; Black, Dubowitz, Hutcheson, Berensonhoward, & Starr, 1995; Jocelyn et al., 1996; Kahn, 1992, 1996; Mattia & deRegnier, 1998; Mirrett, Bailey, Roberts, & Hatton, 2004; Waisbren et al., 1998).

The Communication and Symbolic Behavior Scales Developmental Profile (CSBS DP) contains 3 parts; an infant-toddler checklist (see Appendix B), a parent questionnaire, and a videotaped observation of the child and parent interacting. The complete assessment takes 50 to 75 minutes to administer. The first part, the infant-toddler checklist, is completed by a parent of the child and scored by a health professional. The checklist is a screening tool and appropriate for use with children from 6 to 24 months of age (Wetherby & Prizant, 2003). The checklist contains 24 questions that are grouped into seven prelinguistic skills or clusters; emotion and use of eye gaze, use of communication, use of gestures, use of sounds, understanding of words, use of words, and use of objects. Questions require the parents to answer questions with “Not Yet," "Sometimes," or "Often," or select an appropriate number range. The scores for each cluster are calculated, and then transferred into three ‘composite scores’ for Speech, Symbolic and Social. The total scores possible for each cluster are seen in Table 4.

Table 4. *Social, Speech & Symbolic Composite Scores on the Infant-Toddler Checklist of the Communication and Symbolic Behavior Scales Developmental Profile*

| | |
|---|---|
| Emotion and Eye Gaze | 8 |
| Communication | 8 |
| Gestures | 10 |
| **Social Composite** | **26** |
| | |
| Sounds | 8 |
| Words | 6 |
| **Speech Composite** | **14** |
| | |
| Understanding | 6 |
| Object Use | 11 |
| **Symbolic Composite** | **17** |
| *TOTAL (Social, Speech & Symbolic composites)* | ***57*** |

*Note:* From Wetherby, A. M., & Prizant, B. M. (2003). *Communication and Symbolic Behavior Scales -Developmental Profile*. Baltimore: Paul H Brookes Publishing Company.

Normative data have been collected for the total and composite scores. Scores that are more than 1.25 standard deviations below the mean or in the bottom 10th percentile are considered ‘of concern’ and referral for a developmental assessment is recommended. The Communication and Symbolic Behavior Scales Developmental Profile (CSBS DP) cut-off scores are outlined in Appendix C. Brief observation of the infant or child should be conducted in order to validate parents’ responses (Wetherby, Allen, Cleary, Kublin, & Goldstein, 2002). Validation studies were conducted to measure the concurrent validity and predictive validity of the CSBS DP checklist. The CSBS DP was an effective prelinguistic screening tool for parent. A small proportion of parents of the 232 participants underestimated their children’s communication abilities. The assessment was found to accurately detect language delay in children aged 12 to 24 months (Wetherby et al., 2002; Wetherby, Goldstein, Cleary, Allen, & Kublin, 2003). The assessment achieved sensitivity and specificity of 89% for children with autism spectrum disorder (Wetherby et al., 2004).

The Rossetti Infant-Toddler Language Scale (Rossetti, 1990) measures the preverbal and language skills of children from birth to 3 years by parent questionnaire and clinical observation of 6 developmental areas, (a) interaction-attachment, (b) pragmatics, (c) gestures, (d) play, (e) language comprehension, and (f) language expression. The assessment is used extensively in clinical practice, but few research studies have utilised the language scale. A modified version of the Rossetti Infant-Toddler Language Scale (Rossetti, 1990) was successfully used to measure the language development of children from the date they were adopted to 36 to 40 months of age (Glennon & Masters, 2002). No reliability or validity data are available for the assessment tool.

The MacArthur Communicative Developmental Inventory (CDI) consists of two parent questionnaires to measure verbal and non-verbal communication in infants and children. The first questionnaire 'words and gesture' was developed for children aged 8 to 16 months, and the second 'words and sentences' for children from 8 to 30 months (Fenson et al., 1993). The assessment does not measure precursors to language prior to 8 months of age.

The Capute Scales are a recent assessment developed to measure the cognitive skills of children under 36 months of age (Accardo et al., 2003). The original language assessment was developed in 1978 and called the Clinical Linguistic and Auditory Milestone Scale (CLAMS) (Capute, Accardo, & Vining, 1978). The assessment revised assessment contains 2 parts: 1) Cognitive Adaptive Test (CAT) which contains 52 items measuring visual-motor skills, and 2) Clinical Linguistic and Auditory Milestone Scale (CLAMS) which measures the child's receptive and expressive language skills with 42 items. The assessment takes between 6 to 20 minutes to administer. The aim of the assessment is to identify the presence of developmental delay, deviancy, or dissociation (Accardo et al., 2005). The original tool has been found to have high correlation to the Bayley Scales of Infant Development (Accardo et al., 2005; Hoon, Pulsifer, Gopalan, Palmer, & Capute, 1993).

*3.1.1.3 Developmental assessments*

Many screening and assessment tools are available to measure delays and disorders during infant development. Table 5 provides a summary of key developmental assessments.

Table 5. *Summary of Developmental Assessments*

| Assessment | Description |
|---|---|
| Bayley Scales of Infant Development (Bayley-III) (Bayley, 2005) | The most recent version assesses five developmental areas: cognitive, motor, language, social-emotional and adaptive behaviour skills, in infants from one month up to 42 months. |
| Ages and Stages Questionnaire (ASQ) (Bricker & Squires, 1999) | Assesses a child's development across five separate areas: communication, fine motor, gross motor, problem solving, and personal-social skills, in infants from four to 60 months of age |

The Bayley Scales of Infant Development (BSID) was first developed in 1969 to assess an infants' communication, problem solving, verbal skills, learning,and sensory perception (Niccols & Latchman, 2002). A second edition was produced in 1993, which calculated a Mental Development Index (MDI) and Psychomotor Developmental Index (PDI) to reflect an infant's development. The latest version of the BSID is the third edition that assesses 5 developmental areas: cognitive, motor, language, social-emotional and adaptive behaviour skills, in infants from 1 month to 42 months of age (Bayley, 2005). The latter two developmental areas have been added to the existing assessment as required by United States federal law (Bayley, 2005). The BSID-III is reported to take 25-35 minutes to administer. The stability of BSID-II and BSID scores was examined in a sample of infants with Down Syndrome and medically fragile infants. The BSID-II was found to measure changes effectively in developmental patterns during the first 2 years of life (Niccols & Latchman, 2002). In addition, the BSID found delayed developmental outcomes at 18 and 24 months of very preterm infants born less than 32 weeks gestation. Although 60% of participants were born between 29 and 32 weeks gestation, the study failed to provide a breakdown of developmental outcomes by gestational age

(Stoelhorst et al., 2003). In contrast, the BSID-II obtained poor predictive validity when examining the long term outcomes of infants with extremely low birth weight. The study found that infants demonstrating cognitive scores below the normal range on the BSID-II MDI at 20 months of age, did not accurately predict the child's intelligence level at 8 years or school age (Hack, Taylor, Drotar, Schluchter, Cartar, Wilson-Costello, Klein, Friedman, Mercuri-Minich, & Morrow, 2005).

The Ages and Stages Questionnaire (ASQ) was originally developed in 1995 to screen infants' and young children's development until 5 years of age (Squires, Bricker, & Mounts, 1995). The original assessment measured child development from 4 months to 48 months of age across a number of domains (Lee & Harris, 2005). Additional questionnaires were added to the existing assessment in 1999 to measure infant development up to 60 months of age. (Bricker & Squires, 1999). Parents are required to complete the 30 item questionnaire which covers five developmental areas: communication, gross motor, fine motor, problem solving, and personal-social at the relevant age interval. The questionnaire is reported to take 10-15 minutes to complete. The validity of the ASQ was tested on a sample of children born extremely preterm compared to term infants. The ASQ showed that preterm infants scored below their term counterparts. The total ASQ score was found to be correlated significantly with measures of the infant's intelligence quotient (Klamer, Lando, Pinborg, & Greisen, 2005).

#### *3.1.1.4 Neonatal assessments*

This section will provide a summary of the most common neonatal assessments available for use in the NICU and in other hospital and home environments. A summary of neonatal assessments is in Table 6.

Table 6. *Summary of Neonatal Assessments*

| Assessment | Description |
|---|---|
| Neonatal Behavioral Assessment Scale (NBAS) (Brazelton, 1973) | Observations of healthy term infants are recorded for autonomic, motor, state, and attention systems from birth to 2 months PCA. |
| NICU Network Neurobehavioral Scale (NNNS) (Lester & Tronick, 2001) | To measure the neurologic reflexes, motor development, active and passive tone, and signs of stress and withdrawal in at risk healthy infants, preterm infants, and at risk preterm infants born greater than 30 weeks gestation. |

The Neonatal Behavioral Assessment Scale (NBAS) describes the neurobehavioural patterns of healthy term infants (Brazelton, 1973). A second edition was produced in 1984 and a third edition in 1995. The NBAS-R revised version was developed in 2000. The NBAS-R assesses neurobehavioural development in infants from birth to two months PCA. Specifically, the assessment measures the infant's colour, tone, motor movements, alertness, and activity levels during the neonatal period. In addition, the infant's cries and responses to stimuli are assessed. In the current assessment, the examiner is required to make 28 behavioural, 18 reflexive, and 6 supplementary observations. Neurological items are scored on a 4-point rating scale and behavioural items on a 9-point rating scale. The assessment takes between 12 to 15 minutes to administer (Brazelton, 2000). Training and certification are required to implement the NBAS-R.

In contrast to the NBAS-R, the NICU Network Neurobehavioral Scale (NNNS) was developed as a neonatal assessment for healthy and at risk preterm infants and at risk term infants (Lester & Tronick, 2004). The tool can be used to evaluate the infant's neurobehavioural functioning, such as neurological reflexes and tone, behavioural state, and stress or abstinence of stress in preterm infants from 30 weeks gestation (Lester, Tronick & Brazelton, 2004; Lester & Tronick, 2001). Normative data have been collected on a sample of healthy and at-risk infants (Tronick, Olson, Rosenberg, Bohne, Lu, & Lester, 2004). The administrator of the NNNS must attend a certification course to learn the correct procedure and meet specific criteria to use the tool. Training programs are available in Asia, Europe, South America, and the United States, but not in Australia (Lester & Tronick, 2004).

#### *3.1.1.5. Environmental assessments*

A few of the key assessments used to measure environmental influences on infant development are provided in table 7.

Table 7. *Summary of Environmental Assessments*

| Assessment | Description |
|---|---|
| Home Observation for Measurement of the Environment (HOME) (Frankenburg, 1981) | Three age group assessment tools (0 to 3 year, 3 to 6 years, & 6 to 10 years) assess the personal and physical quality of the infant/child's home learning environment. |
| Home Screening Questionnaire (HSQ) (Coons, Gay, Fandal, Ker, & Frankenburg, 1981) | Birth to 3 year questionnaire contains 30 questions and a checklist of 50 toys that are used by the infant in the home environment. |

The Home Observation for Measurement of the Environment (HOME) inventory was developed by Bradley and Caldwell (1981) to measure the quality of the home environment in which the infant is raised. However, the inventory takes 1 hour to administer. The Home Screening Questionnaire (HSQ) is a screening tool which was adapted to form 2 questionnaires (Coons et al., 1981). The HSQ was developed in 1981 in the United States to assess the home environment (Frankenburg, 1981). (Appendix D). Level 1 was developed for birth to 3 years and Level 2 for preschool children aged 3 to 6 years. The birth to 3 year questionnaire contains 30 questions and a checklist of 50 toys that may be used by the infant in the home environment. The infant receives a ‘questions’ and ‘toys checklist’ subtotal, and a total HSQ score based on the responses of their parents (Coons et al., 1981). The HSQ was validated against the HOME on a sample of 120 families with children aged 13 to 44 months in Porto, Portugal. A strong correlation was achieved between the HSQ and HOME assessments of 0.89. Internal consistency was found on both the HSQ (0.82) and

HOME (0.90) (Pessanha & Bairrao, 2003). The HSQ has been standardised on 174 families with the 45 items in the inventory. Reliability testing, including internal consistency and test-retest reliability of the HSQ tool was conducted on 91 families on three occasions at 6, 12, and 24 months (Bradley & Caldwell, 1981). The tool achieved moderate to high stability of scores across scorers and test items (Frankenburg & Coons, 1986). The assessment was developed as a screening tool and the manual indicates that it does not discriminate between middle and higher socioeconomic status populations (Frankenburg, 1981). The HSQ was tested for developmental predictability with the Denver Developmental Screening Test and the Bayley Scales of Infant Development. The tool was significantly correlated with the Denver Developmental Screening Test at 12 months, but not significantly correlated with the Bayley Scales of Infant Development at 15 months (Camp & Headley, 1994).

A few controversial aspects of the screening tool are present. Question 28 asks how decisions on the family income are made, and a score is obtained if decisions are made solely by the father or in consultation with the father. The implication being that mothers are not required to be involved in the decision-making about family income. The scoring criteria for the HSQ suggest that if a score is 32 or below, the child is suspect of environmental deprivation, and non-suspect if they score 33 or above (Frankenburg, 1981). In addition, no age categories or age norms are provided for scoring the questionnaire.

#### *3.1.1.6 Summary*

Feeding and communication assessment protocols typically assess feeding and communication skills from a modular perspective, suggesting that feeding and communication operate as separate motor control systems. The feeding assessments discussed are not theoretically motivated, but they are the only checklists and assessments currently available to the knowledge of this author. The communication assessments have limited theoretical support. In addition, some of these assessments fail to provide information on reliability and validity testing. This study will not examine phonological development in infants. It will focus on the underlying motor control mechanisms of speech, and provide details on the development of feeding and language development during the first year of life.

### *3.1.2 Development of a theoretical framework*

The feeding process is complex and dynamic. "Dynamic systems" theory acknowledges the complex interface between multiple factors and vast variability in development (Fischer & Pare-Blagoev, 2000). Gracco (1990) highlighted the importance of viewing the motor control system as an 'entire tract' as opposed to individual modular units.

Van der Merwe (1997) proposed a 4 level theoretical model of speech production, shown in figure 10. The 4 phases of the theoretical framework of speech sensorimotor control are: (a) linguistic-symbolic planning, (b) motor planning, (c) motor programming, and (d) execution (Van der Merwe, 1997). The theoretical framework was developed to guide assessment and management of patients with neurogenic and other communication disorders. The framework by Van der Merwe (1997) could also be utilised for explaining speech motor control in children. The theoretical paradigm was adapted to explain the interactive functions during deglutition in adults, see figure 11 (Mann, 1999).

The aim of the current study is to examine the relationship between motor control for feeding and communication. Therefore, the framework developed by Van der Merwe (1997) can be utilised to describe speech production in infants and young children. An adaptation of the framework was produced to guide assessment and management during infant feeding and to describe the phases for feeding sensorimotor control (see Figure 12).

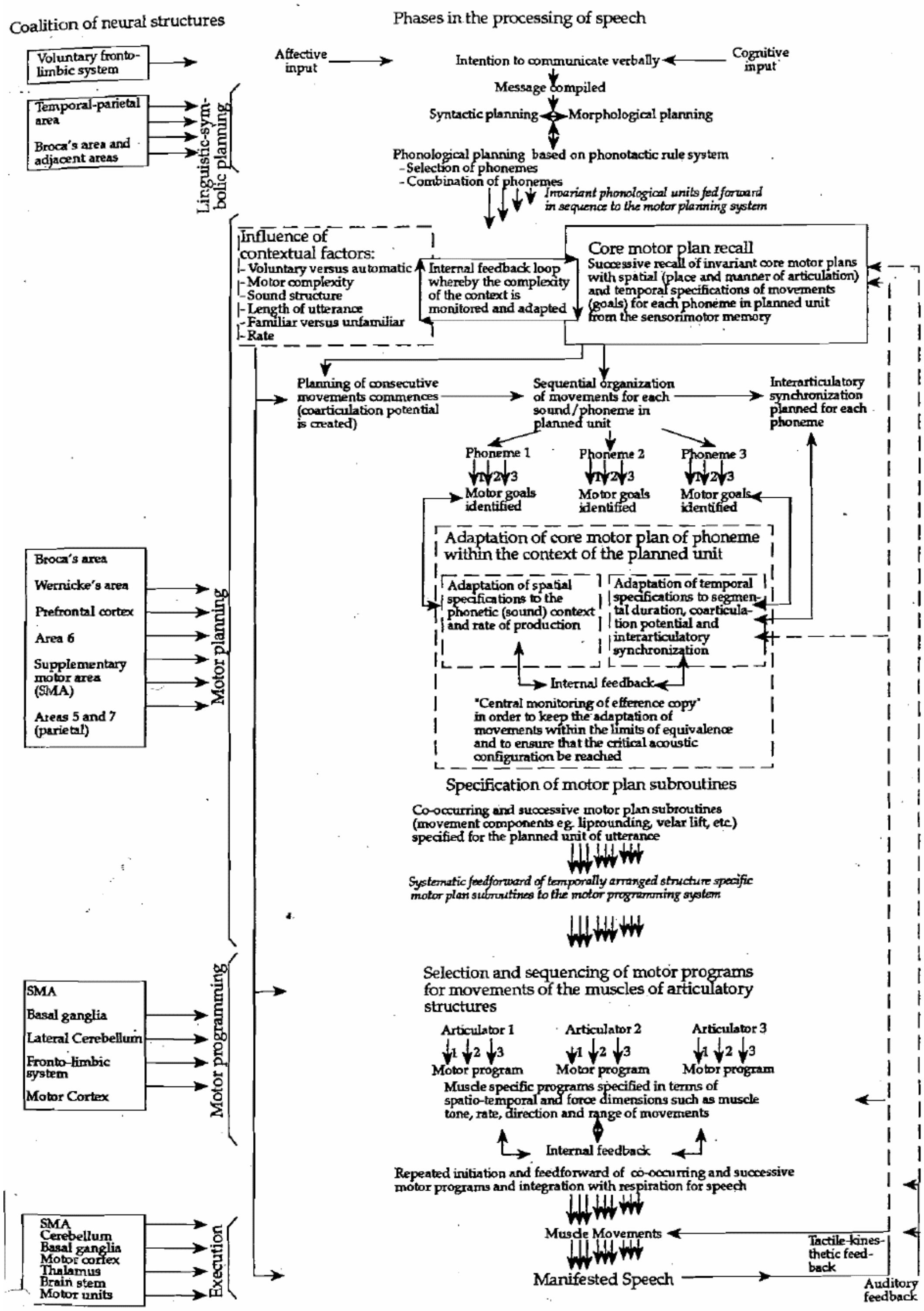


*Figure 10.* Theoretical framework for speech sensorimotor control (Van der Merwe, 1997).

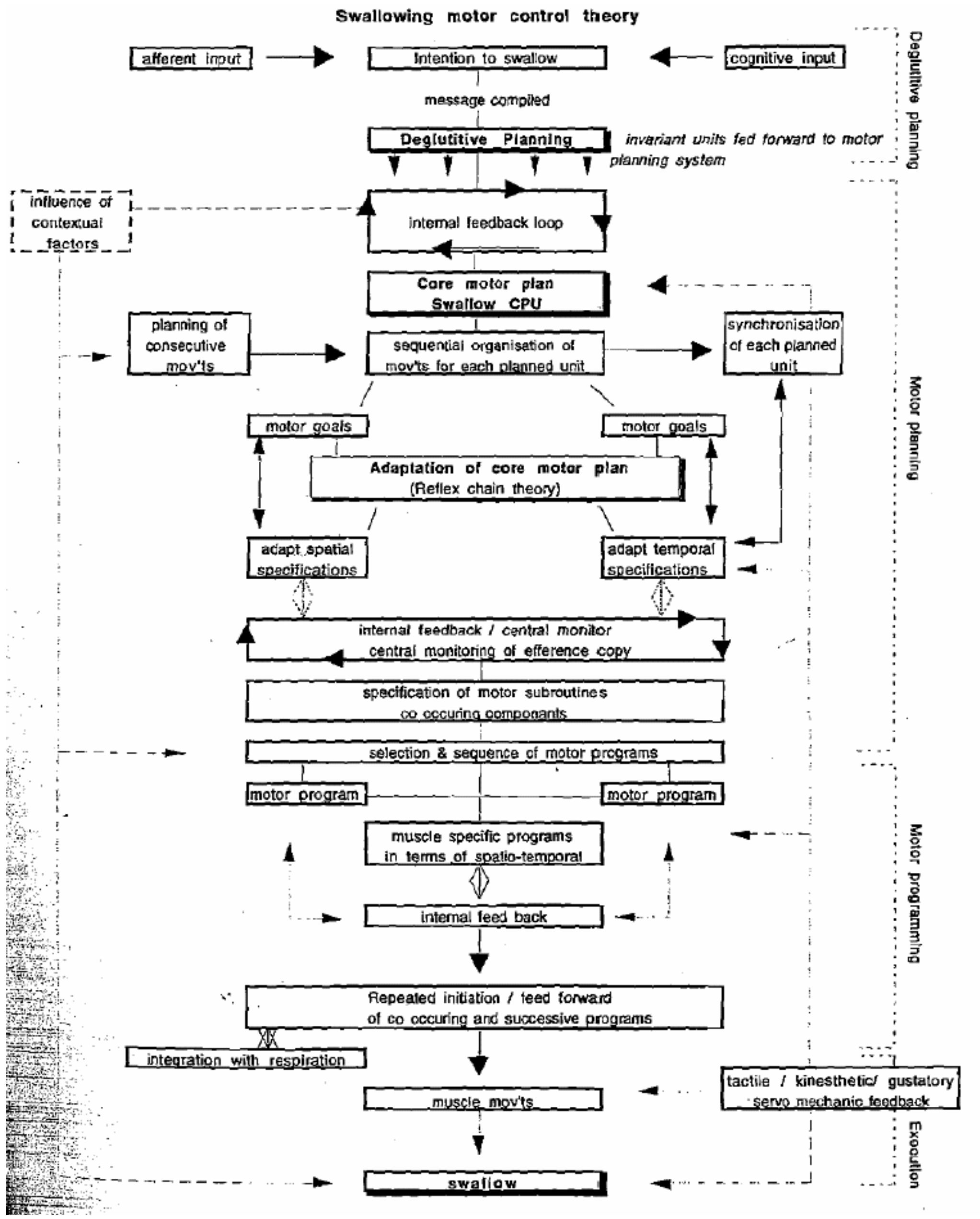


*Figure 11.* Theoretical framework for deglutition (Mann, 1999).

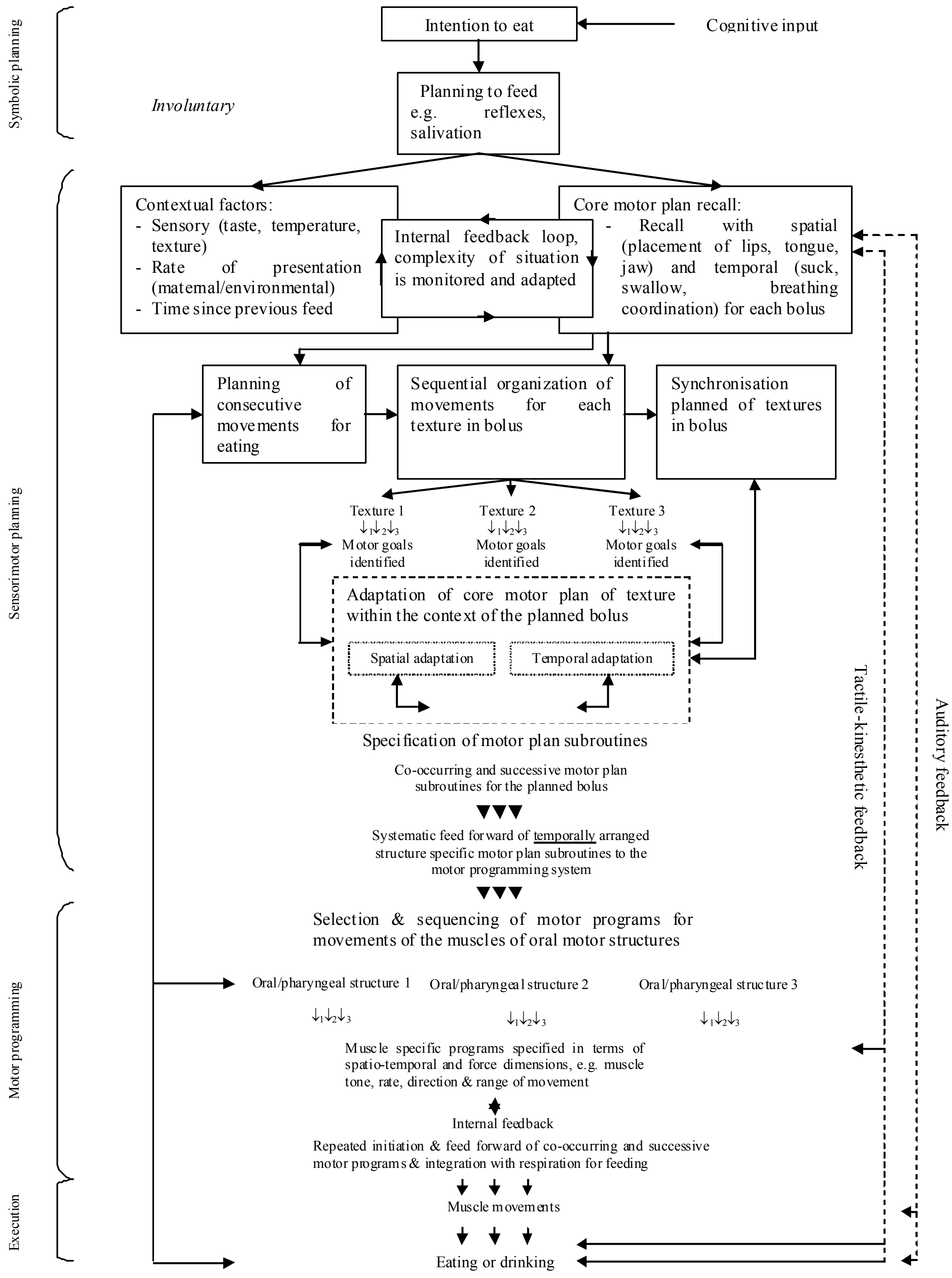


*Figure 12. Theoretical framework of phases for feeding sensorimotor control*

The first stage of the Van der Merve model is the symbolic planning level (Van der Merwe, 1997). This phase of motor control was adapted to the 'intentionality' or 'pre-motor' phase of the feeding model. This stage describes the infant's hunger for feeds, such as crying for a meal as well as the infant's rooting reflex (Bosma, 1997; Rochat, 2007). The rooting reflex can be elicited in response to tactile stimulation around the oral region which results in the infant turning the head in search of a nipple or teat. Infants will also root when they are hungry without any external stimulation.

Motor planning occurs during the second stage of the speech production model (Van der Merwe, 1997). This stage was re-labelled the sensory/motor planning stage in the feeding model to encompass sensory factors, such as taste, temperature, texture, and smell of the bolus during feeding. Spatial and temporal organisation of the bolus is manipulated based on the sensory input. Specific detail for the temperature, presentation and type of liquid offered should be recorded, for example, 150ml Infatrini formula from a slow flow Avent teat and bottle at room temperature.

The third motor programming phase involves the coordination during feeding. Specific parameters which indicate problems with swallowing coordination during infant feeding are described, including gagging, coughing, a wet vocal quality (gurgliness) and increased rate of respiration (breathiness) before, during and after feeding (Kramer & Eicher, 1993; Newman, Keckley, Petersen, & Hamner, 2001; Tuchman, 1988).

The final execution phase of the model describes the control of the individual oral motor structures, including the mouth, lips, and tongue during feeding. Tongue movement milestones include changing from back/front tongue action in young infancy to up/down tongue movements during sucking and swallowing at around 6 to 9 months of age. The infant is also able to lateralize the tongue when food is placed at the side of the mouth to move the bolus to the centre. By 9 to 12 months of age the infant should be able to move the bolus from the centre to the sides of the mouth (Harris, 1986). The infant's tongue lateralization skills are refined with age and experience.

### *3.1.3 Development of feeding assessments and the initial questionnaire*

Feeding assessment protocols were developed based on the proposed theoretical framework of feeding. The assessment included two parts: Feeding Assessment Observations (FAO) (see Appendix E) and the Feeding Assessment Questionnaire (FAQ) (see Appendix F).

#### *3.1.3.1 Feeding Assessment Observation (FAO)*

Blackburn (1986) suggests a list of characteristic feeding behaviours that should be noted during a feeding observation, including the infant's responsiveness to feeding and indications of hunger, such as demonstration of the rooting reflex and crying for a feed.

The FAO checklist includes the participant's age at the date of assessment (see Appendix E) (The preterm participants were seen at 1 to 2 weeks, 4, 8 and 12 months corrected age and term infants were seen 1 to 2 weeks, 4, 8 and 12 months chronological age). The first section involves documenting the presence or absence of the rooting reflex. The scorer records whether the rooting reflex is observed or not observed during the first 15 minutes of the feeding session. The observation in the symbolic planning (intentionality) level is recorded if the 'infant cried for food' and whether this is observed, not observed or unsure if the scorer cannot determine whether the infant is crying for food or another purpose.

The next section of the FAO outlines the texture of food and drinks observed during the session in the sensorimotor planning phase. The left column outlines the liquids observed and the right column the solids observed. Four items in this level have been marked with an asterisk '*'. The observer is required to ask the parent/s these items prior to, during or after the observation.

In order to evaluate sensori-motor planning, the examiner identifies the observed fluid consistency: thin liquids, for example, breast milk, formula, water; thick liquids such as banana milk or a thick shake; or nectar consistency for liquids thickened with a thickening agent such as Resource Thicken Up or Guarcol. The 'nil' item is circled if there is no observation of the infant drinking. The method of liquid presentation to the infant is recorded, such as breast-fed, bottle, spout cup, open cup or straw. The details are recorded for the temperature of the liquid unless the infant is breast-feeding, including cold, room temperature, warm, hot or unsure; and the flow rate of the teat if the infant is bottle-fed. Deficits or difficulties with a particular fluid consistency could suggest that the infant may be less developed or that other factors are impacting on performance.

The second column of the sensorimotor planning section records the solid consistency observed; puree, thickened puree, lumpy puree, mixed texture solids, soft finger food, hard finger food, chewy finger food, nil if no solids are observed, or not applicable if the infant has not started solid food. If multiple textures are observed, these can be recorded with a different colour pen.

The motor programming section outlines the coordination of the infant's swallowing of liquids (left column) and solids (right column). The observations recorded are gagging, coughing, gurgling and increased breathiness on liquid or solids. Items observed are marked with a 'yes', 'no' or 'unsure'.

In the execution level of the FAO, the observer charts the motor function of the oral structures involved during drinking and eating. The execution items recorded during observation of the infant drinking liquids included; lip position, if the lips are sealed during drinking, or leakage is observed on the left, right or both sides of the lips; mouth position, if the mouth opened and remained open whilst liquids are presented; tongue position, indicated if the tongue is positioned on the lower lip for the teat or nipple; and teeth, if the infant had lower central incisors, upper central incisors, or if they are not observed or not applicable for the infant's age.

The execution items for solid observations includes; lip position, if the infant keeps all food in the mouth, or if oral escape is observed from the left, right or both sides of the lips; mouth opening for spoon, if the infant opens the mouth in anticipation of the spoon approaching; and tongue tip elevation, identified when the infant positions the tongue on the alveolar ridge when eating solids, if it is not visible, or not applicable for the infant's age.

The total duration for drinking and the total time for eating are recorded separately, in addition to the total duration of the feed. This measure provides a measure of the overall efficiency of the infant's feeding. If only one consistency is observed, for example a breastfeed, the duration of the breastfeed is recorded in the liquids observed and total column. If the infant is observed eating lumpy puree solids, followed by smooth puree solids, then formula from a bottle, three separate observation tables are completed, including the time for each observation and the total duration of the 3 observations.

#### *3.1.3.2 Feeding Assessment Questionnaire (FAQ)*

The FAO is implemented prior to the FAQ during an assessment to avoid knowledge bias by the parents. Information for the FAQ is collected from the parents report (Appendix F). The FAQ contains categorical data in addition to numerous interval scales. Parents are asked to rate interval measures on a 6.2cm visual analogue scale to rate items from never (0) to consistently (6.2). Like the FAO, the FAQ is organised by the phases of feeding, including reflexes, intentionality, sensorimotor planning, programming, execution, and then the overall efficiency of feeding. The main differences between the FAQ and FAO, is that the FAQ provides interval measures of reflexes, intentionality, sensorimotor planning, execution, whereas the FAO contained categorical measures for all of these phases.

The FAQ will also be a useful tool for confirming feeding observations with the FAO. The questionnaire will provide information to support or refute observations, thus enabling more consistent measurement of feeding skills (Henderson & Meisels, 1994). Parents are also asked to record the confidence of responses on a 6.2cm visual analogue confidence interval scale for each question.

#### *3.1.3.3 Initial Questionnaire*

Infant development relies on the integration of a number of factors in its dynamic system. Blackburn (1986) examined factors that can influence infant development. These factors were obtained during the initial questionnaire (see Appendix G).

The initial questionnaire is based on documented contributors that can influence infant feeding and communication development, including factors affecting infant development, maternal factors, or environmental factors.

Items in the first section of the initial questionnaire provide background information on the infant's development, including predicted date of birth, date of birth, gender; birth details, weight, length, Apgar scores at 1 and 5 minutes; initial review details, current weight and height; medical details, ventilation, Intraventricular Haemorrhage (IVH), Necrotising Enterocolitis (NEC), Respiratory Distress Syndrome (RDS), Bronchopulmonary Dysplasia (BPD); and details on feeding history at birth, including the age oral feeding were introduced and full oral feeds were achieved, whether a feeding assessment or therapy was conducted, and the number of sessions.

Blackburn (1986) suggests the assessment of maternal demographic, pre-pregnancy, prenatal, intrapartum, and neonatal factors. The second section of the initial questionnaire collects background information on maternal factors that may influence infant development, such as: marital status, parents' ages, number and age of other children; pregnancy details, number, and history; birth details, delivery type, infant's position, instruments, complications, medications; presence or absence of post natal depression; parents' language; education level; and geographical factors, type of employment, and home postcode.

The third section summarises environmental factors, including the number of days the infant was in intensive care, special care, high dependency and total days in hospital. It also documents the number of visitors that the participant receives each day or week and the number of adults and children in the home environment.

The questions in the initial questionnaire are based on the literature of maternal, infant, and environmental factors that can influence the infant's feeding and communication development (MacMullen & Dulski, 2000).

## 3.2 Methodology

The Feeding Assessment Observation (FAO) was developed as an observational tool for this study. The FAO was assessed for reliability, including inter-observer bias and observer agreement.

Inter-rater reliability measures the correlation of different raters' scores when rating the same group. The Cochran's *Q* statistic can be implemented to measure inter-observer agreement. Inter-observer agreement determines whether differences in the scorer probabilities of rating that the child has a symptom, such as feeding difficulties, and the bias within individual scorer between items (Aron & Aron, 1994; Everitt, 1996). Analyses will be conducted for participants who have completed all sections in their entirety.

Descriptive statistics will be conducted for individual items on the FAO analysed for the 36 participants. The percent observations will be reported for each item of the FAO including reflexes, intentionality, sensori-motor planning, motor programming, and execution.

### *3.2.1 Participants*

36 fourth year female students enrolled in a Bachelor of Science (Human Communication Science) from Curtin University in Perth, Western Australia participated as raters.

### *3.2.2 Materials*

The stimulus for establishing reliability of the FAO was a single male infant 7 days old during breastfeeding. The feeding session was recorded on a Canon Mv530i digital video camera with a Sony Mini DV digital video cassette. The video footage was transferred to an Emtec SQ E-240 standard quality VHS videotape and shown through the television and video in the lecture theatre at Curtin University.

### *3.2.3 Procedure*

Training

1. All raters were seated in the lecture theatre with audiovisual capabilities, including a television and video.
2. A copy of the Feeding Assessment Observation (FAO) protocol was provided to each student (Appendix E).
3. Students were orientated to the theoretical framework of feeding (Figure 13)
4. Explanation was given for each item requiring a judgement when completing the Feeding Assessment Observation (FAO).
5. An example was provided to show students how to complete the FAO tool. A video taped session of a 7½-month-old infant with feeding difficulties was shown. The feeding behaviours were scored on the FAO through an overhead projector by the author. This was completed to ensure students had a mutual understanding of what to complete for each item of the FAO.
6. Participants were given the opportunity to ask questions related to observations from the case study, and practice scoring on the observation sheet.

Test session

1. Raters were asked to complete and return their consent form to participate in the reliability testing of the FAO.
2. Participants were instructed to complete the FAO for a feeding session of participant number 003, the child's age as newborn (7 days post term) and the date, 2/4/2004 on the observation sheet. Participants were asked to complete the FAO based on observations of on the first 15 minutes feeding session.
3. Participants were instructed not to talk whilst the 15 minutes video sample was playing. Then were told not to ask questions regarding their observations until they had returned a completed FAO sheet.

## 3.3 Results

The reliability of the FAO was tested on a sample of participants. The reliability was tested from two perspectives: (a) inter-observer agreement, and (b) agreement between multiple raters for scoring individual test items, or observer agreement (Haley, Harris, Tada, & Swanson, 1986; Hall, Ellerbee, & Newberry, 1997). Inter-observer agreement was established with multiple raters for one subject. Observer agreement was measured for individual items in the FAO (Everitt, 1996). The observations were coded and entered into a database in SPSS, version 12.0.1 statistical spreadsheet.

### *3.3.1 Inter-observer agreement*

Eighteen of the 36 participants (50%) completed all sections of the FAO. There was significant evidence of inter-observer agreement between the scorers' ratings on the FAO, $Q(17) = 249.773$, $p < .000$.

### *3.3.2 Observer agreement*

Descriptive statistics for individual items on the FAO were analysed for the 36 participants. The percent observations reported for each item within each stage of the FAO are provided: (a) reflexes, (b) intentionality, (c) sensori-motor planning, (d) motor programming, (e) execution. Table 8 outlines the observer agreement for individual questions on the FAO.

Table 8. *Observer Agreement on the Feeding Assessment Observation*

| *Stage* | *Item* | *Percentage observed (%)* |
|---|---|---|
| Reflexes | **Rooting reflex** | |
| | Observed | 58.3 |
| | Not observed | 16.7 |
| | Missing data | 25 |
| | **Excursion reflex** | |
| | Observed | 69.4 |
| | Not observed | 2.8 |
| | Missing data | 27.8 |
| Stage 1: Sensori-motor planning | **Infant cries for food** | |
| | Observed | 94.4 |
| | Not observed | - |
| | Unsure | - |
| | Missing data | 5.6 |
| Stage 2: Motor planning | **Type of liquid** | |
| | Thin | 91.7 |
| | Thick | - |
| | Nil | - |
| | Missing data | 8.3 |
| | **Liquids presentation** | |

| | | |
|---|---|---|
| | Breast | 100.0 |
| | Bottle | - |
| | Spout cup | - |
| | Open cup | - |
| | Straw | - |
| | Other | - |
| | **Liquid temperature** | |
| | Cold | - |
| | Room | 2.8 |
| | Warm | 2.8 |
| | Hot | - |
| | Unsure | - |
| | N/A | 94.4 |
| | **Liquid teat flow** | |
| | Unsure | 2.8 |
| | Not applicable | 97.2 |
| Stage 3: Motor programming | **Gagging on liquids** | |
| | Yes | |
| | No | 97.2 |
| | Unsure | 2.8 |
| | Missing | - |
| | **Coughing on liquids** | |
| | Yes | - |
| | No | 94.4 |
| | Unsure | 2.8 |
| | Missing | 2.8 |
| | **Gurgling on liquids** | |
| | Yes | - |
| | No | 94.4 |
| | Unsure | 5.6 |
| | Missing | - |
| | **Breathiness on liquids** | |
| | Yes | 2.8 |
| | No | 88.9 |
| | Unsure | 8.3 |
| | Missing | - |
| Stage 4: Execution | **Lip seal for liquids** | |
| | Sealed | 91.7 |
| | Not observed | 2.8 |
| | Missing data | 5.6 |
| | **Mouth opening for liquids** | |

| | |
|---|---|
| Yes | 94.4 |
| No | 2.8 |
| Unsure | 2.8 |
| **Tongue position on nipple** | |
| Bottom lip | 11.1 |
| Not observed | 77.8 |
| N/A | 2.8 |
| Missing data | 8.3 |
| **Teeth observed** | |
| Not observed | 38.9 |
| N/A | 61.1 |

The extent of observer agreement was measured all of the 36 participants on all 15 items on the FAO. The average percentage agreement across the 15 items was $M$ = 85.06, $SD$ = 29.46. Sixty six percent of (10/15) observation items on the FAO obtained greater than 90% agreement.

The five items that received less than 90% agreement among the raters were: rooting reflex, excursion reflex, breathiness, tongue position during drinking, and the presence of teeth. The raters appeared to be confused between the rooting and excursion reflexes, indicated by a moderate agreement of 58.3% and 69.4% respectively. These items also had a high frequency of missing data, 25% for the rooting reflex, and 27.8% for the excursion reflex. Better training and the development of standardised scoring criteria for these items could be useful to obtain better agreement among raters.

Poor agreement was indicated for the observation of tongue position. 11.1% reported the tongue positioned on the bottom lip 77.8% did not observe the tongue position, with 8.3% missing data. 2.8% reported this item as not applicable.

## 3.4 Discussion

The FAO involves measurement of the infant feeding by a scorer who views the feeding via video playback. Therefore, human error in measurement on the FAO could have occurred during the observation of infants feeding on the FAO. In addition, different positioning of the video camera could have allowed for a better observation.

The poor agreement on the 'tongue position' observation item in the execution phase could be due to the video footage and poor vision of the tongue area on video playback. Reliability testing was conducted on a term newborn infant who was breastfeeding. Therefore, observation of the execution phase of feeding of a breastfeeding infant was difficult on video playback. As this item on the observation protocol achieved such poor agreement, it was contemplated whether to remove the item. It was decided to keep the item on the observation sheet, as the scoring has the option of scoring this item as 'not observed'. The item was considered to be applicable and would be more easily measured on non-breast fed infants and older infants during the 4, 8, and 12 month review sessions. The data from the observation of the execution phase could also be used to verify reports from the parent questionnaire regarding the execution phase of feeding on the FAQ.

The data collected for the FAO provided slightly higher measures of interrater reliability (85%) than the SOMA (69%) (Reilly et al., 1995). The SOMA focuses its assessment on the oral structures and function during feeding. The FAO and FAQ provided information on all phases during feeding, including intentionality, sensorimotor planning, motor programming, and execution. The FAO and FAQ could be useful measures of feeding skills of infants from birth and may be a useful assessment of feeding skills in the paediatric population, to identify deficits in one or more areas of the feeding system. Variability in inter-observer agreement was revealed on the FAO, this could have been due the large number of questions and number of observers. An important aspect of the FAO and FAQ is that the infant's feeding skills are assessed from a holistic or systemic perspective. The questionnaire and observation protocol describe the overall efficiency of the infant's feeding, the duration, frequency, and volume of feeds. If deficits in the infant's feeding system are identified, closer examination of individual phases of feeding can be reviewed.

# 4.0 FEEDING AND COMMUNICATION RELATIONS

## 4.1 Background

The first stage of the project involved the development of a theoretical framework for feeding, the development of the Initial Questionnaire, the Feeding Assessment Observation (FAO), the Feeding Assessment Questionnaire (FAQ), and conducting preliminary reliability testing of the FAO (see Chapter 3). The second stage of the study involved the application of observational checklists to profile the feeding and communication skills in infants from birth to 12 months. A cohort of term and preterm infants were recruited as participants to be followed over time. Questionnaires were implemented to determine each infant's feeding and communication skills, environmental impacts, and the maternal relationship, and to explore the nature and the inter-relations between environmental and social factors on feeding and communication development. Observation of the infant's feeding skills, information on birth history, and maternal and environmental factors were reviewed at 4 age intervals from birth to 12 months (newborn, 4 months, 8 months, and 12 months).

Throughout this thesis, the term 'communication' will refer to 3 aspects; receptive language, expressive language and speech production. The term 'feeding' will be used to describe the motor control processes specific to feeding. This section will 1) investigate the relationship between parameters of feeding and communication development with contributing environmental and maternal factors, and 2) examine the development of motor control mechanisms for feeding and communication.

## 4.2 Methodology

Preterm infants born less than 33 weeks gestational participated in the study, as they are likely to experience oral motor feeding difficulties (Barlow et al., 2000; Hill et al., 2000). Infants less than 28 weeks were excluded from the study to reduce the potentially confounding impact of associated disease and developmental anomalies. Term infants born greater than 37 weeks gestation were recruited.

### *4.2.1 Participants*

Ten preterm infants born between 28 and 33 weeks gestation and 10 term infants born greater than 37 weeks gestation were recruited to participate in the study. Infants were assessed at 1 to 2 weeks, 4, 8 and 12 months corrected age. For example, a preterm infant born at 32 weeks gestational age was assessed at 2 to 2½, 6, 10 and 14 months chronological age. Of the ten term and 10 preterm infants who were seen for the initial visit at 1 to 2 weeks of age, one preterm infant withdrew from participation at the 4 month and subsequent reviews, and two term infants relocated without advising the chief investigator between the 1 to 2 weeks visit and 4 month follow up. A term infant was unavailable for a 4 months follow up visit, but was reviewed at the 1 to 2 weeks, 8 month and 12 month visits. Attempts to contact these families via the phone numbers and addresses provided were unsuccessful. The details of participants seen at each follow up appointment are outlined in table 9.

Table 9. *Follow up of Term and Preterm Infants*

| | *1-2 wks CA* | *4 mos CA* | *8 mos CA* | *12 mos CA* | ***Total visits*** |
|---|---|---|---|---|---|
| Preterm | 10 | 9 | 9 | 8 | **37** |
| Term | 10 | 7 | 8 | 8 | **35** |
| **Total visits** | **20** | **16** | **17** | **16** | **72** |

Of the 8 preterm and 7 term infants who participated in all visits, 5 preterm infants were male and 3 female, and of the term infants 5 were female and 2 were male. Only the data from infants who participated in all visits are included in the results in Chapters 5 to 8.

The selection criteria for participation in the study were:

*Inclusion Criteria*

- Preterm: Infants who are born between 28 and 33 weeks gestation
- Term: Infants who are born greater than 37 weeks gestation

*Exclusion Criteria*

- Infants who live greater than 200km outside the Perth metropolitan area
- Parents who have given birth within the past 24 hours will not be approached
- Parents who do not speak English
- Infants with major abnormalities or significant diseases

*Withdrawal Criteria*

- Infants that move outside the Perth metropolitan area
- Parent's choice to withdraw from the study

The recruitment procedure for term and preterm infants is described.

Term infants:

Recruitment of term infants followed a quasi-random procedure. Term participants were recruited from Ward 3, a general antenatal and postnatal ward at King Edward Memorial Hospital. The Nursing Manager was the contact for recruiting term infants. She managed all staff on the ward and oversaw the recruitment of families for this and other research projects. The Nursing Manager was provided with background information about the research aims and the inclusion and exclusion criteria for participation in the project. The chief investigator arranged mutually convenient times and days to recruit participants between March and August 2004. On each occasion, the Nursing Manager identified infants and parents who fit the inclusion and exclusion criteria for the project. The chief investigator then approached the parent/s in their room and invited them to participate in the project.

Preterm infants:

Details from the information sheet, inclusion and exclusion criteria were described to staff in the High Dependency Unit and Special Care Nurseries at King Edward Memorial Hospital by the chief investigator and Professor Karen Simmer, Director of Neonatology at King Edward Memorial Hospital. The chief investigator visited these units between March and August 2004 to identify potential participants that fit the inclusion and exclusion criteria. The chief investigator then approached the parent/s whilst visiting their infant or contacted parents by telephone to explain the details with inclusion and exclusion criteria for the project, and to determine their interest in participation. Table 10 outlines the reasons for non-participation of both term and preterm infants.

Table 10. *Term and Preterm Infants Approached and Reasons for Non-Participation*

| | ***Preterm*** | ***Term*** |
|---|---|---|
| Busy with visitors when approached | | 1 |
| Infant in special care nursery | | 1 |
| Participating in too many studies | 1 | |
| Does not want to be videotaped breastfeeding | 2 | 1 |
| Not interested | 1 | 3 |
| Advised they were thinking and would contact chief investigator if interested, but they never followed through. | 2 | |
| | *6* | *6* |

### *4.2.2 Materials*

#### *4.2.2.1 Assessments and questionnaires*

Assessment and observation protocols were used to measure the infant's feeding, communication skills, and environmental and maternal factors. The order of presentation of tests conducted at each four month visit is explained in the procedure.

**Feeding Assessments**

Feeding Assessment Observation (FAO)

The Feeding Assessment Observation (FAO) was developed during phase one of the study (refer to section 3.1.3.1 and Appendix E).

Feeding Assessment Questionnaire (FAQ)

The Feeding Assessment Questionnaire (FAQ) was also developed during the first phase of the project. The infant's parents were asked questions about the infant's feeding skills using the FAQ, which included 25 questions (refer to section 3.1.3.2 and Appendix F).

**Communication Assessments**

The Receptive-Expressive Emergent Language Scale, second edition (REEL-2) (Appendix A) and the infant-toddler checklist from the Communication and Symbolic Behavior Scales Developmental Profile (CBSB DP) (Appendix B) were administered. The Ages and Stages questionnaire was being completed by parents of the preterm infants as part of the infant's neonatal follow-up.

**Assessment of Infant, Maternal, and Environmental factors**

The initial questionnaire developed during phase one of the study was administered to participants (refer to section 3.1.3.3 and Appendix G).

4, 8, & 12 month developmental reviews

The infant's measures of weight, height, and the date were obtained from the yellow health book and parent report. Maternal and environmental changes and the infant's milestone development were also recorded (Appendices O, P and Q).

Home Screening Questionnaire

The 0 to 3 year questionnaire of the Home Screening Questionnaire (HSQ) was used to measure the quality of the home environment (Frankenburg, 1981). The HSQ for children aged 0 to 3 years is attached in Appendix D.

*4.2.2.2 Other Apparatus*

A Canon Mv530i digital video camera was used to videotape feeding sessions using Sony Mini DV digital video cassettes. A tripod was connected to the video camera when required.

### *4.2.3 Procedure*

*Longitudinal participants*

The procedure for collecting data from participants is seen in Table 11.

Table 11. *Schedule of Visits and Assessments*

| *Hospital visit* | *1-2 weeks CA* | *4 months CA* | *8 & 12 months CA* |
|---|---|---|---|
| 1. Information sheet given<br>2. Written consent provided<br>3. Expected & actual date of birth collected<br>4. Contact details obtained | 1. Rapport building<br>2. Set up video camera<br>3. Initial Questionnaire<br>4. REEL-2<br>5. Home Screening Questionnaire<br>6. Feeding observation<br>7. Feeding Assessment Questionnaire | 1. Rapport building<br>2. Set up video camera<br>3. 4 month review<br>4. REEL-2<br>5. Home Screening Questionnaire<br>6. Feeding observation<br>7. Feeding Assessment Questionnaire | 1. Rapport building<br>2. Set up video camera<br>3. 8 & 12 month reviews<br>4. REEL-2<br>5. CSBS<br>6. Home Screening Questionnaire<br>7. Feeding observation<br>8. Feeding Assessment Questionnaire |

Hospital visit

Parents with infants who fit the selection criteria were given verbal information about the project and a participant information sheet (see Appendix H). Parents were asked if they were interested in taking part in the project. If they agreed to participate, a written consent form was given, completed and returned to the chief investigator (see Appendix I). Following the provision of informed consent, address and contact details were collected from the parents, and the infant's estimated and actual date of birth were collected from the parents (see Appendix J). Parents were contacted before their infant turned 1 to 2 weeks corrected age to organise the first assessment. Parents were advised that they would be seen at 4 month chronologic age intervals until the infant was 12 months of age. Parents were contacted by telephone 1 to 2 weeks prior to each 4 month visit to confirm address details and arrange a mutually convenient time for each home visit. Ethical approval was granted by Curtin University of Technology Human Research Ethics Committee and the Women and Children's Health Service Human Ethics Committee (see Appendix K).

First visit – 1 to 2 weeks CA

All visits were conducted by the chief investigator. Home visits were conducted at 4 month age intervals at 1-2 weeks, 4, 8, and 12 months. Preterm infants were seen at 4 month corrected age intervals, and term infants were seen at their chronological age. Appointments were scheduled at a mutually convenient meal time for the family and chief investigator to allow observation of a meal appropriate for the infant's age, for example, a breast or bottle feed, solids, or solids and liquids. Sessions were usually organised around breakfast, morning tea, lunch, or afternoon tea. Additional time was usually required to develop rapport with the parent and the infant before and after the questionnaire and feeding sessions. Table 11 shows the schedule of assessments.

The observation of the infant feeding was usually conducted between completion of the HSQ and FAQ. The cassette was inserted and the video camera was set up on the tripod at the beginning of the session in case the infant became hungry and the feeding was observed earlier in the session. If the infant was hungry when the chief investigator arrived for the visit, observation of the infant feeding was conducted at the beginning of the session, and questionnaires were completed during or after the infant had finished the feeding. This observation was videotaped and the feeding session was scored after the visit. Variation in the duration of the sessions depended on the duration of the feed observed, parents demonstrating feeding and communication behaviours reported, and the duration of rapport and general discussion with families. The time for the initial visit varied from about 40 minutes to 3 hours. The videotaped feeding session was saved on the cassette and the observation sheet was completed on video playback.

After the first assessment at 1 to 2 weeks corrected age, 1 preterm infant and 2 term infants withdrew from participation. An additional term infant was unable to participate in the 4 month visit due to family commitments, but was seen at 8 and 12 months. The mother of the preterm infant indicated that she had returned to work on a full-time basis and chose to withdraw. The family of a preterm infant was unable to participate in the 12 month CA review due to family bereavement requiring her to leave Perth for an extended period of time. The remaining participants were happy and willing to participate in the study from birth to 12 months, which results in preterm N=8 and term N=7.

#### *4.2.4 Scoring*

Data from each participant were scored on the initial questionnaire, developmental review forms, FAO, FAQ, REEL-2 and CSBS forms at each age of 1-2 weeks, 4, 8, and 12 months corrected age. The data were coded and entered into the SPSS for Windows statistical software program, and the analyses were then conducted.

The videotaped observation of the infant feeding was scored after the home visit using the FAO document. Video footage was collected for the first 15 minutes of each liquid and solids texture trial given to the infant. Each trial presented was scored after the relevant 1-2 weeks, 4, 8, and 12 month corrected age or chronological for term infant's visit. The most complex solid texture or liquid consistency was scored on each of the FAO sheets. The scores of the most complex texture observed for liquids and solids were entered into the database for analysis. This was chosen as it reflected the highest level of coordination or most developed feeding skill for the infant during drinking and eating. For example, if an infant was observed at the 12 month corrected age review eating a biscuit (hard finger food), a cheese stick (soft finger food) and strawberry yogurt (lumpy puree), and water from a spout cup, the most complex liquid observation was scored as a thin liquid from a spout cup and the most complex solid texture was the hard finger food. If motor programming or execution difficulties are indicated on a less complicated texture, for example on the lumpy puree but not on the hard finger food, this observation would be scored on the FAO as the most complex texture.

Scoring of the FAQ involved measuring each response and confidence rating along the visual analogue scale to the nearest millimetre, at each of 1 to 2 weeks, 4, 8, and 12 months CA visits. The total length of each scale on the FAQ form is 62mm.

The ceiling age range that the infant achieved on the REEL-2 was recorded into the SPSS database and used for statistical analysis. Syntaxes were developed to calculate the infant's receptive language age (RLA), expressive language age (ELA), and combined language age (CLA) for each assessment at 1 to 2 weeks, 4, 8, and 12 months corrected age for preterm infants and chronological age for term infants.

The infant-toddler checklist of the CSBS DP was scored directly with the parents at 8 and 12 months. The data were coded and input directly into SPSS for Windows. Syntaxes were developed to calculate each infant's composite scores (social, speech and symbolic) and total score on the developmental profile (Appendix R).

Individual questions on the HSQ were coded and input into a SPSS for Windows data file. Syntaxes were developed to obtain a sub-total and total score at each age interval, in accordance with the scoring criteria in the HSQ manual.

## 4.3 Results

The results for this study will be reported in 4 chapters. The first chapter (5.0) will discuss the results from the initial questionnaire and will be organised according to the triad of contributing influences, incorporating infant, maternal and environmental factors (Carpendale & Lewis, 2004). Chapter 6.0 will describe the feeding results on the observation and questionnaire protocols. Chapter 7.0 will outline the communication results, and chapter 8.0 will provide details on the feeding and communication relationship and the results of comparative analyses.

# 5.0 CONTRIBUTING FACTORS

The following sections describe comparisons between term and preterm participants. An understanding of the contributing factors will provide details of potential confounding variables that may influence interpretation of the feeding and communication relationship data. This chapter will provide a description of the impact of contributing factors separated into three sections, infant (5.1), maternal (5.2) and environmental (5.3) factors.

Each section will present results from the initial questionnaire administered at the 1-2 week CA review, and data from the developmental reviews at 4, 8, and 12 months CA. Independent sample t-tests will be used to compare the results for term and preterm infants for interval variables, total numbers or frequency data will be provided for categorical and ordinal variables. Repeated measures ANOVA will be conducted for the HSQ to calculate the difference between in environmental factors between term and preterm infants from birth to 12 months.

## 5.1 Infant factors

### *5.1.1 Infant questionnaire*

*Background and birth information*

There was a statistically significant difference between the gestational age, birth weight, length, head circumference, but not for Apgar scores of term and preterm infants. The mean scores and standard deviations are shown in Table 12.

Table 12. *Participant Details, Gestational Age, Birth Weight, Length, Head Circumference and Apgar Scores*

| | *Term* n=7 | *Preterm* n=8 | *Significance* |
|---|---|---|---|
| Gestational age | 39 wks ± 5 (9.4) | 30wks ± 6 (6.8) | $t(13) = 15.761, p < 0.001$* |
| Birth weight in grams | 3603 (563.3) | 1534 (301.6) | $t(13) = 9.044, p < 0.001$* |
| Length in cm | 50.0 (2.8) | 41.0 (3.1) | $t(13) = 5.859, p < 0.001$* |
| Head circumference in cm | 35.3 (1.8) ^ | 28.4 (1.5) | $t(12$^$) = 8.065, p < 0.001$* |
| Apgar scores | | | |
| - 1 minute | 8.6 (.8) ^ | 7.2 (1.5) | $t(12$^$) = 1.839, p = 0.091$ |
| - 5 minutes | 9.5 (.5) ^ | 8.7 (1.2) | $t(12$^$) = 2.187, p = 0.173$ |

^ - These measures were not available for 1 term participant, therefore n=6 for head circumference and Apgar scores at 1 and 5 minutes.

* Statistically significant difference

*Medical details*

Background medical details were collected by parent report, medical records, and notes in the infant's personal health record, a yellow record book provided by the Health Department containing contact numbers, child health clinics, immunisation records, and numerous records of child development from birth to secondary school (*Personal Health Record*, 2000). The details included whether the infant was ventilated and the number of days ventilated (if applicable), the presence of intraventricular haemorrhage, necrotising enterocolitis, respiratory distress syndrome, and bronchopulmonary dysplasia as a neonate. As would be expected, the preterm group experienced more difficulties that term participants. Specifically, 4 out of 8 preterm infants and 0 out of 7 term infants were reported to have been ventilated as a neonate. The mean number of days ventilated in preterm infants ranged from 1 to 4 days ($M$ = 2.25, $SD$ = 1.50). There were no reports of intraventricular haemorrhage for either the term or preterm infants. No preterm infant (0/8) reported to have had necrotising enterocolitis, but 1/8 preterm infant was reported to have had bronchopulmonary dysplasia.

*Feeding details*

Prior to the commencement of the study, 2 of the 7 term infants and 6 out of 8 of preterm infants were seen for a feeding review as a neonate. Preterm infants ($n$ = 6) were seen by a lactation consultant or nursing staff at KEMH, for 4.67 sessions ($SD$ = 4.08), for an average of 20.83 minutes ($SD$ = 13.93). In comparison, term infants ($n$ = 2) were seen for by a midwife at KEMH for feeding assessment and therapy, for an average of 1.5 sessions ($SD$ = 0.71), for a mean of 45.00 minutes ($SD$ = 13.93) per visit.

The feeding methods of infants at birth as reported by parents and the details are illustrated in Table 13. At the 1-2 week CA review, all 7 term infants were breast fed. In comparison, 3 preterm infants were breast fed, 3 infants were bottle fed and the remaining 2 infants received a combination of breast and bottle feeds. As expected, oral feeds were introduced significantly later in the preterm group, $t(13) = 3.927$, $p < 0.001$, and full oral feeds were achieved significantly later in the preterm group, $t(13) = 6.466$, $p < 0.001$. The difference between groups is outlined in Table 14. During the hospital admissions, the preterm infant who was bottle fed received expressed breast milk from a bottle.

Table 13. *Initial Feeding Methods*

| | *Term* | *Preterm* |
|---|---|---|
| Oral feeds | | |
| - breast fed | 6/7 | |
| - bottle fed | | |
| - bottle & breast fed | 1/7 | |
| Non-oral feeds | | |
| - nasogastric or orogastric | | 6/8 |
| Combination | | |
| - nasogastric & breast fed | | 1/8 |
| - nasogastric, breast & bottle fed | | 1/8 |

Table 14. *Days after birth that Oral Feeds are introduced and Full Oral Feeds are achieved by Term and Preterm Infants*

| | *Term* n=7 | *Preterm* n=8 |
|---|---|---|
| Oral feeds introduced (days) | 1.0 (0.00) | 14.0 (11.90) |
| Full oral feeds achieved (days) | 1.1 (0.38) | 35.2 (13.88) |

The main finding from the initial questionnaire was that prematurity had a significant influence on a range of infant factors, including a significantly longer duration to commence oral feeds and accept full oral feeds. More preterm infants required feeding assessments, and they occurred more frequently. Preterm infants had more neonatal medical anomalies, with significantly lower birth weight, length, head circumference at birth.

### *5.1.2 Developmental review*

The results of the infants' corrected age, weight and length, health, feeding changes and motor milestones were collected at each developmental review.

*Age at each assessment*

There was no significant difference between the mean corrected ages for any of the infants at assessments. Table 15 provides a summary table for the ages of infants at each of the visits.

Table 15. *Corrected Ages of Preterm and Chronological Age of Term Infants at each Assessment*

| | *Term* n=7 | | *Preterm* n=8 | | *Significance* |
|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | |
| 1- 2 weeks | 12.1 d | 8.90 | 11.2 d | 9.60 | $t(13) = .185, p = 0.856$ |
| 4 months | 4.2 m | 0.40 | 4.4 m | 0.38 | $t(13) = .965, p = 0.352$ |
| 8 months | 8.3 m | 0.30 | 8.5 m | 0.67 | $t(13) = .624, p = 0.544$ |
| 12 months | 12.8 m | 0.62 | 12.2 m | 0.44 | $t(13) = 2.12, p = 0.054$ |

d=days, m=months

*Weight and length measures*

The participants' weight and length measurements were collected from the parent report at each developmental review. Parents reported that infants were weighed at various times and not specifically at the age intervals of 1-2 weeks, 4, 8, and 12 months CA, therefore missing data is present for a number of weight and length measures, and the relevant sample numbers are variable. There was no significant difference between length and weight of preterm and term at any of the age intervals at 1-2 weeks, 4, 8, or 12 months CA. The anthropometric measures are highlighted in Table 16.

Table 16. *Anthropometric Characteristics at 1-2 weeks, 4, 8 and 12 months CA*

| | *Term* | *Preterm* |
|---|---|---|
| 1-2 weeks CA | | |
| Weight (kg) | 3.55 (0.540) | 3.15 (0.551) |
| | (*n* = 7) | (*n* = 8) |
| Length (cm) | 52.8 (1.44) | 49.4 (3.08) |
| | (*n* = 3) | (*n* = 6) |
| 4 months CA | | |
| Weight (kg) | 6.04 (0.691) | 6.33 (0.902) |
| | (*n* = 6) | (*n* = 8) |
| Length (cm) | 62.9 (4.289) | 62.4 (3.367) |
| | (*n* = 4) | (*n* = 7) |
| 8 months CA (n) | | |
| Weight (kg) | 8.00 (0.708) | 7.96 (1.469) |
| | (*n* = 7) | (*n* = 7) |
| Length (cm) | 69.3 (5.400) | 68.84 (2.873) |
| | (*n* = 6) | (*n* = 7) |
| 12 months CA (n) | | |
| Weight (kg) | 10.18 (1.337) | 9.10 (1.788) |
| | (*n* = 5) | (*n* = 7) |
| Length (cm) | 71.5 (9.192) | 75.4 (4.852) |
| | (*n* = 2) | (*n* = 5) |

Standard deviation is reported in brackets

*Infant's health*

Parents reported a range of infant illnesses in both the term and preterm groups. The illnesses described by parents at each developmental review are outlined in Table 17.

Table 17. *Type of Illnesses Experienced by Term and Preterm Infants at 4, 8 and 12 months CA*

| | *Term*<br>n=7 | *Preterm*<br>n=8 |
|---|---|---|
| 4 months | | |
| - Cold/flu | 3 | 5 |
| - Respiratory | 1 | |
| - Hospital < 3 days | | 2 |
| - Hospital > 3 days | 1 | 2 |
| 8 months | | |
| - Cold/flu | 4 | 2 |
| - Gastroenteritis | 1 | |
| - Respiratory | 2 | |
| - Hospital < 3 days | | 4 |
| - Hospital > 3 days | 1 | |
| 12 months | | |
| - Cold/flu | 2 | 6 |
| - Respiratory | 1 | 1 |
| - Ear infections | | 1 |
| - Hospital < 3 days | 2 | |

*Motor milestones*

A range of developmental milestones were collected from parent reports at the 4 months (Appendix L), 8 months (Appendix M), and 12 months (Appendix N) chronological age for term infants and corrected age for preterm infants. The motor score for each infant was calculated for each review. Individual milestones were recorded and scored 2 points if exhibited 'always', 1 point for 'sometimes' and 0 points for never. The mean scores and significance levels at each age interval are reported in Table 18. No statistically significant difference was seen at any age interval.

Table 18. *Motor Milestone Development of Term and Preterm Infants at 4, 8 and 12 months CA as Scored on the Developmental Review Assessments in Appendices L to N.*

| | *Term* n=7 | *Preterm* n=8 | *Significance* |
|---|---|---|---|
| 4 months | 16.0 (.1.291) | 16.0 (2.390) | *t*(13) = .000, p = 1.000 |
| 8 months | 20.0 (0.816) | 17.8 (2.053) | *t*(13) = 2.708, p = .0180 |
| 12 months | 11.4 (1.902) | 9.5 (2.563) | *t*(13) = 1.633, p = 0.126 |

In summary, the results of the developmental reviews showed that term and preterm infants were seen at matched time intervals. Preterm infants had more illnesses and hospitalisations at 4 and 12 months CA. Motor scores were all within normal developmental expectations.

## 5.2 Maternal factors

### *5.2.1 Initial questionnaire*

Carpendale and Lewis (2004) highlighted the consideration of maternal factors in infant development. Details of maternal influences were collected in the initial questionnaire including the family status, pregnancy details, birth details, post birth details, and language, education, and geographical details. These details were collected from parent report during the initial visit at 1-2 weeks CA.

All participating mothers were either married or in a defacto relationship with the infant's father. The average age of parents of preterm infants and term infant parent counterparts was statistically significant for mothers, $t(13) = 2.362$, $p = 0.034$ but not for fathers, $t(13) = 1.240$, $p = 0.237$.

Two of the 7 mothers of term infants had previous pregnancies, and all of the preterm mothers had prior pregnancies. Two of 7 mothers of term and 3/8 mothers of preterm infants took medications during the pregnancy. The participants' birth details were recorded by parent report during the initial questionnaire. The delivery method, position of infant at delivery, and use of instruments for term and preterm infants are reported in Table 19.

Table 19. *Birth Details for Term and Preterm Infants*

| | *Term* n=7 | *Preterm* n=8 |
|---|---|---|
| Delivery method | | |
| - vaginal | 5 | 1 |
| - caesarean | 2 | 7 |
| Position | | |
| - normal | 7 | 3 |
| - breech | | 4 |
| - unsure | | 1 |
| Complications | | |
| - Nil | 3 | 4 |
| - High blood pressure | 1 | |
| - Haemorrhage | 2 | 1 |
| - Other | 1 | 3 |

The mothers of 3 term and 5 preterm infants were reported to have had medication during child birth for high blood pressure, inducing labour and epidural. There were no reports of postnatal depression in mothers of either the term or preterm infants.

English was the primary language for all parents of preterm infant participants. One parent in the term group spoke Indonesian as a primary language and spoke English as a second language, therefore the infant was eligible to participate in the study. The parents' educational level and employment situation prior to the birth of the infant participating in the study is reported in Table 20.

Table 20. *Educational Level and Employment Situation for Mothers and Fathers of Term and Preterm Infants*

| | *Term* | | *Preterm* | |
|---|---|---|---|---|
| | Mother | Father | Mother | Father |
| | n=7 | | n=8 | |
| Educational level | | | | |
| - Year 10 | | 1 | 1 | 4 |
| - Year 12 | | 1 | 1 | 2 |
| - TAFE | 3 | | 3 | 1 |
| - Undergraduate | 3 | 4 | 2 | 3 |
| - Postgraduate | 1 | 1 | 1 | |
| Employment before birth of infant | | | | |
| - Full time | 3 | 7 | 2 | 7 |
| - Part time | | | 1 | |
| - Casual | 1 | | 1 | |
| - No work | 3 | | 4 | 1 |

### *5.2.2 Developmental review*

During the review sessions at 4, 8, and 12 months CA, mothers were asked about their health in the previous 4 months. Mothers of term and preterm infants reported the number of illnesses experienced; the responses are shown in Table 21.

Table 21. *Maternal Health and Reports of Illness at 4, 8 and 12 months CA*

| | *Term*<br>n=7 | *Preterm*<br>n=8 |
|---|---|---|
| Maternal sickness | | |
| - 4 month review | 3 | 3 |
| - 8 month review | 6 | 5 |
| - 12 month review | 2 | 2 |

There was no significant influence of maternal factors between the term and preterm groups. Both groups demonstrated similar family status, pregnancy details, post birth details, language, educational levels, and maternal health.

## 5.3 Environmental factors

### *5.3.1 Initial questionnaire*

As expected, preterm infants ($M$ = 43.38, $SD$ = 15.306) spent statistically significantly more days in hospital compared to their term infant counterparts ($M$ = 3.14, $SD$ = 1.952), $t(13) = 6.874$, $p < 0.001$. Preterm infants spent statistically significantly more days in the intensive care unit, $t(13) = 2.694$, $p = 0.018$. In addition, a statistical significance was observed for the number of days preterm infants ($M$ = 38.50, $SD$ = 12.154) spent in the special care nursery/high dependency unit (HDU) compared to term infants ($M$ = .12, $SD$ = 0.205), $t(13) = 8.314$, $p < 0.001$. There was no significant difference between the number of visitors for the term and preterm infants, $t(13) = 1.574$, $p = 0.140$.

Details on the number of adults and children in the home environment were collected from parents. Seventy one percent of families (5/7) had no other children and 29% (2/7) had one other child. The ages of the siblings ranged from 18 months to 6 years in the term group. Two out of 8 preterm families had one other child, and 6/8 reported two other children. Siblings of the preterm infants ranged from 8 months to 11 years. There was a statistically significant difference between the number of children in the preterm and term infant families, $t(13) = 4.051$, $p < 0.001$. No significant differences were found for the number of adults in the home of term and preterm participants.

### *5.3.2 Developmental review*

The parents of term and preterm infants reported any changes in the environment for the infant. Parents reported when infants had spent a period of time in hospital, if they had been away for weekend trips, or if they had been on longer holiday. The environmental changes for term and preterm infants at 4, 8 and 12 months CA are reported in Table 22.

Table 22. *Environmental Changes for Term and Preterm Infants at 4, 8 and 12 months CA*

| | *4 months* | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Nil | 2 | 4 | | 1 | 5 | 7 |
| Hospital > 5 days | 2 | | 2 | | | |
| Holidays | | | | | | |
| - weekend | 1 | 1 | 1 | 3 | 2 | |
| - > 5 days | 1 | 2 | 2 | 4 | | 1 |
| Moved/living in different house | 1 | 1 | 2 | | | |

### *5.3.3 Home Screening Questionnaire*

Comparisons between the quality of the home environment was analysed. A repeated measures ANOVA showed no significant difference between term and preterm participants from birth to 12 months $F(1,13) = .183$, $p = .676$. Individual t-tests at individual age intervals showed no statistically significant differences between the preterm and term group scores on the Home Screening Questionnaire (HSQ) at 1-2 weeks CA, $t(13) = 0.226$, $p = 0.825$, 4 weeks CA, $t(13) = 1.492$, $p = 0.160$, 8 months CA, $t(13) = 0.745$, $p = 0.470$, and at 12 months CA, $t(13) = 0.212$, $p = 0.835$.

A number of statistically significant environmental differences were reported within the initial questionnaire between the term and preterm groups with the term infants spending more time in hospital. There were also statistically significantly more children within preterm than term families. Environmental changes were observed for term and preterm participants at each developmental review. A repeated measures ANOVA revealed that the environmental scores on the HSQ improved over time for all participants, $F(1,13) = 458.74$, $p < 0.001$. The HSQ scoring manual suggests that a score of 32 or below is indicative of a suspect home environment and above 33 a non-suspect environment. Based on the results of this study, all term and preterm infant participants at all age intervals are indicative of suspect home environments. However, this was not the impression of the chief investigator.

## 5.4 Summary

Comprehensive data were collected on influencing infant, maternal, and environmental factors from the initial questionnaire, and at 4, 8, and 12 months CA. Statistically significant differences were found among a range of infant and environmental factors. However, there were no differences for maternal factors between groups. It is important to acknowledge the small sample from whom data were collected in this pilot study.

The infant factors that were significant between groups include birth weight, length, and head circumference. Preterm infants took significantly longer to commence oral feeds and accept full oral feeds, and received a higher number and more frequent assistance feeding by midwifes and lactation consultants.

Significant environmental differences were found between the term and preterm groups in the neonatal period. Preterm infants spent a significantly longer time in hospital, and in the high dependency unit/ special care nursery in hospital. There was also a statistically significant difference between the number of children in the preterm and term infant families.

# 6.0 FEEDING DEVELOPMENT

The results of the feeding development of participants will be presented within stages of the theoretical framework for feeding: (a) overall efficiency, (b) reflexes, (c) symbolic planning (intentionality), (d) sensorimotor planning, (e) motor programming, and (f) execution. Results will be presented for observation of the infant feeding (FAO) and parent reports of infant feeding (FAQ).

The results for the correlation between FAO and FAQ scores, and parents' confidence ratings on the FAQ are provided for each step of the model. Only infants who participated in all assessments are included in Chapter 6, that is 8 preterm and 7 term infants. There is variability between the numbers of participants observed feeding at each assessment. For example, one term infant was not observed feeding at the 1-2 week assessment, and a number of infants were observed eating solids, but not drinking liquids at the 4, 8, and 12 month CA assessment. Therefore, the number of participants included in analyses will be presented for each measure in chapter 6.

Independent sample t-tests will be conducted to calculate differences between the term and preterm groups for interval variables, total numbers or frequency data will be provided for categorical and ordinal variables. Correlation measures were made to confirm parent reports of feeding behaviours and to establish reliability between the observation and questionnaire. The applicable correlation analyses for each feeding parameter are seen in Table 23.

Table 23. *Types of Correlation Analyses between Items on the Feeding Assessment Questionnaire (FAQ) and Feeding Assessment Observation (FAO)*

| | FAQ | FAO | Measure |
|---|---|---|---|
| Overall efficiency | Ratio | Ratio | Spearmans |
| Reflexes | Interval | Categorical | Eta statistic |
| Symbolic planning (intentionality) | Interval | Categorical | Eta statistic |
| Motor planning | Interval | Categorical | Eta statistic |
| Motor programming | Interval | Categorical | Eta statistic |
| Execution | Ratio | Categorical | Eta statistic |

The Spearmans rho ($r_s$) is a measure of association between rank orders when both table factors are quantitative or ratio variables {Aron, 1994 #107}. The Eta statistic ($\eta^2$) is a measure of association between an interval or ratio dependent variable and a categorical independent variable. The Eta statistic provides a percentage that the independent variable can be explained by the dependent variable {Olejnik, 2003 #847;Aron, 1994 #107}. Both the Spearmans rho and Eta statistic will be used to conduct correlation analyses between items on the Feeding Assessment Questionnaire (FAQ) and Feeding Assessment Observation (FAO).

## 6.1 Overall efficiency - duration, volume and frequency

### *6.1.1 Feeding observation*

A maximum of 20 minutes observation was conducted for each infant's feeding of liquid and/or solids. The total duration of the meal time was also recorded on the FAO. There was no difference between the time taken to consume liquids at 1-2 weeks, 4, 8, and 12 months CA. During the 20 minute observation, there was a statistically significant difference between the duration for term and preterm infants to eat solids at 4 months C, $t(8) = 2.359$, $p = 0.046$. No statistically significant differences were seen at 8 and 12 months CA. There was large variability in the sample numbers at each age intervals as different infants were introduced to solids at differing times. The duration of the mealtime meal depended on whether liquids, solids, or a combination of both solids and liquids were observed. Table O1 shows the mean and standard deviation of the time spent taking liquid, solid, and total duration of feeds.

### *6.1.2 Feeding questionnaire*

Data on the duration, frequency, and volume of liquids and solids consumed were also collected from parent report. There was no statistically significant difference between the term and preterm groups for mean duration, frequency, or number of feeds, volume of liquids at 1-2 weeks, 4, 8, and 12 months CA. The mean data for each time interval for the duration, frequency, and volume of liquids are presented in Table O2.

The FAQ also measured the duration, frequency, and volume of solids consumed by infants at 4, 8 and 12 months CA (Table O3). There was no significant difference in the time or frequency, volume and duration of solids between term and preterm infants at the 4, 8, and 12 month CA assessments. Four out of 7 term infants and 6 out of 8 preterm infants had commenced solids at the 4 month corrected age review.

## 6.2 Reflexes

### *6.2.1 Feeding observation*

3/6 term and 4/8 preterm infants were observed exhibiting a rooting reflex at 1-2 weeks CA. After the initial assessment at 1-2 weeks CA, no term or preterm infant was observed eliciting the rooting reflex. The frequency of rooting reflex observations is illustrated in Table 23.

Table 24. *Frequency of 'Rooting Reflex' during Liquid Observations for Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA*

| | *1-2 weeks CA** | | *4 months CA#* | | *8 months CA^* | | *12 months CA∞* | |
|---|---|---|---|---|---|---|---|---|
| | Term n=6 | Preterm n=8 | Term n=6 | Preterm n=7 | Term n=5 | Preterm n=7 | Term n=5 | Preterm n=8 |
| Yes | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| No | 3 | 4 | 6 | 7 | 5 | 7 | 5 | 8 |

* One term infant was not observed feeding liquids at this assessment

# One term and one preterm infant were not observed drinking liquids

^ Two term infants and one preterm infant were not observed drinking liquids

∞ Two term infants were not observed drinking liquids

### *6.2.2 Feeding questionnaire*

At 1-2 weeks CA, all infants were reported to exhibit rooting reflexes on the FAQ, and no significant difference was reported between the term and preterm group for turning the head to the source of the liquid and opening mouth when touched around the mouth. Table O4 outlines the descriptive data for infant reflexes on the FAQ.

## 6.3 Symbolic planning (intentionality)

### *6.3.1 Feeding observation*

Table 25 outlines the frequency 'crying for food' of term and preterm infants at each assessment.

Table 25. *Frequency of 'Crying for Food' for Liquids for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA*

| | *1-2 weeks CA** | | *4 months CA#* | | *8 months CA^* | | *12 months CA∞* | |
|---|---|---|---|---|---|---|---|---|
| | Term n=6 | Preterm n=8 | Term n=6 | Preterm n=7 | Term n=5 | Preterm n=7 | Term n=5 | Preterm n=8 |
| Yes | 2 | 5 | 2 | 4 | 0 | 1 | 0 | 1 |
| No | 4 | 3 | 4 | 3 | 5 | 6 | 5 | 7 |

* One term infant was not observed feeding liquids at this assessment

# One term and one preterm infant were not observed drinking liquids

^ Two term infants and one preterm infant were not observed drinking liquids

∞ Two term infants were not observed drinking liquids

### *6.3.2 Feeding questionnaire*

There was no statistically significant difference for 'crying for food' between groups at 1-2 weeks, 4, 8 and 12 months CA.

## 6.4 Sensorimotor planning

### *6.4.1 Feeding observation*

**Liquids**

Most term and preterm infants were observed drinking thin liquids, such as water, formula, breast milk or juice at each assessment. Only 1 infant was observed drinking thickened liquids at 8 months CA due to difficulties swallowing. Table P1 in Appendix P highlights the 'type of liquids' term and preterm infants consume at each age interval.

Six out of 6 term infants and 6/8 preterm infants were breast-fed at 1-2 weeks (Table P2 in Appendix P). By 4 months CA 5/6 term infants were still observed breastfeeding and 1/6 bottle-feeding. In comparison, more preterm infants were bottle-fed (4/7) than breast-fed (3/7). Three out of 5 term and 3/7 preterm infants were drinking from a spout cup at 8 months CA, increasing to 4/5 term and 4/8 preterm infants at 12 months CA.

The temperature of the liquid was recorded for bottle and cup drinking. The temperature of the liquid observed was recorded as ‘not applicable’ for the breast-fed infants. Table P3 in Appendix P shows the temperature of liquids taken by infants at each age interval.

The teat flow was recorded for infants who were bottle-fed (Table P4 in Appendix P). The flow rate for the observation of breast-fed infants and drinking from a spout cup was recorded as ‘not applicable’.

**Solids**

Four out of 7 term and 6/8 preterm infants were observed eating solids at 4 months CA. Of the infants observed eating solids at 4 months, 4/4 term infants and 5/6 preterm infants ate puree solids, 1/6 preterm infant was eating soft finger foods. At 8 months CA, 6/8 preterm infants were observed eating more soft, hard or chewable finger foods compared to 2/7 term infants. At 12 months CA, 7/8 preterm and 4/6 term infants were observed eating soft, hard, and chewy finger foods. The type of solids that were observed at each assessment is shown in Table P5 in Appendix P. Table P6 in Appendix P illustrated the method that solids were presented to infants at each assessment.

Parents were asked the temperature of the solids given to infants during the solid meal observation. Table P7 in Appendix P shows the temperature of solids for term and preterm infants at each age review. Most infants had room temperature or warm solids during the observation.

The taste of solids observed at each review was recorded on the FAO. At 4 months CA, all infants were observed eating sweet solids. In contrast, at 8 months 5/7 term and preterm infants were eating savoury solids and 2/7 ate sweet solids in both groups. The tastes of solids observed at each review are shown in Table P8 in Appendix P.

### *6.4.2 Feeding questionnaire*

**Liquids**

The consistencies of fluids that term and preterm infants drank at 1-2 weeks, 4, 8, and 12 months CA is illustrated in Table P9 in Appendix P.

More term infants (7/7) were reported to be breast-fed than preterm infants (3/8) at 1-2 weeks CA. Six out of 7 term infants and 4/8 preterm infants were breast-fed at 4 months CA (Table P10 in Appendix P). By 8 months CA, 4/7 term and 4/8 preterm infants were breast-fed. Table P10 in Appendix P outlines the presentation of fluids to infants on the FAQ at each age assessment. Parent's reported infant's preference of liquid temperature at each age interval, as illustrated in Table P11 of Appendix P.

**Solids**

No term or preterm infants had been introduced to solids at 1-2 weeks CA. The textures of solids accepted by term and preterm infants at 4, 8, and 12 months CA are shown in Table P12 of Appendix P. Preterm infants were introduced to solids at an earlier corrected age than term infants at their chronological ages. At 4 months CA, 7/8 preterm infants had been introduced to solids, compared to 4/7 term infants. By 8 months CA, all term and preterm infants had been introduced to solids and tried smooth, thick and lumpy purees.

More preterm infants were spoon-fed at 4 months CA (Table P13 of Appendix P). In addition, more preterm infants (8/8) ate finger foods than term infants (4/8) at 8 months CA. By 12 months CA, all term and preterm infants were accepting solids from the spoon and having finger foods. Of the infants accepting solids at 4, 8, and 12 months CA, the solid texture preferences are shown in Table P14 of Appendix P.

Parents were asked the temperature preference for solid foods for their infant (Table P15 of Appendix P). The majority of preterm infants preferred warm solids at 4, 8 and 12 months CA, the frequencies were 5/7, 7/8 and 6/8 respectively, the remaining preterm infants preferred room temperature solids. In comparison, the results of term infants were more diverse, and some term infants were reported not to have a temperature preference for solids.

More preterm infants preferred sweet tasting solids at 4, 8 and 12 months CA, the results were 6/7, 7/8 and 6/8 according to parent report in the FAQ (Table P16 of Appendix P). In contrast only 2/4, 3/7, and 2/7 of term infants were reported to prefer sweet tasting solids at the 4, 8, and 12 month assessment. A larger proportion of term infants preferred savoury taste solids, or had no taste preference for solids.

## 6.5 Motor programming

### *6.5.1 Feeding Observation*

Infant's motor programming skills were measured by parameters of feeding difficulty as described in the theoretical framework, including gagging, coughing, increased gurgliness and breathiness observed and scored on the FAO. The observation of these parameters will not provide information on the presence of other influencing factors such as gastroesophageal reflux disease or silent aspiration. First the results for motor programming with liquids will be presented. The results for solids will follow.

**Liquids**

One preterm infant exhibited gagging on liquids at 1-2 weeks CA and one term infant at 8 and 12 months CA. A larger proportion of infants were observed coughing on liquids at each assessment. The number of coughs observed on liquids is shown in Table 26.

Table 26. *Number of times 'Coughing on Liquid' was observed for Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA*

| | *1-2 weeks CA** | | *4 months CA#* | | *8 months CA^* | | *12 months CA∞* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=6) | Preterm (n=8) | Term (n=6) | Preterm (n=7) | Term (n=5) | Preterm (n=7) | Term (n=5) | Preterm (n=8) |
| Yes | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 |
| No | 6 | 8 | 6 | 7 | 3 | 6 | 4 | 8 |

* One term infant was not observed feeding liquids at this assessment

# One term and one preterm infant were not observed drinking liquids

^ Two term infants and one preterm infant were not observed drinking liquids

∞ Two term infants were not observed drinking liquids

One term and one preterm infant demonstrated more gurgliness on liquids at 1-2 weeks CA. No gurgling observations occurred at 4 months CA, and one term infant exhibited gurgliness on liquids at 8 months CA, and no gurgles were observed at 12 months CA. A number of infants sounded increasingly breathy during and after liquid feeds. However, there does not appear to be substantial differences between the groups. Table 27 highlights the frequency of breathiness observations for term and preterm infants.

Table 27. *Frequency of 'Breathiness on Liquid' Observations of Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA*

| | *1-2 weeks CA** | | *4 months CA#* | | *8 months CA^* | | *12 months CA∞* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=6) | Preterm (n=8) | Term (n=6) | Preterm (n=7) | Term (n=7) | Preterm (n=7) | Term (n=5) | Preterm (n=8) |
| Yes | 2 | 0 | 0 | 1 | 1 | 2 | 0 | 0 |
| No | 4 | 8 | 6 | 6 | 6 | 5 | 5 | 8 |

* One term infant was not observed feeding liquids at this assessment

# One term and one preterm infant were not observed drinking liquids

^ Two term infants and one preterm infant were not observed drinking liquids

∞ Two term infants were not observed drinking liquids

**Solids**

One preterm infant demonstrated gagging on solids at 4 months CA and one term infant at 8 months CA. No other observations of gagging on solids were made. Table 28 shows the frequency of coughing for term and preterm infants on solids.

Table 28. *Frequency of 'Coughing on Solids' Observations of Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA*

| | *4 months CA** | | *8 months CA^* | | *12 months CA#* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=6) | Term (n=7) | Preterm (n=7) | Term (n=6) | Preterm (n=8) |
| Yes | 0 | 1 | 0 | 2 | 0 | 0 |
| No | 4 | 5 | 7 | 5 | 7 | 8 |

* Four term and 6 preterm infants were observed eating solids

^ One preterm infant was observed drinking liquids only and not on solids at 8 months CA

# One term infant was observed drinking liquids only and not on solids at 12 months

Two preterm infants were observed sounding increasing gurgly during and after solids at 4 months CA. No other observations were recorded for both groups at any age interval. One term and one preterm infant were observed sounding increasingly breathy on solids at 4 months CA. No further observations were recorded.

### *6.5.2 Feeding Questionnaire*

Four parameters of the infants' motor programming skills, to include gagging, coughing, gurgliness and breathiness on both liquids and solids were scored on a 6.2 rating scale from never observed (0) to consistently observed (6.2) on the FAQ.

**Liquids**

No significant differences were found between motor programming parameters for term and preterm infants at 1-2 weeks, 4, 8 and 12 months CA. Table P17 in Appendix P reports the mean gagging, coughing, gurgliness, and breathiness on liquids at each four month age interval.

**Solids**

There was no significant difference between groups at any age interval for gagging, coughing, gurgliness, and breathiness while they ate solids. Table P18 in Appendix P outlines the mean and standard deviations for infants gagging, coughing, gurgliness, and breathiness on solids across time and between term and preterm groups.

## 6.6 Execution

### *6.6.1 Feeding observation*

The FAO was used to record observations of the infant's execution phase of feeding on liquids and solids. First, the execution on liquids will be discussed and then execution for solids.

**Liquids**

The execution phase of the FAO captured the infant's lip seal on liquids, mouth opening for liquids, and observation of the tongue position for the nipple or teat, and the number of teeth. Term infants demonstrated better lip seal around the nipple or teat than preterm infants at every age assessment. The maintenance of lip seal of term and preterm infants during observation on the FAO for liquid feeds are shown in Table 29.

Table 29. *Maintenance of 'Lip Seal during Drinking' observed on FAO of Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA*

| | *1-2 weeks CA** | | *4 months CA#* | | *8 months CA^* | | *12 months CA∞* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=6) | Preterm (n=8) | Term (n=6) | Preterm (n=7) | Term (n=5) | Preterm (n=7) | Term (n=6) | Preterm (n=8) |
| Sealed | 6 | 5 | 5 | 3 | 4 | 5 | 4 | 7 |
| Leak (L, R or both) | 0 | 3 | 1 | 4 | 1 | 2 | 1 | 1 |

* One term infant was not observed feeding liquids at this assessment

# One term and one preterm infant were not observed drinking liquids

^ Two term infants and one preterm infant were not observed drinking liquids

∞ Two term infants were not observed drinking liquids

All term and preterm infants demonstrated mouth opening for liquids at 1-2 weeks, 4 and 12 months CA. One preterm infant refused to open the mouth for fluids at 8 months CA. No observations of the position of the tongue for fluids were recorded during feeding observations for term infants at any age interval. The presence of teeth was not observed during taking liquid for term infants at any age interval. One preterm infant was observed with one tooth at 8 months CA.

**Solids**

More preterm infants showed leakage of solids at 4 months and 8 months CA. The lip seal of both groups improved with each assessment. Maintenance of lip seal of term and preterm groups during eating is shown in Table 30.

Table 30. *Lip Seal during Eating of Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA on the FAQ*

| | *4 months CA** | | *8 months CA^* | | *12 months CA#* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=6) | Term (n=7) | Preterm (n=7) | Term (n=6) | Preterm (n=8) |
| Sealed | 2 | 2 | 6 | 4 | 6 | 8 |
| Leak | 2 | 4 | 1 | 3 | 0 | 0 |

* Four term and 6 preterm infants were observed eating solids

^ One preterm infant was observed drinking liquids only and not on solids at 8 months CA

# One term infant was observed drinking liquids only and not on solids at 12 months

One term and one preterm infant were observed not opening the mouth for solids at 4 months CA. All infants observed eating solids demonstrated mouth opening at 4, 8 and 12 months CA.

### *6.6.2 Feeding questionnaire*

The motor execution level outlines results of the participant's mouth opening for food and/or liquids, the presence and number of teeth, and teething behaviours. The difference between groups for mouth opening, number of teeth present, and teething was not statistically significant at any of the age intervals. The average number of teeth is shown in Table 31.

Table 31. *Average number of Teeth Present for Term and Preterm Infants on the FAQ at 4, 8, and 12 months CA*

| | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| No. of teeth | 0.00 (0.00) | 0.29 (0.76) | 1.29 (0.49) | 1.63 (0.52) | 6.71 (2.21) | 5.38 (1.60) |

Mean score and standard deviation in brackets

### 6.7 Correlation between the FAO and FAQ

Correlation analyses were conducted between items observed on the FAO and parent reports on the FAQ, for overall efficiency, reflexes, and each phase of feeding: intentionality, sensorimotor planning, motor programming, and execution.

Correlation analyses of the overall efficiency of feeding were conducted with a Spearmans rho at an alpha level of 0.05 with two tailed significance. No significant correlation was found for time taken for liquids at 1-2 weeks, 4, 8, and 12 months CA. Parents reported longer times to feed their infant than the duration of observations during the session on the FAQ; this is an expected finding since the feeding observation was limited to 20 minutes.

The correlation between rooting reflex scores on the FAO and FAQ was measured using the Eta statistic. The correlation at 1-2 weeks CA was $\eta^2 = 0.14$ and $\eta^2 = 0.59$ at 4 months CA. Therefore, there was increasing correlation between the groups to explain the rooting reflex scores. Correlations could not be measured at 8 and 12 months CA, as no infants were observed exhibiting the rooting reflex on the FAO.

Correlation analyses were also conducted to measure intentionality scores on the FAO and parent reports on the FAQ with the Eta statistic. The correlation between the FAO & FAQ was $\eta^2 = 0.42$ at 1-2 weeks CA, $\eta^2 = 0.16$ at 4 months CA, $\eta^2 = 0.25$ at 8 months CA, and $\eta^2 = 0.39$ at 12 months CA review.

It was not possible to attain an overall measure of association of the FAO and FAQ for the motor planning level, as each question on both the FAO and FAQ measured individual skills using nominal measures, which were not consistent between assessment tools.

The Eta statistic was conducted to measure the correlation between motor programming measures on the FAQ and FAO. An association of $\eta^2 = 0.27$ was found at 1-2 weeks CA, $\eta^2 = 0.45$ at 4 months CA, $\eta^2 = 0.59$ at 8 months CA, and a very weak correlation of $\eta^2 = 0.01$ at 12 months CA. Therefore, the variance between the FAQ and FAO between groups was 27% at 1-2 weeks CA, 45% at 4 months CA, 59% at 8 months CA, and 1% at 12 months CA.

A perfect correlation $\eta^2 = 1.00$ was found between the FAO and FAQ at the execution level, as all infants' demonstrated mouth opening for liquids and/or solids at each age interval.

Overall, fair to moderate correlations were found between observed feeding skills scored on the FAO and parent reports of feeding ability on the FAQ. The correlation scores may be influenced by parent's confidence ratings of items on the FAQ, which are discussed next in section 6.8.

## 6.8 Confidence ratings

Parents' confidence ratings were recorded for 25 items on the FAQ measuring overall efficiency, reflexes, intentionality, sensorimotor planning, motor programming, and execution. Ratings were scored on a scale of 'very unsure' (0) to 'very sure' (6.2) on the FAQ, and these scores were converted to a percentage confidence out of 100. The results from the confidence ratings could influence the interpretation of the correlation scores between the FAO and FAQ, as large variations in confidence rating exists between groups and across time. This variability may reflect their understanding of the question, the ability to observe, or their confidence in reporting. As not all parents completed all sections of confidence ratings, the participant numbers are variable throughout this section.

Confidence ratings for the overall efficiency of the infants' feeding could not be conducted at 1-2 weeks CA, as there were only a few completed confidence ratings. There was no significant difference between term and preterm infants when parents reported confidence intervals at 4, 8, and 12 months CA. The mean confidence ratings on the FAQ for the overall efficiency of feeding are reported in Table Q1 in Appendix Q.

No significant difference was found for confidence ratings of rooting reflex reports between the term and preterm group at 1-2 weeks, 4, 8, and 12 months CA (Table Q2 in Appendix Q). Confidence ratings for the infant's intentionality revealed no significant difference between the term and preterm group at 1-2 weeks, 4, 8 and 12 months CA (Table Q3 in Appendix Q).

Parents were asked to record their confidence ratings of their infant's preference of texture, tastes, and temperature for liquids and solids. There was no significant difference between confidence ratings of parents of term and preterm at all age intervals on liquids. Parents of preterm infants reported less confident responses over time. No significant difference was found for confidence ratings on solids between parents of term and preterm infants at 4 months CA. Parents of preterm infants recorded statistically significantly more confident responses for solids taste preferences than parents of term infants at 8 months CA, $t(13) = 2.176$, $p = 0.049$, and 12 months CA, $t(13) = 2.177$, $p = 0.049$. The confidence rating for both groups dropped substantially between 8 and 12 months CA. Confidence ratings of parents of term and preterm infants' motor planning measures on liquids are shown in Table Q4, and solids in Table Q5 of Appendix Q.

Confidence ratings for motor programming were reported for gagging, coughing, gurgliness, and breathiness for liquids (Table Q6 of Appendix Q) and solids (Table Q7 of Appendix Q). A statistically significant difference was found between the term and preterm groups for gagging on liquids at 1-2 weeks CA, $t(12) = 2.890$, p = 0.014. No other statistically significant differences were seen between the groups at 1-2 weeks, 4, 8, and 12 months CA for liquids. There was no significant difference across the motor programming parameters for solids at 4 and 8 months CA. There was a significant difference between confidence ratings of parents of term and preterm infants for gagging on solids at 12 months CA, $t(13) = 2.987$, $p = 0.011$, and coughing on solids at 12 months CA, $t(13) = 2.378$, $p = 0.033$.

Confidence ratings for the execution phase were recorded for mouth opening for food, the presence and number of teeth, and teething (Table Q8 in Appendix Q). Parents of preterm infants recorded statistically significantly more confident responses than parents of term infants for teething at the 1-2 weeks CA, $t(13) = 2.386$, $p = 0.033$ and 12 months CA assessments, $t(12) = 2.342$, $p = 0.037$.

Overall parents reported moderate to strong confidence on the majority of rating scales on the FAQ. Large variation and statistically significant differences were observed at different phases of feeding and across time.

### 6.9 Feeding changes reported at developmental assessments

At each developmental assessment, parents were asked to report changes and concerns regarding their infant's feeding. At 4 months CA, 4 of 7 term infants had been introduced to solids compared to 6 of 8 preterm infants. By 8 months CA, all infants had been introduced to solids in accordance with developmental expectations.

### 6.10 Summary

Overall, the FAO and FAQ provide a comprehensive view of the infant's feeding through direct observation and from parent reports. Parents demonstrated moderate to strong confidence on the majority of rating scales on the FAQ, suggesting that parents feel that they accurately reported feeding behaviours on the FAQ. However, only a fair to moderate correlation was found between observed feeding skills scored on the FAO and parent reports of feeding ability on the FAQ. This could be due to differences between observations of the infant feeding from a single video recording at each age interval, compared to the parent report.

# 7.0 COMMUNICATION DEVELOPMENT

This chapter will summarise the development of infants' communication skills as measured by the Receptive and Expressive Emergent Language Scale (REEL-2) and the Infant-Toddler checklist of the Communication and Symbolic Behaviour Scales Developmental Profile (CSBS DP).

A repeated measures analysis of variance will be conducted to determine if there is a significant difference in the scores achieved by infants on the REEL-2 at any stage across the 12 month assessment period. All analyses in this section satisfied the assumptions of equal variances, normality and independence; therefore, non-parametric statistics will not be required. Only infants assessed at every time interval will be included in the analyses. The results of the REEL-2 assessment were not complete for one preterm infant, therefore, the total number of preterm participants is n=7, and term infants n=7. Prematurity was the between subjects factor, and time was the repeated measure. Within this chapter, all preterm infants were seen at 1-2 weeks, 4, 8, and 12 months corrected age and term infants at 1-2 weeks, 4, 8, and 12 months chronological age.

An independent samples t-test will be used to determine whether the means from the preterm and term group differed significantly from one another at 8 and 12 months CA for each cluster, composite, and total score on the checklist from the CSBS DP assessment (Aron & Aron, 1994). Data satisfied the Levene test of homogeneity.

A Spearman rho ($r_s$) correlation will be used to calculate the correlation between communication measures on the CSBS DP and REEL-2 assessments at 8 and 12 months CA.

## 7.1 Receptive and Expressive Emergent Language Scale (REEL-2)

### *7.1.1 Receptive Language Age (RLA)*

The results revealed a significant increase in the RLA scores over time $F(3,36) = 316.866$, $p < 0.001$, but no significant difference was found for the receptive language scores between term and preterm groups $F(1,12) = 1.577$, $p = 0.233$, and there was no group by time interaction, $F(3,36) = 0.682$, $p = 0.569$. Figure 13 provides a comparative illustration of the mean scores for each group over time.

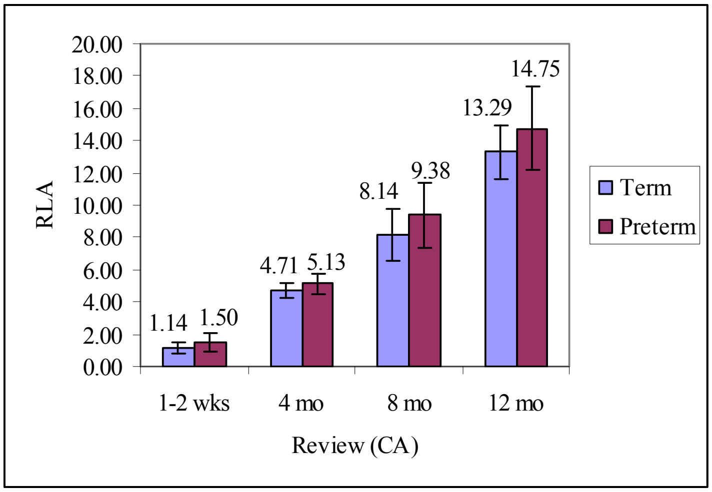


*Figure 13.* Receptive Language Age (RLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) of Term and Preterm Infants from Birth to 12 months.

### *7.1.2 Expressive Language Age (ELA)*

The results of a repeated measures analysis of variance showed a significant increase in the ELA scores over time $F(3, 36) = 216.09$, $p < 0.001$, but no significant difference was found for the expressive language scores between term and preterm groups $F(1,12) = 0.489$ , $p = 0.498$, and there was no group by time interaction, $F(3,36) = 0.599$, $p = 0.620$. Figure 14 illustrates the mean scores for each group over time.

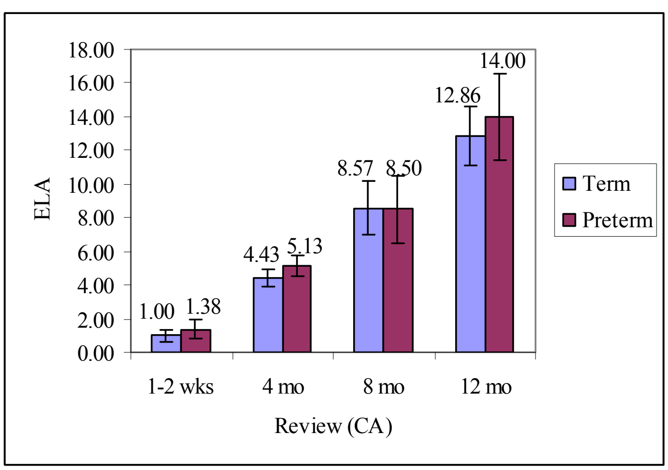

*Figure 14.* Expressive Language Age (ELA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) of Term and Preterm Infants from Birth to 12 months.

### *7.1.3 Combined Language Age (CLA)*

The repeated measures analysis of variance was conducted for the CLA of term and preterm infants from birth to 12 months, who were seen at all assessment. No statistically significant difference was found between the CLA scores of term and preterm infant groups, $F(1,12) = 0.943$, $p = 0.351$. The results revealed a significant linear trend in CLA scores across time $F(3,36) = 426.722$, $p < 0.001$, but there was no group by time interaction, $F(3,36) = 0.430$, $p = 0.733$. Figure 15 illustrates the mean CLA scores for each group over time.

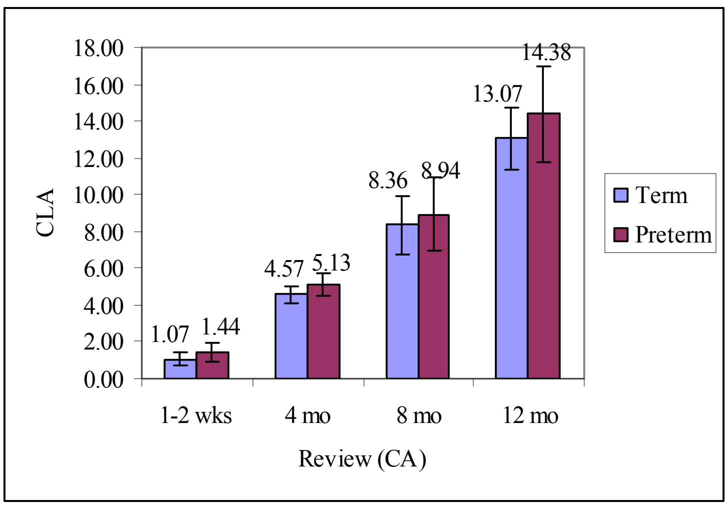


*Figure 15.* Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) of Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months Corrected Age (CA).

Figure 16 illustrates the mean and standard deviation RLA, ELA and CLA scores for the term and preterm infant groups at 1-2 weeks, 4, 8 and 12 months corrected age. Preterm infants showed greater variability in RLA, ELA and CLA measures as observed by larger standard deviations at all at all age intervals.

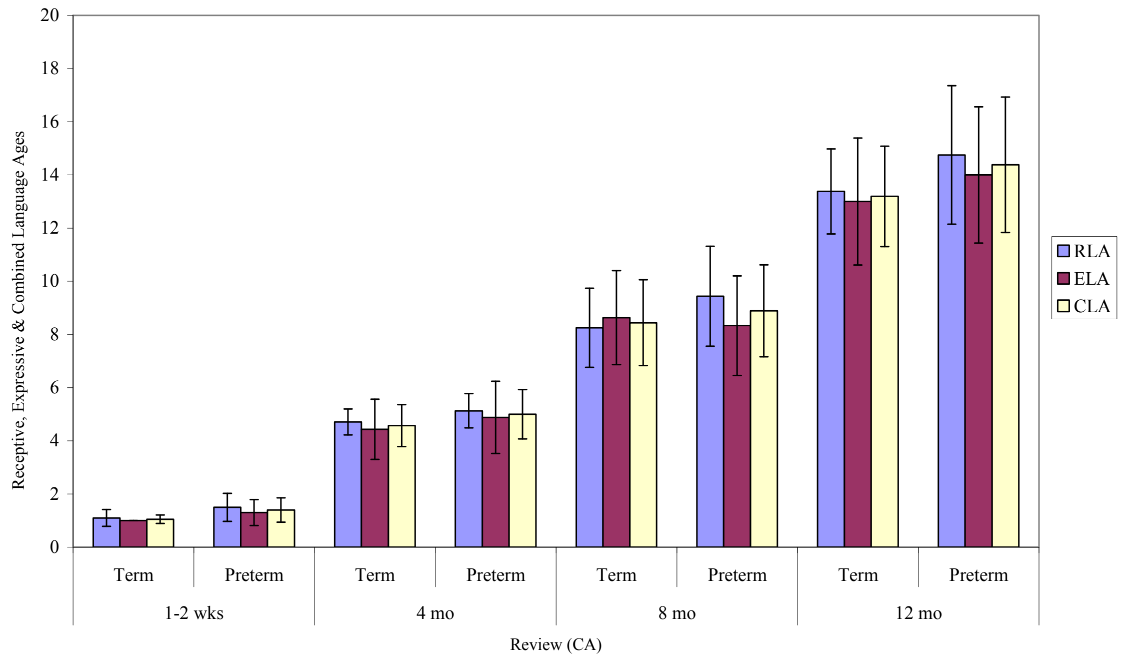


*Figure 16.* Mean and standard deviation Receptive Language Age (RLA), Expressive Language Age (ELA) and Combined Language Age (CLA) scores for term and preterm infants at 1-2 weeks, 4, 8, and 12 months corrected age.

## 7.2 Infant-Toddler checklist of the Communication and Symbolic Behaviour Scales Developmental Profile

Scores were collected from the Infant-Toddler checklist of the Communication and Symbolic Behaviour Scales Developmental Profile (CSBS DP) for both the term and preterm groups at 8 and 12 months CA. The results from the infant-toddler checklist are presented in 3 composite subheadings: social, speech and symbolic. Syntaxes were developed to calculate cluster, composite, and total scores of the infant-toddler checklist of the CSBS DP in the SPSS software program (Appendix R). No significant differences were found between the preterm ($M$ = 24.33, $SD$ = 7.762) and term ($M$ = 23.75, $SD$ = 8.311) groups on the CSBS DP total score at 8 months CA, $t(15)$ = .150, $p$ = .883. No significant differences were found between the preterm ($M$ = 37.75, $SD$ = 7.265) and term ($M$ = 37.37, $SD$ = 7.745) groups at 12 months CA, $t(14)$ = 0.100, p = 0.922. The mean total scores for both groups can be measured against cut off scores in the infant-toddler checklist of the CSBS DP (Appendix C). One term infant demonstrated a total score of concern at 8 months CA, and one preterm infant had a total score of concern at 12 months CA. Figure 17 illustrates the mean term and preterm composite scores on the infant-toddler checklist of the CSBS DP at 8 and 12 months CA.

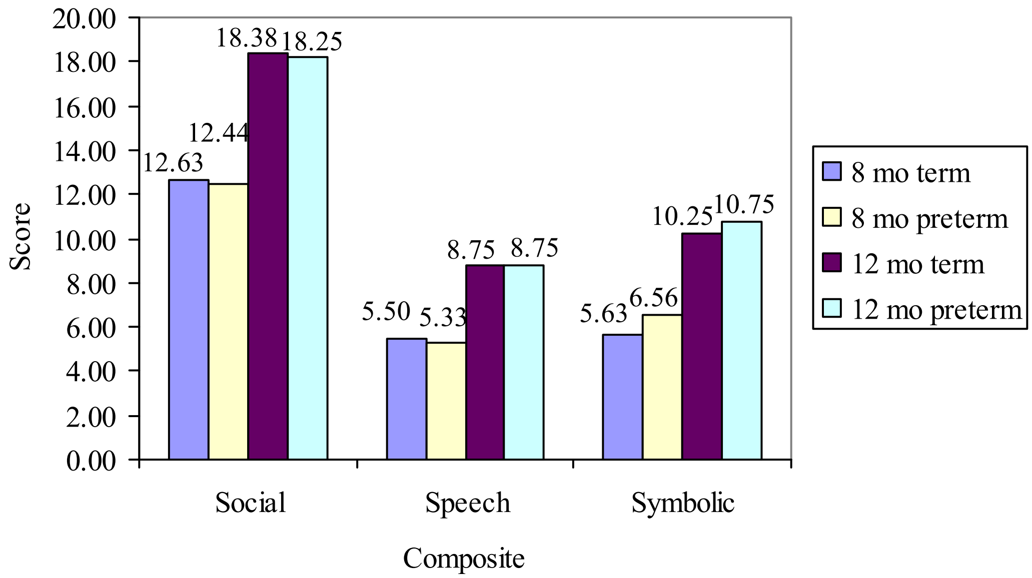


*Figure 17.* Social, Speech and Symbolic Composite Scores on the Infant-Toddler Checklist of the Communication and Symbolic Behaviour Scales Developmental Profile (CSBS DP) for Term and Preterm Infants at 8 and 12 months Corrected Age (CA).

### *7.2.1 Social composite*

There was no significant difference between term and preterm groups for the social composite score or individual cluster scores for emotion and eye gaze, communication, and gesture at 8 and 12 months CA. One preterm infant obtained a score of 10 at 12 months CA, indicating concern in the social composite.

### *7.2.2 Speech composite*

Similarly, no significant difference was found between the two groups for the speech composite score or cluster scores for sounds and words at 8 and 12 months CA. One term infant and 3 preterm infants obtained a score of 0 to 3 at 8 months CA, highlighting concern in the speech composite. By 12 months CA, only 1 preterm infant had a speech composite score of ‘concern’.

### *7.2.3 Symbolic composite*

No significant difference was found between the symbolic composite or individual cluster scores at 8 and 12 months CA. Three term infants obtained a symbolic composite score in the concern range at 8 months CA, and 2 term infants continued to highlight a symbolic composite score of concern at 12 months CA.

## 7.3 Summary

Overall, the results of the participants' receptive, expressive, and combined language scores on the REEL-2 revealed significantly linear development across time from birth to 12 months. All group scores were within the normal developmental language ages

Similarly, preterm and term infants scored similar results for symbolic, speech, and social skills on the CSBS DP at 8 and 12 months CA. An important observation is that preterm infants achieved corrected age appropriate development of both receptive and expressive language skills, comparable with their term infant counterparts.

## 7.4 Correlation between CSBS and REEL-2 scores

A Spearman rho ($r_s$) correlation was used to calculate the correlation between communication measures on the CSBS DP and REEL-2 assessments at 8 and 12 months CA. Two tailed analyses were used with a 0.01 alpha level. A statistically significantly correlation was observed between the CSBS and REEL-2 at 8 months CA, $r_s(17) = 0.852$, $p < 0.001$, and 12 months CA, $r_s(16) = 0.920$, $p < 0.001$. Figure 18 illustrates the correlation between term and preterm infants CLA scores on the REEL-2 and total score on the CSBS DP at 8 and 12 months corrected age.

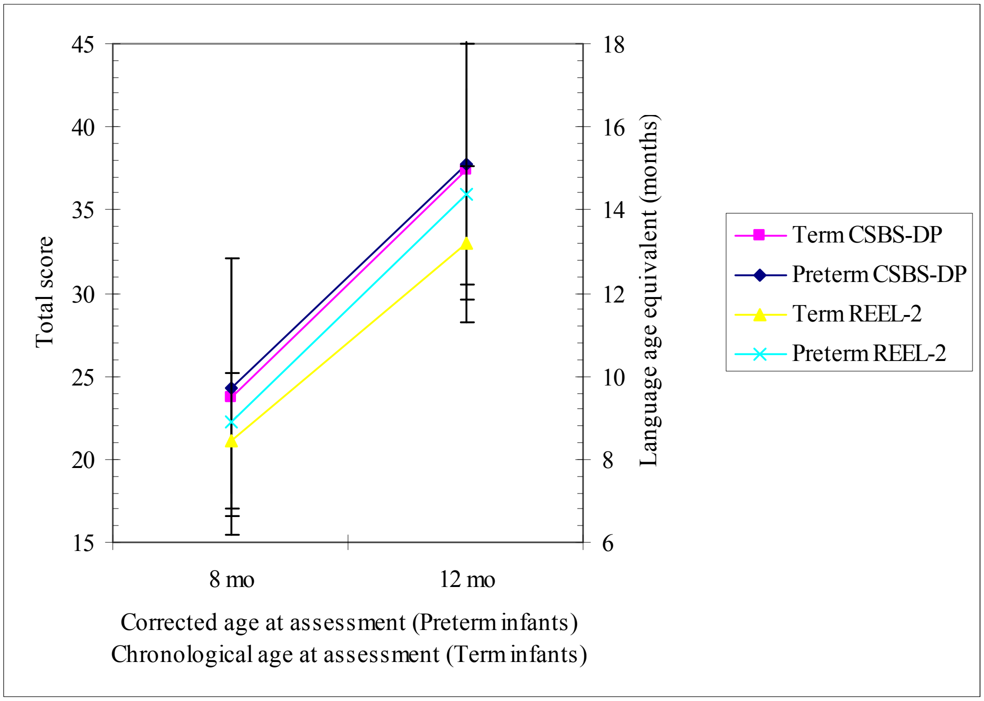


*Figure 18.* Correlation between Term and Preterm Infants Combined Language Age (CLA) scores on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) and Total Scores on the Communication and Symbolic Behaviour Scales Developmental Profile (CSBS DP) for Term and Preterm Infants at 8 and 12 months Corrected Age (CA).

# 8.0 FEEDING AND COMMUNICATION DEVELOPMENT

The relationship between feeding and communication development will be analysed using a two-way repeated measures analyses of variance to determine the difference between feeding efficiency on the FAQ and communication scores on the REEL-2 for infants who were assessed at all age intervals. The independent variables were the 4 assessment times, 1-2 weeks, 4, 8, and 12 months CA. The 2 groups were preterm and term infants. The relationship between the feeding efficiency with liquids and communication development in infants will be discussed with regard to the trends demonstrated over time.

## 8.1 Feeding Development

### *8.1.1 Liquids*

The infant's feeding efficiency was determined from the total duration of feeds, the number of feeds the infant had in a 24 hour period, and the volume the infant accepted each day as reported by parents on the FAQ. Efficiency measures were obtained for intake of liquids at 1-2 weeks, 4, 8, and 12 months CA, and solids at 4, 8 and 12 months CA.

The duration of liquid feeds in minutes for term and preterm infants at 1-2 weeks, 4, 8, and 12 months CA is illustrated in Figure 19. A significant negative linear trend was found over time $F(1,13) = 42.525$, $p < 0.001$. No significant differences were found between the term and preterm groups over time.

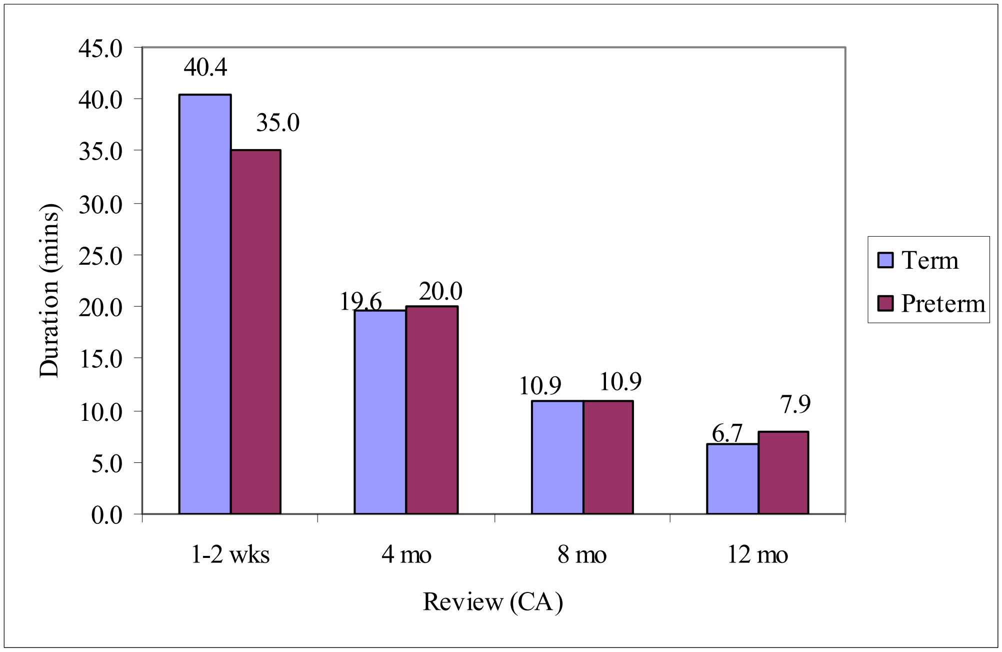


*Figure 19.* Time Taken for Feeding of Liquids on the Feeding Assessment Questionnaire (FAQ) for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

The frequency or number of feedings of liquids within 24 hours by term and preterm infants at 1-2 weeks, 4, 8, and 12 months CA is highlighted in Figure 20. A significant negative linear trend was found over time $F(1,13) = 43.324$, $p < 0.001$, but no significant difference was found between the term and preterm groups over time.

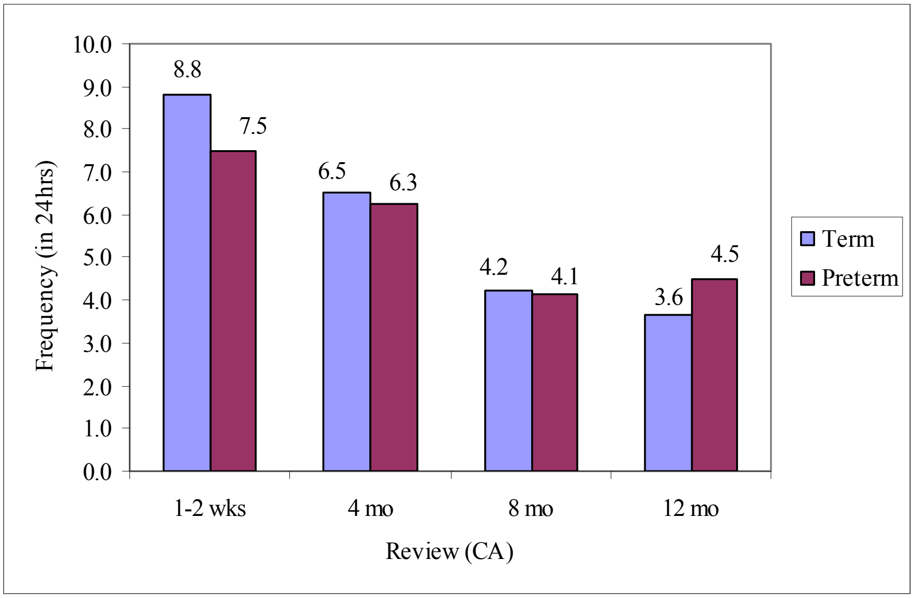


*Figure 20.* Frequency of Feeding in 24 hours for Liquids on the Feeding Assessment Questionnaire (FAQ) for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

The volume of liquids accepted by term and preterm infants at 1-2 weeks, 4, 8, and 12 months CA as reported by parents in the FAQ is shown in Figure 21. The results are available for only a few of the participants over time as many infants were breastfed at the initial review, where the volume of fluids could not be determined. Thus, these infants are excluded from the analysis. A statistically significant cubic trend was found over time $F(1,2) = 47.256$, $p = 0.021$, but no significant differences were found between the preterm and term groups over time.

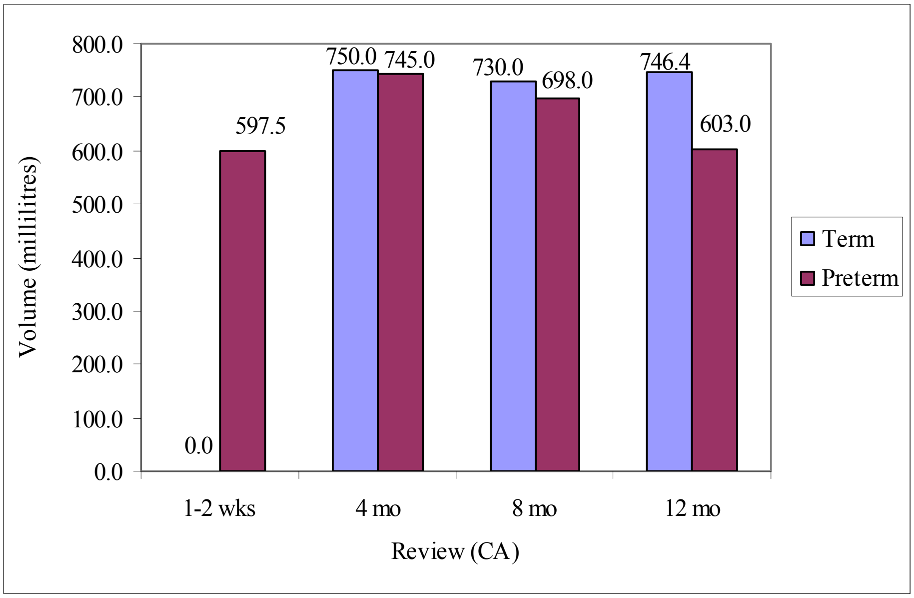


*Figure 21.* Average volume of Liquids per feed on the Feeding Assessment Questionnaire (FAQ) for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

### *8.1.2 Solids*

The infant's feeding efficiency on solids for term and preterm infants is reported at 4, 8, and 12 months CA. Efficiency measures are provided for the time taken, frequency, and total volume of solids accepted by infants as reported by parents in the FAQ.

The time taken for infants to eat solids at 4, 8 and 12 months CA is reported in Figure 22. No significant trend was determined over time. A statistically significant quadratic difference was found between groups over time $F(1,9) = 7.985$, $p = 0.020$.

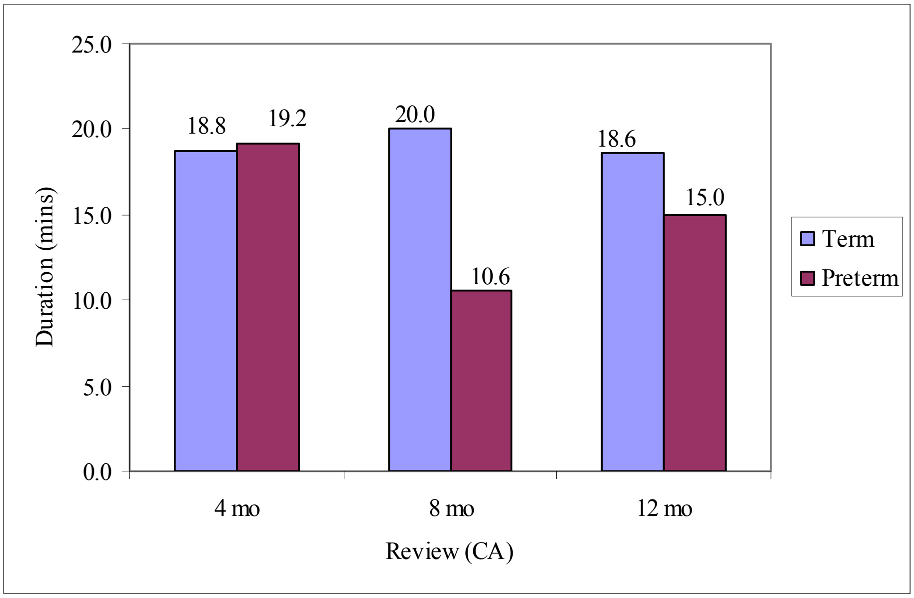


*Figure 22.* Time Taken for Solids on the Feeding Assessment Questionnaire (FAQ) for Term and Preterm Infants at 4, 8, and 12 months Corrected Age (CA).

The number of solid feeds within 24 hours for term and preterm infants at 4, 8, and 12 months CA is shown in Figure 23. A statistically significant linear trend was found over time $F(1,8) = 87.883$, $p < 0.001$, but no significant difference was determined between preterm and term groups over time.

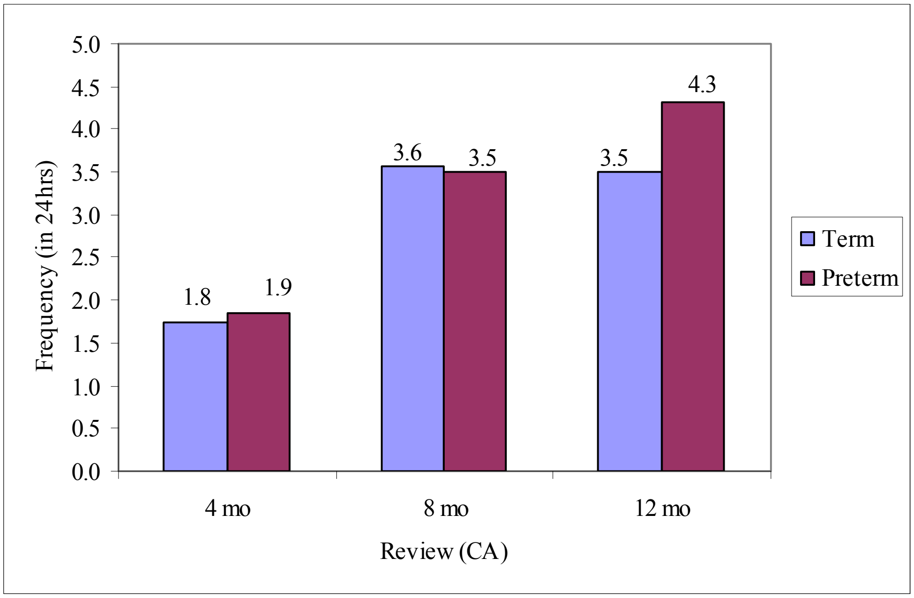


*Figure 23.* Number of Solid Feeds in 24 hours on the Feeding Assessment Questionnaire (FAQ) for Term and Preterm Infants at 4, 8, and 12 months Corrected Age (CA).

The volume of solids accepted by term and preterm infants at 4, 8, and 12 months CA is reported in Figure 24. A statistically significant linear trend of increasing volume was found over time $F(1,8) = 40.395$, $p < 0.001$, but there were no significant differences between the term and preterm groups.

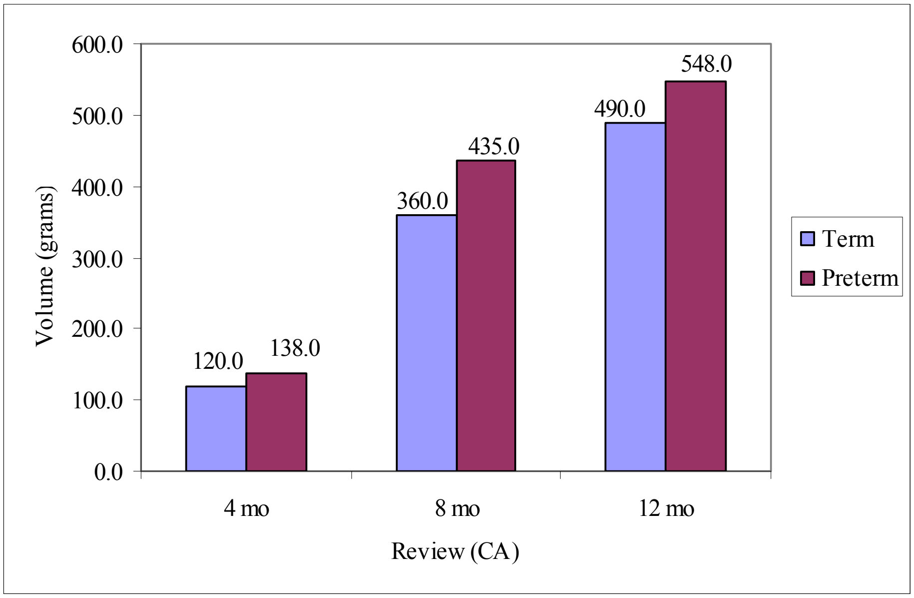


*Figure 24.* Volume of Solids per feed on Feeding Assessment Questionnaire (FAQ) for Term and Preterm Infants at 4, 8, and 12 months Corrected Age (CA).

### 8.2 Communication Development

Communication scores were measured using the REEL-2 assessment, from which each infant's receptive, expressive, and combined language age was calculated. Figure 15 in section 7.1.3 illustrated the combined language age (CLA) on the REEL-2 of term and preterm infants at 1-2 weeks, 4, 8, and 12 months CA. A statistically significant linear trend was determined over time $F(1,12) = 426.722$, $p < 0.001$. There was no significant difference between the preterm and term groups over time.

### 8.3 Efficiency with liquids and communication development

The relationship between the feeding efficiency with liquids and communication development in infants will be discussed with regard to the trends demonstrated over time. Infants showed better efficiency for drinking liquids over time, taking less time and drinking liquids less frequently as they took more solid food. The mean duration to drink liquids and communication development for term and preterm infants is illustrated in Figure 25. The time taken to drink liquids and frequency of liquids accepted by infants showed a significant negative linear trend. In contrast, communication development showed a significantly positive linear trend. The results suggest inverse co-occurrence of liquid feeding efficiency and communication development. Figures 26 to 40 illustrate the feeding efficiency on liquids and solids, and combined language age development for each participant from birth to 12 months CA.

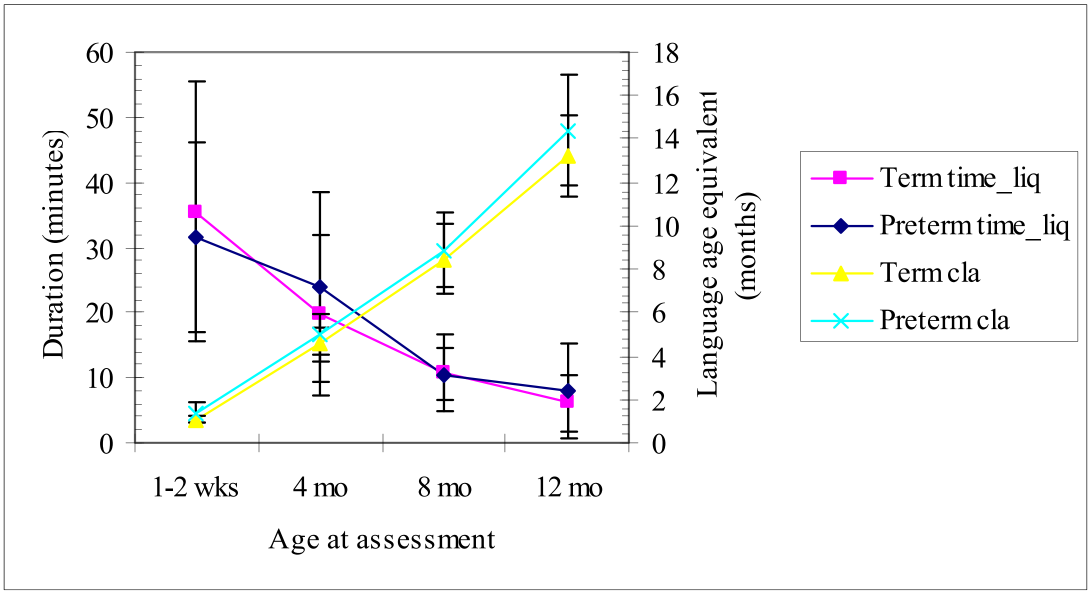


*Figure 25.* Mean Feeding Efficiency on Liquids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

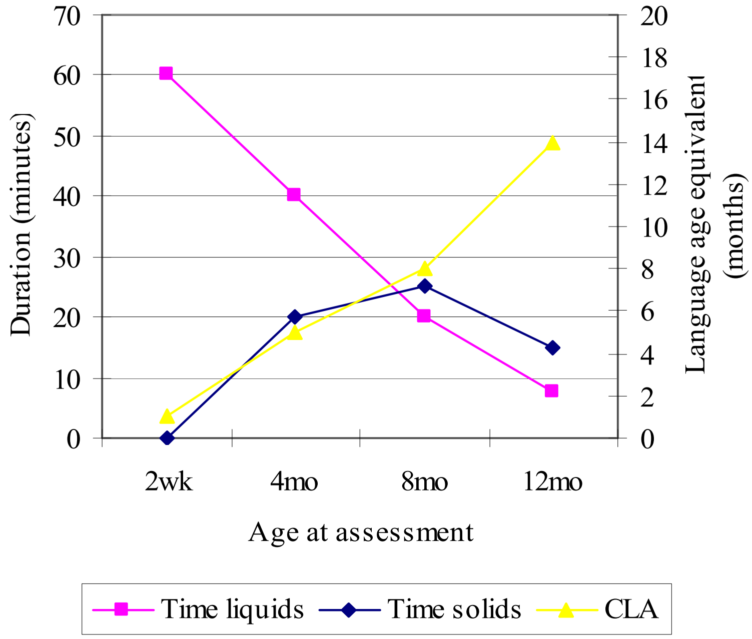


*Figure 26.* Term infant 1 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months chronological age.

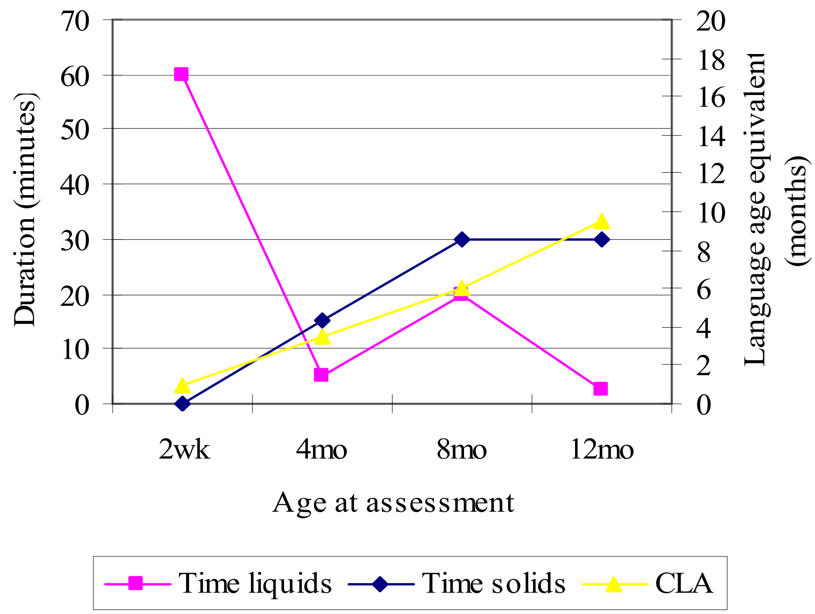


*Figure 27.* Term infant 2 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months chronological age.

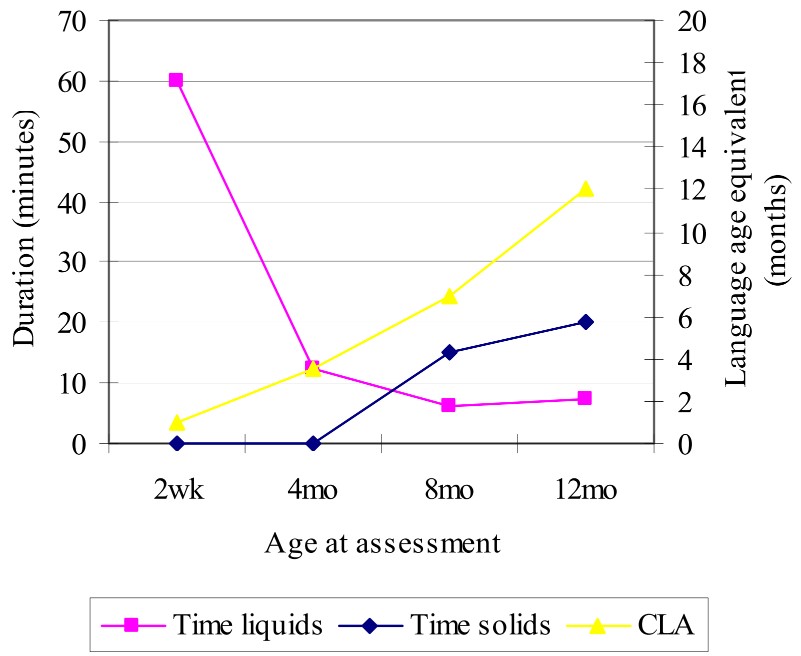


*Figure 28.* Term infant 3 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months chronological age.

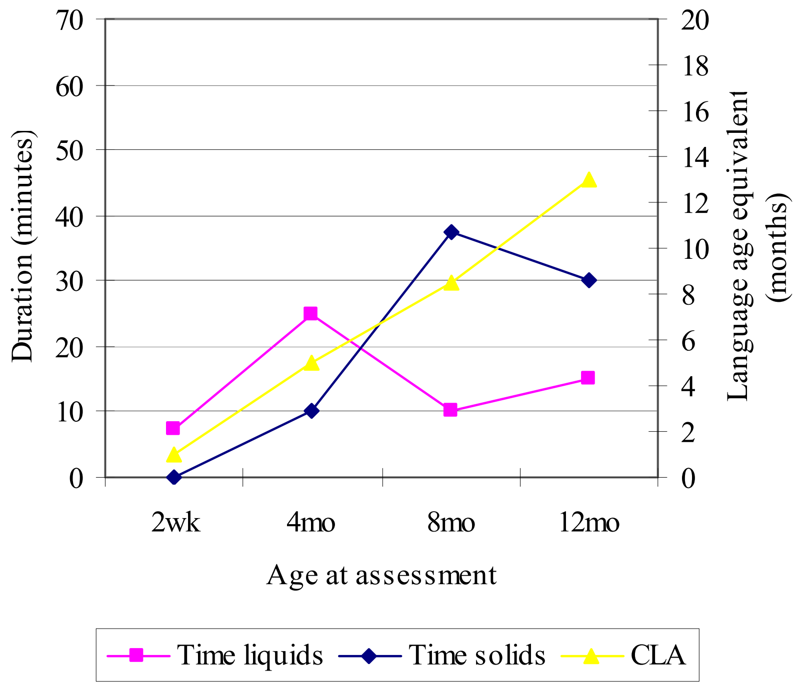


*Figure 29.* Term infant 4 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months chronological age.

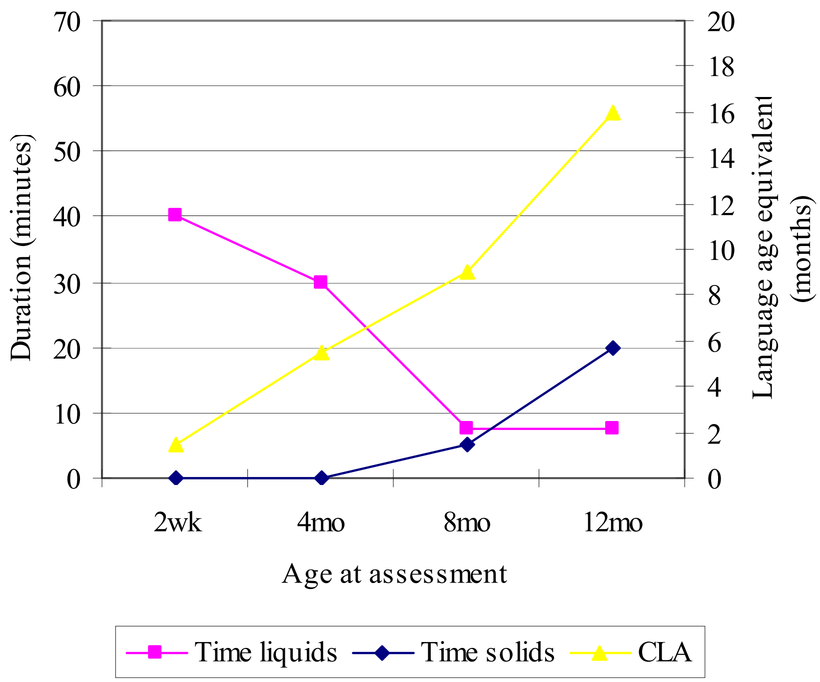


*Figure 30.* Term infant 5 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8 and 12 months chronological age.

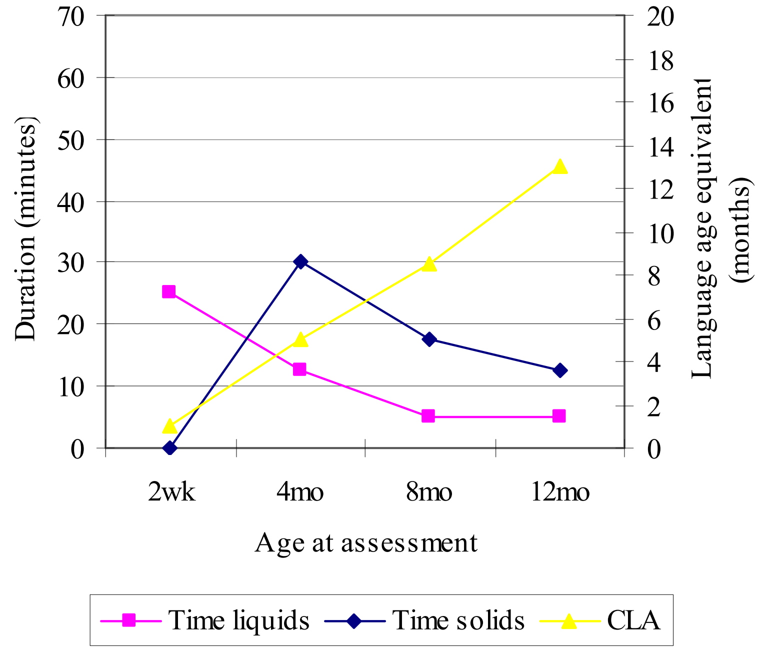


*Figure 31.* Term infant 6 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months chronological age.

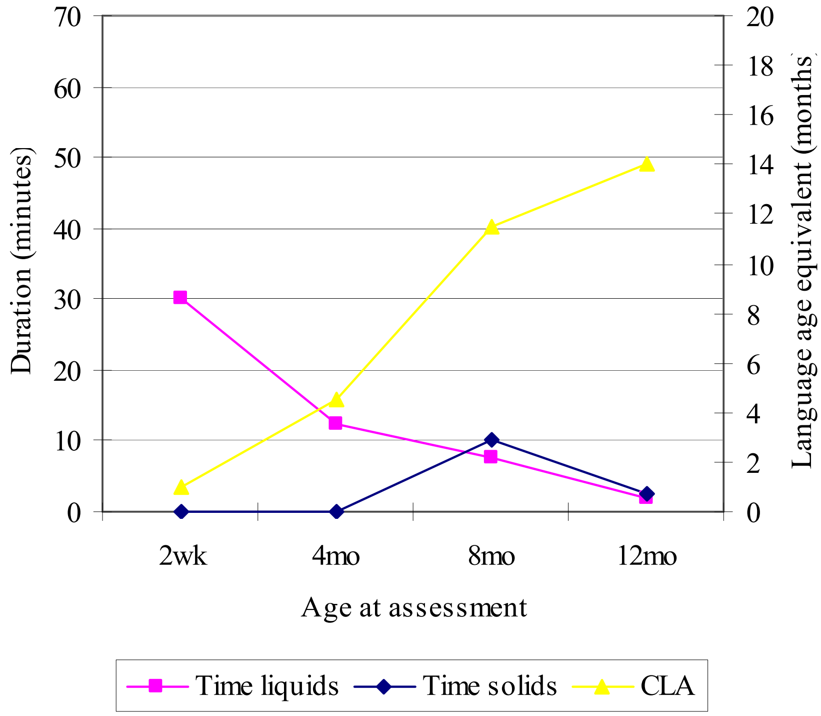


*Figure 32.* Term infant 7 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months chronological age.

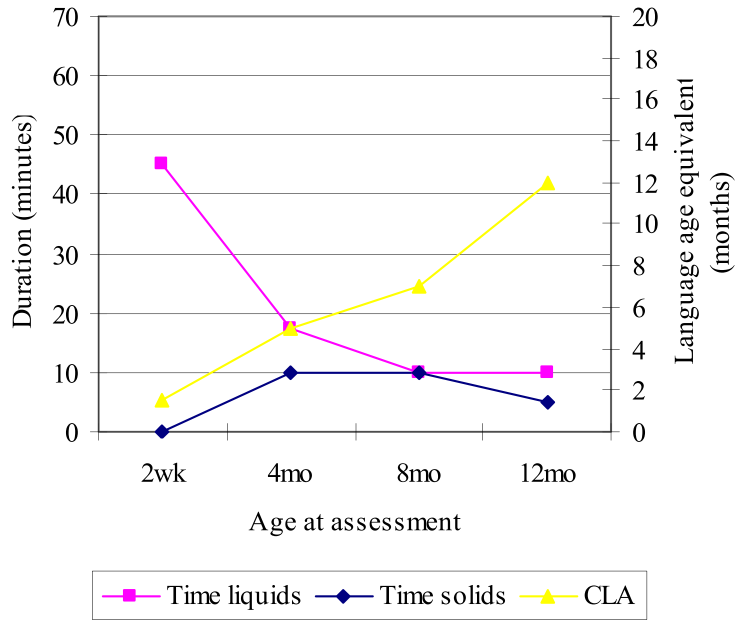


*Figure 33.* Preterm infant 1 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

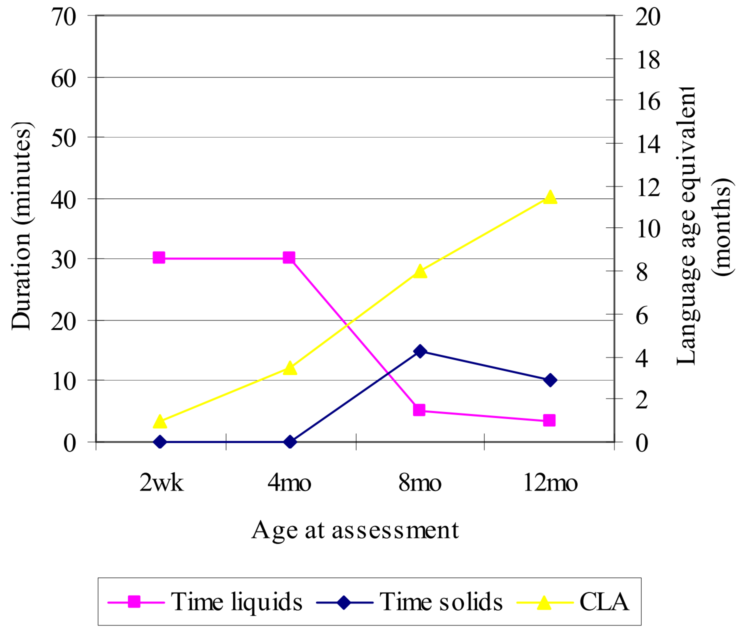


*Figure 34.* Preterm infant 2 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

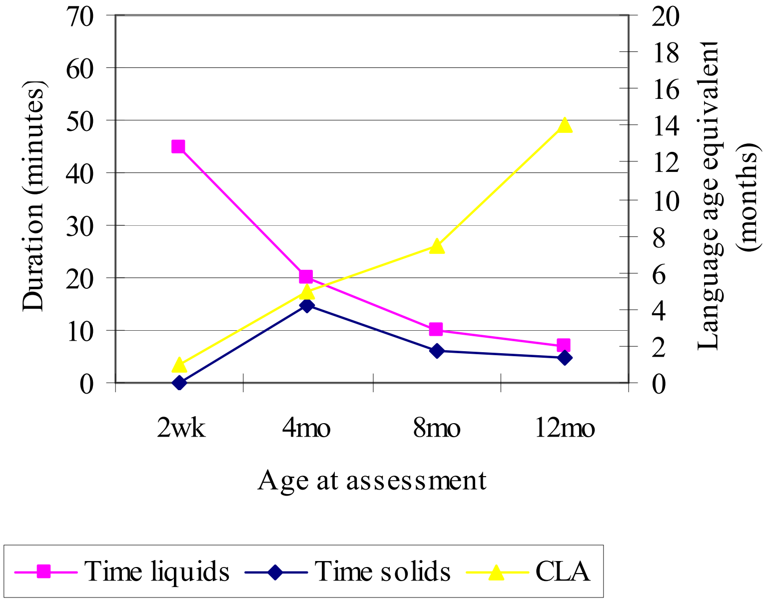


*Figure 35.* Preterm infant 3 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

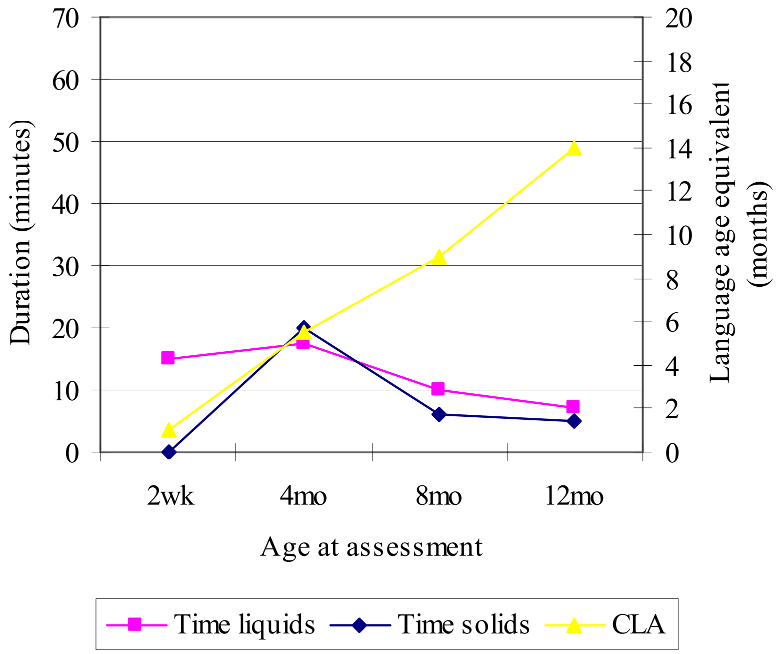


*Figure 36.* Preterm infant 4 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

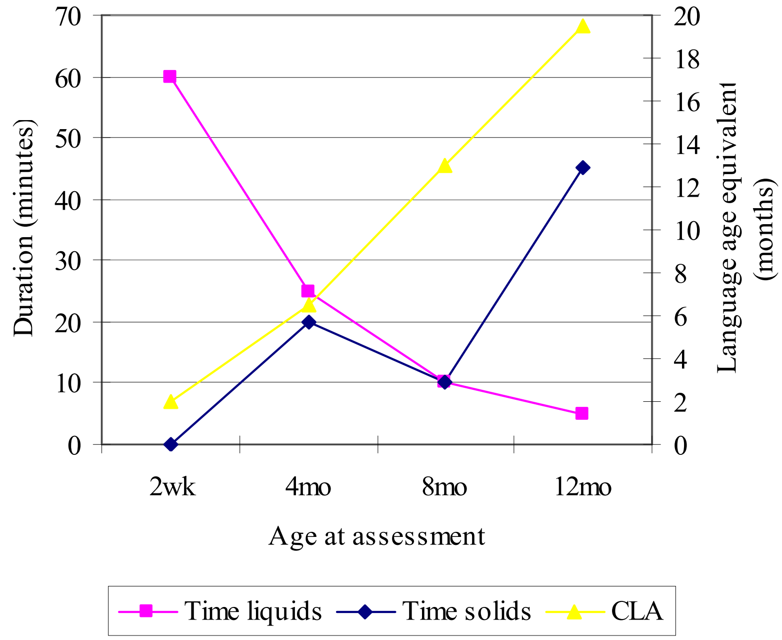


*Figure 37.* Preterm infant 5 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

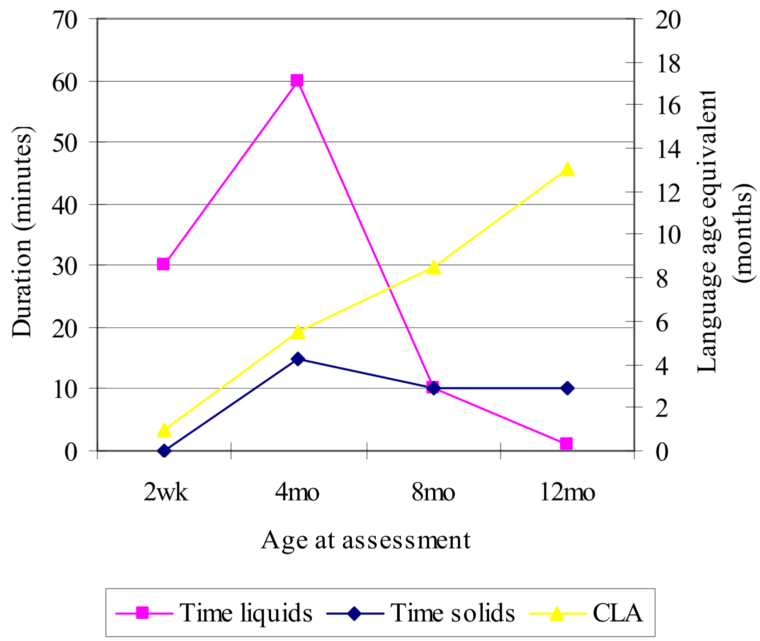


*Figure 38.* Preterm infant 6 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

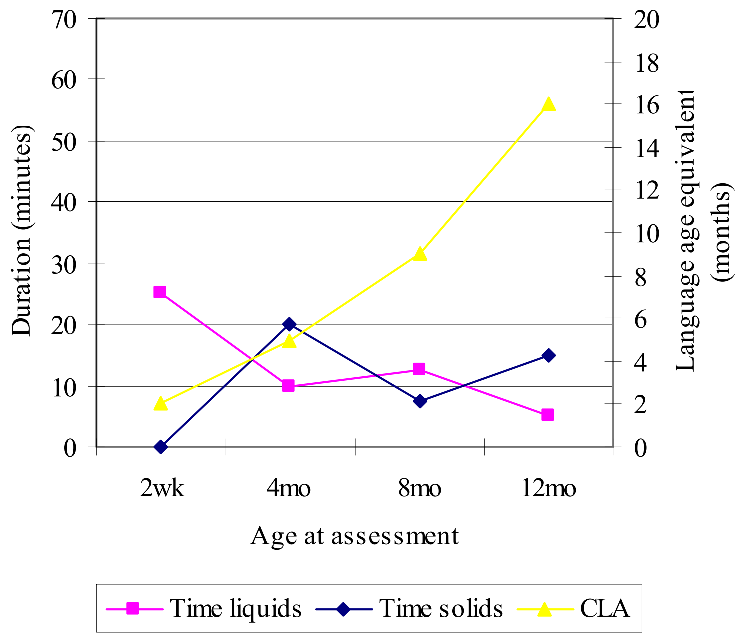


*Figure 39.* Preterm infant 7 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

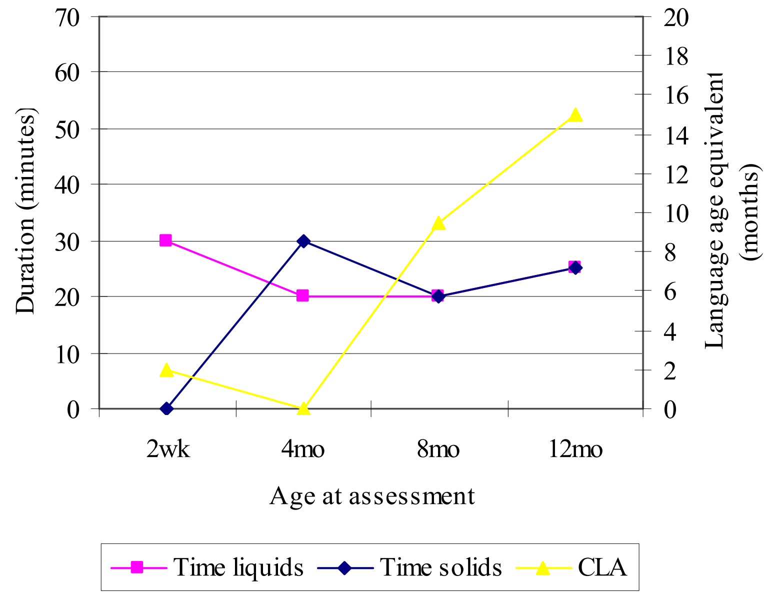


*Figure 40.* Preterm infant 8 – Feeding Efficiency on Liquids and Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

### 8.4 Efficiency on solids and communication development

The trends for feeding efficiency related to eating solids and communication development will also be discussed. Figures 26 to 40 have illustrated the feeding efficiency on solids and combined language age development for each participant individually from 4 to 12 months CA. The results showed a statistically significant positive linear trend for the number of feeds in 24 hours and volume of solids offered to infants over time at 4, 8 and 12 months CA, but not taking into account the between group factors (term and preterm infants). The mean duration to eat solids as observed in the FAQ and combined language age scores on the REEL-2 for term and preterm infants is illustrated in Figure 41. These results throughout show parallel co-development of communication and feeding skills from 4 to 12 months corrected age, however, variable scores were achieved for the duration of eating solids reported for both term and preterm infant groups between 4 and 8 months corrected age, and 8 and 12 months corrected age.

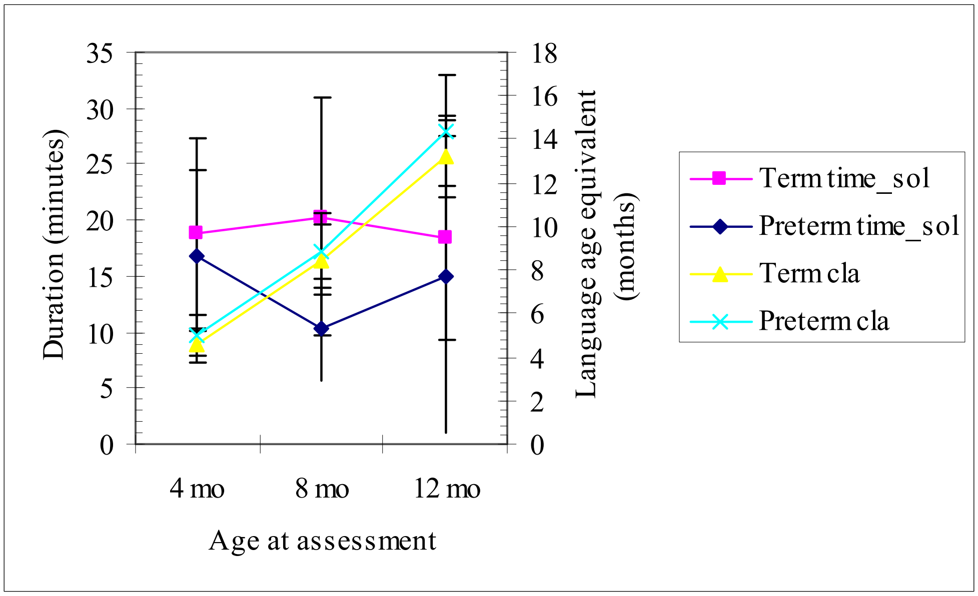


*Figure 41.* Mean Feeding Efficiency on Solids on the Feeding Assessment Questionnaire (FAQ) and Combined Language Age (CLA) on the Receptive and Expressive Emergent Language Scale 2 (REEL-2) for Term and Preterm Infants at 4, 8, and 12 months Corrected Age (CA).

## 8.5 Preterm Case Example

The feeding and communication development will be examined more thoroughly for a male, preterm infant, participant number eight (P6). The results for this participant will be presented in 3 sections. The first section (8.5.1) will provide a summary of contributory infant, maternal, and environmental factors. Section 8.5.2 will outline the feeding efficiency of P6 on liquid and solid textures compared to the means of term and preterm groups. The third section 8.5.3 will provide a summary of the participant's communication scores on the REEL-2 and CSBS DP. Section 8.6 will provide a summary of the results incorporating the case example provided in this section in addition to the term and preterm feeding and communication relationship data.

### *8.5.1 Contributory Factors*

The specific infant, maternal and environmental background for P6 will be summarised in order to evaluate the potential impact of contributory factors for feeding and communication development. When P6 was seen initially at 1-2 weeks CA, he had a 12 month-old brother and 6 year-old sister. P6 was reported to be unwell throughout his first year of life. He had a cold/flu before 4 months CA, was unwell for over a week between 4 and 8 months CA, and a respiratory infection and cold between 8 and 12 months CA. P6 demonstrated poor weight gain and poor feeding at 1-2 weeks, 4, 8, and 12 months CA, although the difference between was not statistically significant. A comparison of P6's weight compared to the mean weight for term and preterm infants is illustrated in Figure 42.

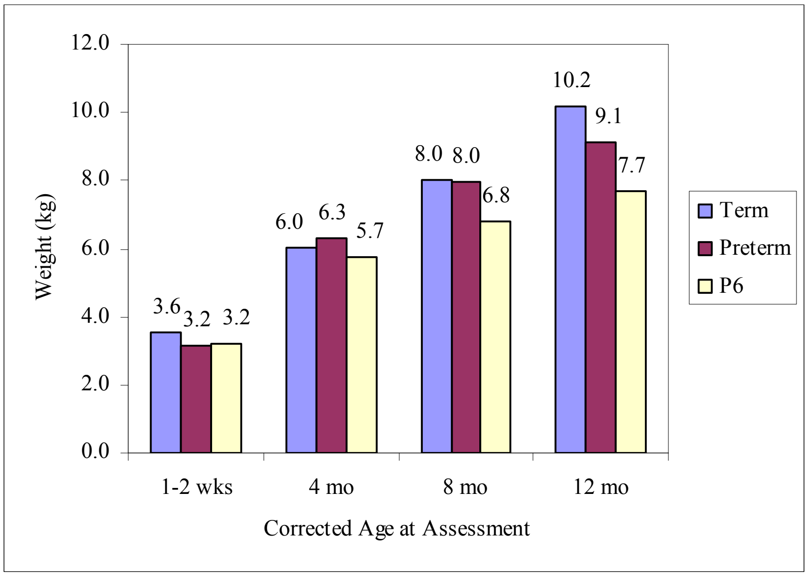


*Figure 42.* Weight of Preterm Infant P6 compared to the Mean Weight Measures for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

P6's motor development was compared to the average measures for the term and preterm groups. No statistically significant difference was found between P6's motor milestone measures and the term and preterm groups at all age intervals. Figure 43 illustrates P6's motor milestone developmental scores at 4, 8, and 12 months CA.

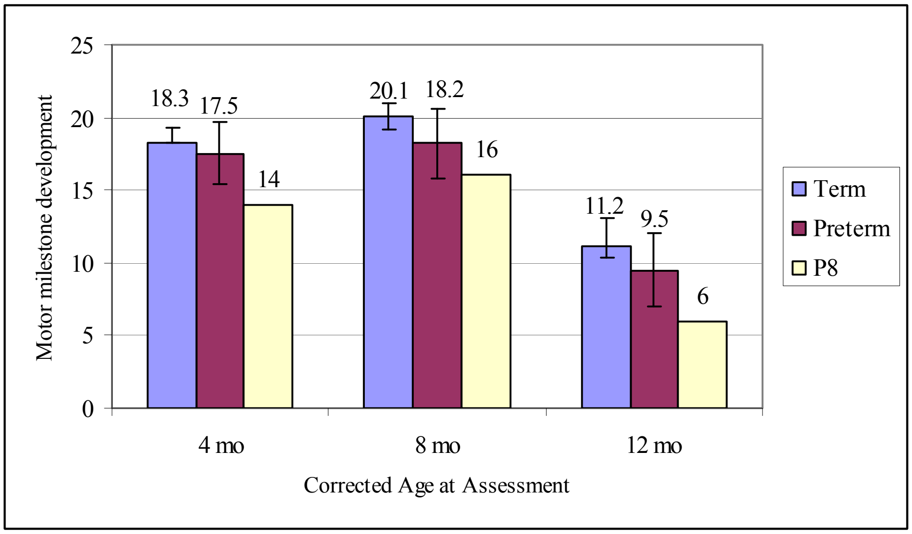


*Figure 43.* Mean Motor Milestone Development of Preterm Infant P6 compared to the Mean Scores for Term and Preterm Infants at 4, 8, and 12 months Corrected Age (CA).

P6 was involved in regular weekends away until 12 months CA. The environmental scores of P6 on the HSQ were within the average range of term and preterm participants in the study at all developmental reviews. These scores are outlined in Figure 44.

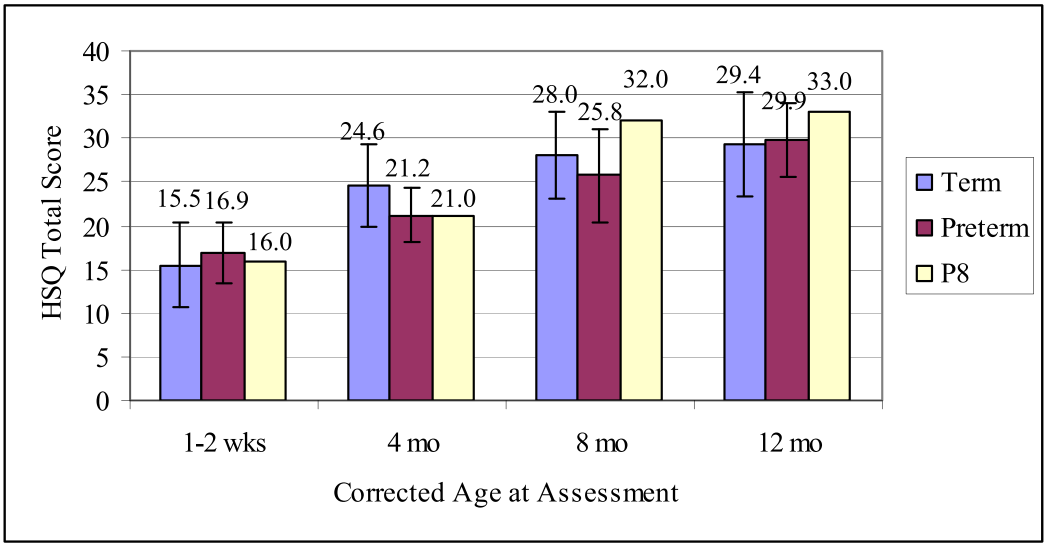


*Figure 44.* Total Environmental Score on the Home Screening Questionnaire (HSQ) of Preterm Infant P6 compared to the Mean Scores for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

### *8.5.2 Feeding Development*

The feeding efficiency measures of the preterm case example P6 were within one standard deviation of the mean for both the preterm and term group for eating solids. Figure 45 shows the mean duration (in minutes) for P6 and the term and preterm infants to eat solids, and liquids (Figure 46).

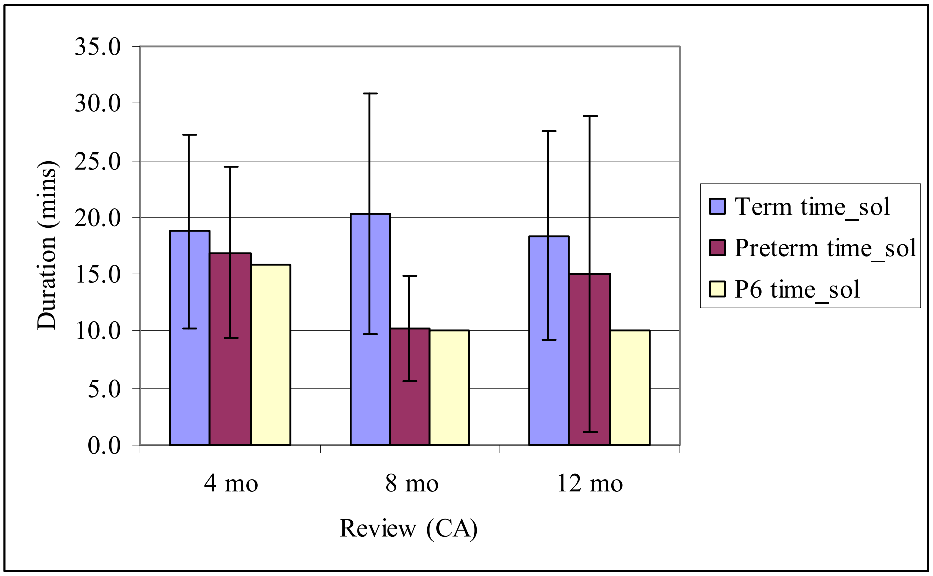


*Figure 45.* Feeding Efficiency on Solids as observed on the Feeding Assessment Questionnaire (FAQ) of Preterm Infant P6 compared to the Mean Scores for Term and Preterm Infants at 4, 8, and 12 months Corrected Age (CA).

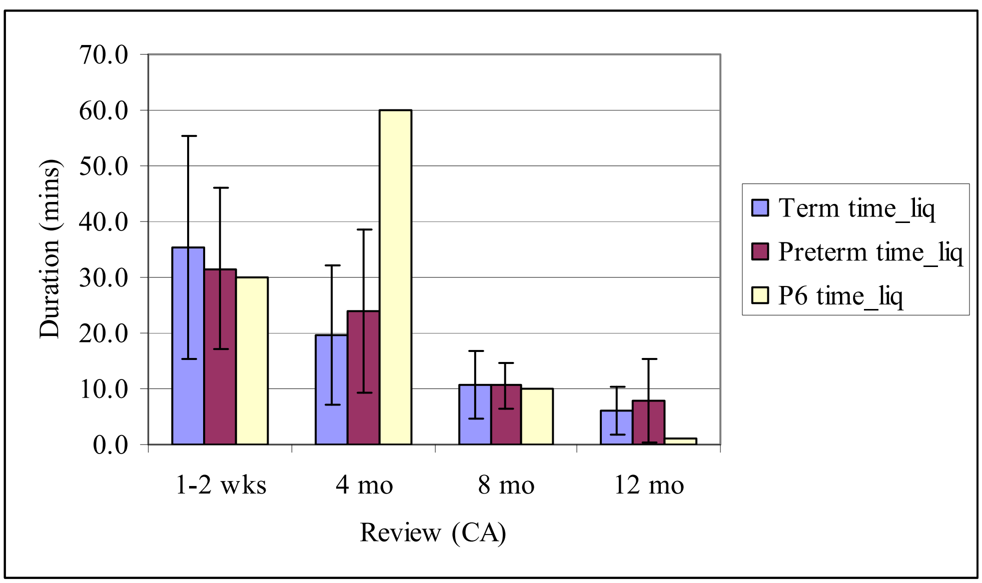


*Figure 46.* Feeding Efficiency on Liquids as observed on the Feeding Assessment Questionnaire (FAQ) of Preterm Infant P6 compared to the Mean Scores for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

Participant P6 demonstrated similar durations of time to drink liquids as did the term and preterm infant groups at 1-2 weeks, 8, and 12 months CA. However, at 4 months CA, P6 showed a significantly longer duration to drink liquids compared to all other participants, $F(2,13) = 8.492$, $p < 0.005$, and a significantly longer total duration to eat solids and drink liquids than the term and preterm infant groups, $F(2,13) = 4.648$, $p < 0.005$. During a retrospective analysis of P6's feeding data at 4 months CA, he demonstrated poor lip seal and presented with bilateral oral escape. He was also reported to gag on solids consistently at 4 months of age, but not significantly more than the term and preterm infant groups. Due to the poor oral motor skills, poor weight gain, and hypersensitive gag reflex present in P6's feeding at the 4 month CA review, it was recommended to his mother that a referral from the local General Practitioner be obtained to a Specialist Feeding Clinic to assess P6's feeding difficulties.

At 8 months CA, P6 was reported to continue to gag significantly more on solids than the term and preterm infants CA $F(2,14) = 5.280$, $p < 0.005$, and further evidence of motor programming difficulties was observed with P6 coughing on soft finger food solid textures. At the 8 months CA review, P6 was eating solids and drinking liquids within a similar timeframe to other term and preterm participants.

By the 12 month CA review, P6 was no longer reported to gag on liquids, but he was described as gagging significantly more on liquids than both the term and preterm infant groups, $F(2,12) = 19.853$, $p < 0.005$. This was the only indicator of feeding difficulty reported or observed at the 12 month CA review.

### *8.5.3 Communication Development*

The results of P6's communication skills will be interpreted in light of both the CSBS DP and REEL-2 assessments. P6 did not demonstrate significantly different RLA, ELA and CLA scores on the REEL-2 assessment to the mean term and preterm group scores. Comparative graphs of the RLA, ELA and CLA scores for P6 and the term and preterm infants groups are illustrated in Figures 47, 48 and 49 simultaneously.

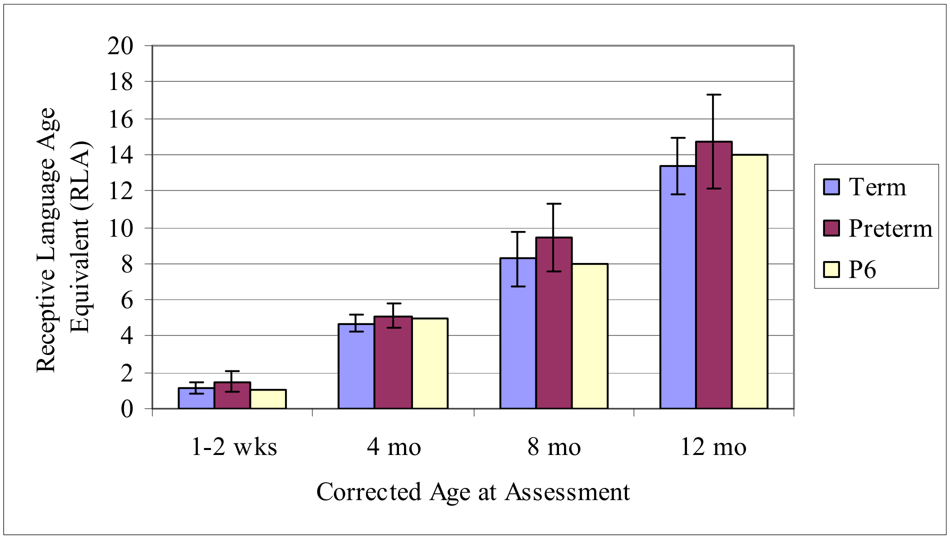


*Figure 47.* Receptive Language Age (RLA) Equivalent on the Receptive and Expressive Emergent Language Scale (REEL-2) of Preterm Infant P6 compared to Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

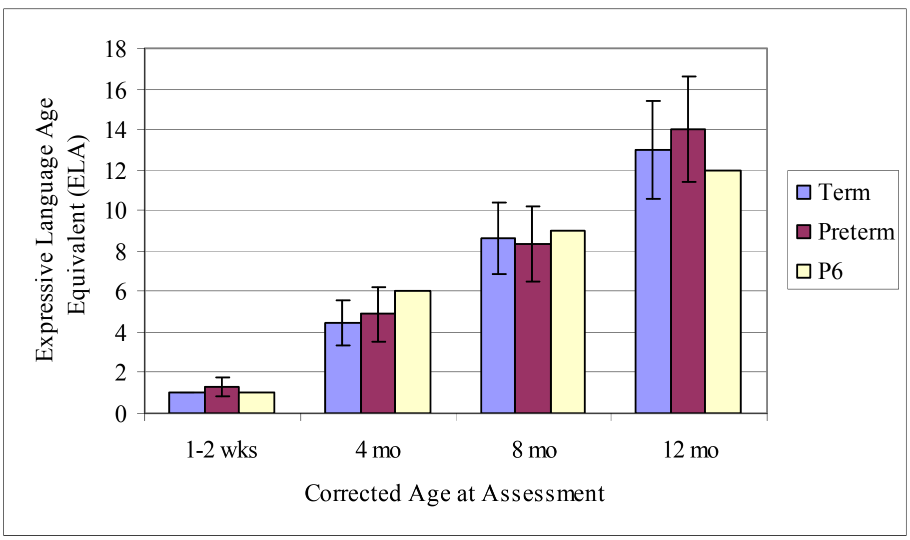


*Figure 48.* Expressive Language Age (ELA) Equivalent on the Receptive and Expressive Emergent Language Scale (REEL-2) of Preterm Infant P6 compared to Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

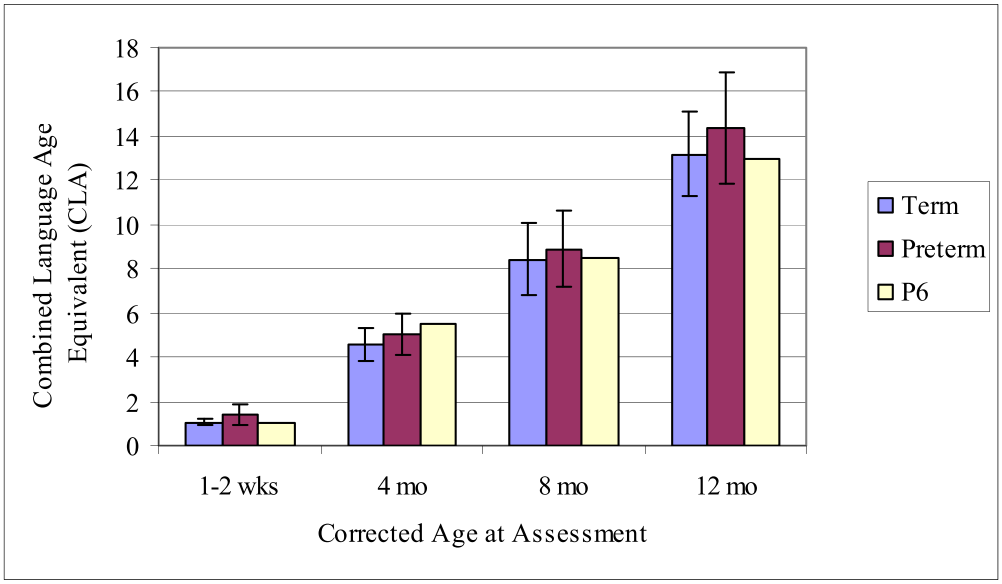


*Figure 49.* Combined Language Age (CLA) Equivalent on the Receptive and Expressive Emergent Language Scale (REEL-2) of Preterm Infant P6 compared to Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months Corrected Age (CA).

Similar findings were revealed on the CSBS DP. No significant differences were found between P6's composite or total scores and the term and preterm group scores at either the 8 or 12 month CA review. However, P6 did score below one standard deviation for the speech composite score at 8 months CA. His composite score of 3 points was below the cut off score for this subtest, indicating an area of 'concern'. By the 12 months CA, all CSBS DP scores, including his speech composite scores had improved, and were comparable to the mean preterm group scores. Figure 50 illustrates the speech, social, and symbolic composite scores for P6, the term and preterm infant groups at the 8 and 12 months CA reviews. Figure 51 provides a visual representation of the infant's total scores on the CSBS DP at 8 and 12 months CA.

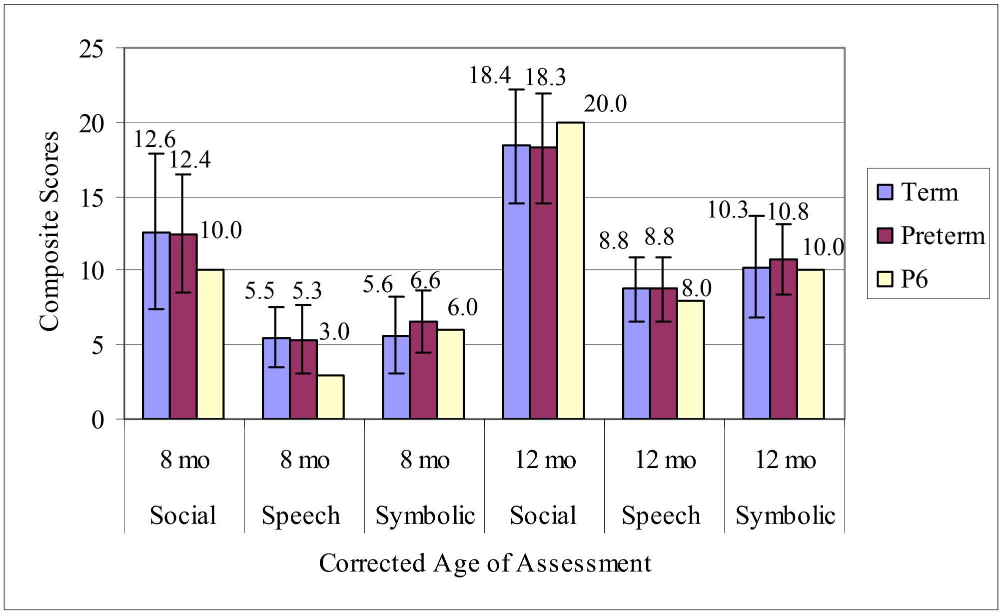


*Figure 50.* Social, Speech and Symbolic Composite Scores on the Communication and Symbolic Behaviour Scales Developmental Profile (CSBS DP) for Preterm Infant P6 compared to Term and Preterm Infants at 8 and 12 months Corrected Age (CA).

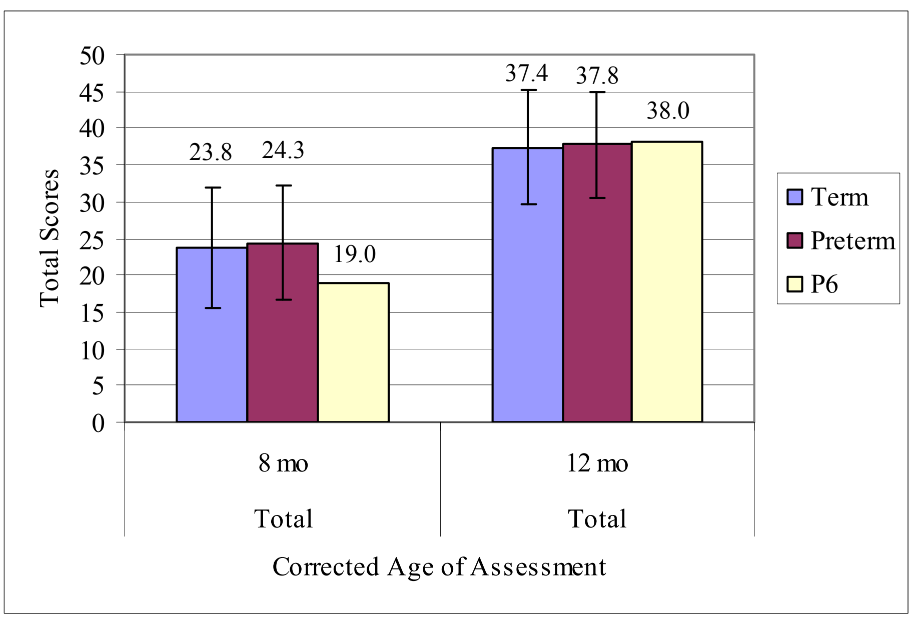


*Figure 51.* Total Scores on the Communication and Symbolic Behaviour Scales Developmental Profile (CSBS DP) for Preterm Infant P6 compared to Term and Preterm Infants at 8 and 12 months Corrected Age (CA).

## 8.6 Summary

The findings suggest that all term and preterm infants were observed making developmental gains in all areas, including feeding and communication development. The only statistically significant difference between the term and preterm groups was the time taken to eat solids. Prematurity did not result in significantly deviant feeding or communication development in this study. The evidence from the results of one male preterm infant provides preliminary reports for the communication development of an infant with poor feeding skills.

# 9.0 DISCUSSION

This study sought to examine the relationship between early feeding and communication development in preterm and term infants from birth to 12 months CA. The aim of the study was to gather evidence to support or refute the development of differentiated versus integrative control mechanisms for feeding and motor speech control. The study also sought to determine the influence of contributing infant, maternal, and environmental factors over the first 12 months of life. The impact of significant influences was investigated for term and preterm infants and their feeding and communication development.

It was hypothesised that integrative control mechanisms are utilised in feeding and communication development, and that the development of feeding and communication would be equally subject to the enhancing effects of a rich stimulating environment, healthy maternal relationship, and normally developing neuroanatomy and physiology. On the other hand, it was also hypothesised that a deficit in this triad would impact both feeding and communication development. It was predicted that there will be a more powerful impact of these factors on the development of feeding and communication for preterm infants. Furthermore, feeding and communication will develop significantly slower for preterm compared to term infants, and delayed or disrupted feeding development would be accompanied by a similar delay or dysfunction in the development of communication in these infants.

The discussion will include 3 major sections. The first section will focus on the quantitative and qualitative evaluation of the feeding assessment protocols developed during this study (9.1.1). The significance of the type of data collected using this protocol will be discussed in the context of dynamic systems theory (9.1.2), and suggestions for the further development of this tool will also be made (9.1.3). A summary of the main results of the feeding assessments is provided (9.1.4).

The second section will highlight the main finding of this research and the impact of prematurity on the relationship between feeding and communication skills in the first 12 months of life (9.2.1). The importance of the triadic relationship of infant, maternal, and environmental factors in the development of this relationship will be discussed (9.2.2). The results will then be examined in light of separate or integrative control processes for feeding and communication outlined in Chapter 8 (9.2.3). A summary of the findings and compliance with the research hypotheses are discussed (9.2.4).

The concluding section will summarise the research and reflect on the strengths and limitations of the research involving participant numbers of participants in a repeated measures design (9.3.1). Suggestions for further development of this topic are also outlined (9.3.2).

## 9.1 Feeding assessments

### *9.1.1 Evaluation of the feeding assessment protocols*

Existing neonatal, clinical, and instrumental feeding assessments were carefully considered for implementation prior to the development of the FAO and FAQ. However, none of the existing tools provided an appropriate age range or the required data required to address the research questions for this study. The FAO observation protocol and the FAQ parent questionnaire were developed from a theoretical framework of sensorimotor speech production, adapted for feeding function (Van der Merwe, 1997). The theoretical assumption underlying the FAO and FAQ protocols was that the infant feeding system operates dynamically and utilises integrative control (Rommel et al., 2003). The protocols provide data on the overall efficiency of the infant's feeding, reflexes, intentionality, sensorimotor planning, motor programming, and execution. This enables the scorer to interpret skills and plan management according to the theoretical scaffold.

The Feeding Assessment Questionnaire (FAQ) will be discussed in the first instance. The motor programming questions on the FAQ determined the presence of coughing on liquids and solids at the appropriate ages. During this study, 71.4% of term infants and 25.0% of preterm infants were reported to cough more than 10% of the time at 1-2 weeks CA. The results for term infants were comparable to a study that found 55% of infants demonstrating coughing with feeding at 4 weeks of age (Motion, Northstone, & Emond, 2001).

Completion of the FAQ was conducted in two ways, either the parent completed the tool unaccompanied, or the chief investigator completed the tool together with parents, and they would indicate the relevant location on the rating scale. The FAQ was found to be an easy tool to administer. Parent support was required to clarify some abbreviations on the FAQ, such as 'thin L' for thin liquids, 'lumpy P' for lumpy purees, and 'hard FF' for hard finger food. Parents demonstrated little difficulty completing the FAQ.

Confidence intervals were included on the FAQ to measure parent's assurance for all questions at each level of the feeding assessment. Overall, parents reported high confidence ratings over 80% for their infants' reflexes, intentionality, motor planning for liquids, motor programming for liquids and solids, and execution on the FAQ. Lower confidence ratings were obtained for motor planning for liquids and solids, duration, frequency, and volume of liquid and solid intake, with confidence ratings between 65% and 80%. The motor planning section asked parents to score their infant's taste, temperature, and texture preferences for solids, and temperature and flow rate preference for liquids. Many parents found it difficult to report preferences for taste, temperature, and texture, providing 'no preference' responses. Similar reporting difficulties occurred when parents were asked to rate their confidence for the volume of liquids their infant was drinking on the FAQ. Given that 6/6 term infants and 6/8 preterm infants were breast feeding at 1-2 weeks CA, it was not surprising that parents reported low confidence for the volume of liquids the infant was accepting each day on the FAQ. It would be impossible for the parents of a breast-fed infant to predict the volume of liquids taken each day as such this should be eliminated as a confidence rating for breastfed infants. In contrast, parents reported higher confidence for the frequency and duration of liquid feeds on the FAQ, increasing the overall confidence ratings of parents.

Birth weight and length measurements were collected during the initial questionnaire, and updated weight and length measures at each developmental review for the parents of infants that had this information available. It would have been useful for weight and length measures to be included on the FAQ, as an indicator of feeding difficulties. For example, an infant accepting adequate fluid volume, having frequent bottle feeds, and taking a reasonable duration to feed could appear to demonstrate adequate feeding skills. However, the infant may not be gaining sufficient weight, indicating that the feeding system may not be functioning at a satisfactory level, and closer examination could be warranted. This issue was highlighted with the male preterm case example. The infant demonstrated adequate measures for duration, frequency, and volume of liquids and solids at all age intervals; however, his weight gain was inadequate. The only discrepancy within his feeding profile on the FAQ was more swallowing in-coordination, indicated by higher motor programming scores on solids at 8 and 12 months CA. If the infant's weight measures had been examined together with the other measures on the FAQ, difficulties could have been more transparent during assessment. Weight and length measures could be included within the FAQ for future studies. The use of electronic scales on home visits to obtain an accurate current weight, and use of a Rollermat or a similar portable tool for length measures are also suggested.

Data collected from the Feeding Assessment Observation (FAO) revealed strong agreement of 85% between items on the observation tool. This scale provided greater reliability than the SOMA with 69% interrater reliability (Reilly et al., 1995). Training was conducted for how to complete the FAO. A case example was demonstrated immediately before interrater reliability testing. The stimulus for reliability testing was a breast-fed newborn term infant, who did not feature any feeding difficulties. Further interrater reliability testing of the FAO with feeding impaired infants is suggested.

During this study, feeding observations were scored on the FAO from video playback. However, the FAO could be completed during a clinical feeding assessment, and management implemented according to the deficits identified. For example, if an infant was observed drinking formula from a bottle with a fast flow teat (sensorimotor planning) and showed gagging and coughing (motor programming level) with poor lip seal (execution level) the clinician could address the deficit at the sensorimotor planning level and trial a medium or slow flow to improve coordination that may reduce or eliminate gagging and coughing and improve lip seal at the execution level.

There are a number of benefits and limitations to utilising a repeated measures research design when measuring feeding scores on the FAO and FAQ at four month age intervals. One benefit was that parents became familiar with the FAQ protocol and how to score items; therefore, the tool was able to note changes over time. Parents were aware that the study was targeting feeding and communication development and those infants were being filmed to assess their feeding skills. Therefore, specific features inherent to the feeding situation, such as texture, taste, and temperature of liquids and solids were brought to the parent's awareness. Some parents would consciously try their infants on a variety of tastes, temperatures, and textures and share information on their infants' success or failure, which they may otherwise have not tried. Whilst comprehensive data have been collected on this sample of infants, the results may not be representative, as parents may have been learning as the project progressed. Thus, the study could have actually served as a positive intervention for parents and participants.

In addition to the feeding assessment tools developed during this study, the initial questionnaire was developed, which provided a standard reporting format for factors that can influence feeding and communication development in infants. The structure of the initial questionnaire supported the frameworks proposed by the literature, encompassing the interactions of infant, maternal and environmental influences (Anderson, 2003; Blackburn, 1986; Carpendale & Lewis, 2004). However, it is unique as no existing measures of the clinical history are useful conceptually. The questionnaire provided a structure for the evaluation and allowed for a clear differentiation between the triad relationship, the infant, maternal and environmental factors. Therefore, the initial questionnaire was a useful reporting tool to describe the background of infants and young children.

### *9.1.2 Dynamic systems and feeding assessment protocols*

Normal infant development is influenced by a number of contributing factors, and variability occurs within both a child or intra-individual and across children or inter-individual (Darrah, Hodge, Magill-Evans, & Kembhavi, 2003). The FAO and FAQ protocols developed for this study examine mechanisms influencing feeding from a multilevel dynamic perspective. The FAO and FAQ assessments provide a more comprehensive perspective of the infant's motor system than existing assessments as they take into account co-occurring infant, maternal, and environmental factors, and intra and inter-individual variations. A dynamic approach also allows measurement of the infant's overall feeding efficiency in the first instance, and if a problem is detected, the rest of the data can be used to determine the pattern of difficulties across a number of processes.

The framework for feeding was adapted from a model of sensorimotor control of speech production (Van der Merwe, 1997). The feeding assessment protocols were developed based on the Van der Merwe (1997) framework which was adapted for feeding. This provided a foundation to compare the development of motor control for feeding with the development of speech motor control, as both assessments were based on a similar fundamental structure.

### *9.1.3 Future development of the feeding assessments*

The FAO and FAQ provided a preliminary framework for the assessment and monitoring of feeding skills of infants. Limitations and suggestions for further development of the FAO and FAQ will be discussed.

A limitation of the FAO was revealed during the second phase of the project, with the inclusion of nominal measures during the motor programming phase on the FAO. Items were scored 'yes', 'no' or 'unsure', for gagging, coughing, gurgling and breathiness, which are subjective measures of 'problem' observations at the motor programming level. Measurement of the frequency of these observations provided a look at 'problems' with swallowing coordination at the motor programming level. Within the execution stage of the tool, observations of tongue position on the teat for drinking liquids, and tongue tip elevation on solids were scored as 'not observed' on 77.8% of observations. Tongue position may not necessarily be observed in an infant with good lip seal around a teat or nipple, or lips together when chewing solids. In addition, for infants with poor lip seal, the observation of tongue position was difficult during video playback, but may have been be more readily observable during direct observation.

The current organisation of the FAQ reports the infant intentionality at the beginning of the questionnaire, then reflexes, sensorimotor planning, motor programming, execution, followed by measures of the overall efficiency of the system. During future studies, it would be more advantageous to reorganise the FAQ to collect data on the overall efficiency of the system at the beginning of the protocol. This re-organisation will allow the scorer to determine whether there is an overall deficit in the system. Preliminary data have been collected for a small sample of term and healthy preterm infants. It would be beneficial to collect normative data of efficiency measures for infants and young children at a range of baseline ages to make comparisons during direct observation. The overall efficiency measures would operate similar to a screening protocol, and if deficits in the feeding system are identified, closer examination of individual phases of the feeding framework and items in the feeding system can be evaluated. To enable this to occur, the FAQ could be separated into two sections; part one to measure overall efficiency, and part two would contain individual questions for each phase of feeding to identify the locus of problems or compensatory strategies that may or may not be effective.

Parents are required to complete 25 confidence ratings in the completion of the FAQ. Although this could be tedious and monotonous for parents, the data suggested large variability in confidence ratings at different phases of feeding on the FAQ. Confidence ratings could be completed for each composite or phase of feeding evaluated, including the overall efficiency items on the questionnaire; duration, frequency and volume of liquids and solids, instead of individual questions. In addition, ratings on the FAQ were measured on a scale of 6.2cm. This should be changed to a more straightforward number such as 10cm, to make the measurements simpler for scoring purposes. The number of questions asking for confidence ratings should be reduced within the FAQ, perhaps just in the first part of the new tool measuring overall feeding efficiency.

Minor structural changes are suggested for the motor programming section of the FAQ (13.1 to 16.2). Questions are arranged by ‘problems’ with motor programming function, for example, gagging on solids, gagging on liquids, coughing on solids, and coughing on liquids. The chief investigator needed to ensure that parents were completing the correct item for *liquid* and *solid* questions. It is suggested that the motor programming section be restructured to document function on liquids in the one part, and solids in the next.

Records of participants' birth weight and review weights, length and head circumference were collected from the infant's yellow child health book. A number of families did not visit their local child health centre on a regular basis, and up to date weight and length measures were frequently unavailable. A suggestion for future studies would be for the researcher to carry portable scales and a measuring tape and board to home visits. This would also reduce the amount of missing data for this item.

#### *9.1.4 Summary*

The assessment protocols developed during this study and the adapted theoretical framework for feeding provide a starting point to address the need for standardised observation tools for evaluating feeding skills of infants and young children (Rogers & Arvedson, 2005). The FAO and FAQ assessments developed during this study differ from the existing commonly used protocols to suggest that feeding be evaluated in terms of overall efficiency. This allowed for the observation of features at all stages of the infant's feeding system.

## 9.2 Feeding and communication relations

The data showed a negative linear trend, meaning improved feeding efficiency on liquids, a positive linear trend for feeding efficiency on solids, and a positive linear trend for the development of communication skills in term and preterm groups from birth to 12 months corrected age for preterm infants and chronological age for term infants. A trend for development was shown where communication, and fine and gross motor skills appeared to develop independently at a non-linear rate (Darrah et al., 2003). This proposition is supported by dynamic systems theory which states that that multiple factors and subsystems contribute to infant motor development (Abbott & Habel, 1999).

The communication assessments were included based on the reliability and validity data for each tool available at the time of data collection in early 2004. New and revised tools, such as the CLAMS section of the Capute Scales may be useful for inclusion in future studies for measuring feeding and communication relations (Accardo et al., 2005).

### *9.2.1 Impact of prematurity on feeding and communication relations*

One aim of this study was to examine prematurity as a contributory factor influencing feeding and communication development in infants. Preterm infants develop distinct neuromotor behaviours compared to term infants (Bartlett & Piper, 1993). As such, healthy preterm infants were recruited for the study. Infants with major cardiac, respiratory, and other significant difficulties were excluded from participation.

The main finding of the study provides preliminary support that the same motor control mechanisms are used for feeding and communication development in term and healthy preterm infants. Feeding and communication development was co-occurring for term and preterm participants. Despite the literature suggesting increased incidence of communication delay in preterm infants, there was no obvious impact of prematurity on the development of feeding or communication skills in this study. The results of the current study found that preterm and term infants developed equally. This is most likely due to the inclusion of a healthy sample of preterm infants, to eliminate the impact of co-morbidities associated with prematurity. This finding is of importance as previous studies have not necessarily isolated the results of healthy preterm infants from those with numerous co-morbidities.

A significant difference was obtained between the term and preterm groups for CLA on the REEL-2 at 1-2 weeks chronological age for term and CA for preterm infants, but no differences were found at 4, 8 or 12 months or for measures of ELA and RLA between groups. Preterm and term groups developed normal feeding and communication skills despite the preterm infants starting with immature physiology.

Mothers of preterm infants have been shown to engage in significantly more turn-taking than mothers of term infants. However, term infants engaged in significantly more turn-taking vocalisations when communicating with their mothers than preterm infants and their mothers (Reissland & Stephenson, 1999). These findings suggest that preterm mothers provide greater maternal stimulation for preterm infants, but term infants have more developed expressive language and speech production. The results of the current study found no significant differences between receptive and expressive language between term and preterm infants at any age interval. In addition, no maternal influences were found to be significantly different between the term and preterm groups.

The results of the current study found that preterm infants commenced oral feeds and achieved full oral feeds significantly later than term infants. However, the commencement of oral feeds did not impact on the communication development of participants in the current study. These findings support existing studies that preterm infants experience feeding delay, and oral feeding is usually delayed in preterm infants until their respiratory and cardiac systems are stable (Harris, 1986; Rommel et al., 2003). Again, consideration must be given to the small sample size and possible recruitment bias in the current study.

Preterm infants are reported to experience delays in cognitive and language development (Burns et al., 2004; Magill-Evans et al., 2002). The results of a previous study investigating preterm infants born less than 1800 grams and before 38 weeks gestation, found that preterm infants scored significantly lower than term infants for language development on the REEL at 1 and 8 months (Crnic et al., 1983). In the current study, 5 out of 8 preterm infants were born at less than 1800 grams and before 38 weeks gestation, although, overall the preterm group experienced normal development of receptive and expressive language skills. Additionally, no significant difference was found between the communication development of term and preterm infants on the REEL-2 at 1-2 weeks and 4 months chronological age for term and CA for preterm infants, and the REEL-2 and the CSBS DP at 8 and 12 months chronological age for term and CA for preterm infants.

The male preterm case study who demonstrated feeding difficulties and delayed communication development until the 8 months corrected age review, provided some evidence to support the theory of linked motor development. It is important to reiterate that healthy preterm participants born at 28 to 33 weeks gestation participated in this study to eliminate the impact of potential confounders associated with other medical complications. In this sense, the study was able to focus on the impact of prematurity in isolation from other medical disorders that have an impact on other aspects of development. Future studies are suggested to examine development of feeding and communication skills in a cohort of preterm infants born during a similar age range, but exhibiting associated confounding factors, such as respiratory, cardiac difficulties or associated syndromes.

### *9.2.2 Impact of infant, maternal and environmental factors*

There were benefits of considering influencing factors within the context of the triadic model of development described by Carpendale and Lewis (2004), in contrast to the existing assessments that focus only on the 'infant' factors (Blackburn, 1986; Carpendale & Lewis, 2004). Potential infant, maternal, and environmental factors were investigated in an infant with poor feeding and lower communication scores at 8 months corrected age. This infant scored the highest environmental (HSQ) score of the preterm group. A close age gap of 8 months was present between the infant and his older brother (in addition to a school age sibling). This may have influenced his delayed communication development at 8 months corrected age. However, a female preterm participant also had a sibling with an 8 month age gap, and a school age sibling, and her communication skills were within normal limits at all age intervals. Studies on language development in families have shown that older siblings receive more linguistic attention from parents than younger children, and the younger siblings are more passive and have less child-focused conversations with their mothers (Wellen, 1985; Woollett, 1986). A more recent study found that secondborn children have better pronoun development, with similar general language development (Oshima-Takane, Goodz, & Derevensky, 1996). Therefore, it was concluded that environmental factors did not appear to have had an impact on his feeding and communication development.

*Infant factors*

The parent's choice of feeding method may have an impact on the infant's feeding skills. There are numerous reasons for mothers to cease breast feeding. Broad and Duganzich (1983) found that breastfeeding incidence decreases with birth order, with first born children breast-fed more often than younger siblings. Mizuno and colleagues (2004) asked parents to describe the rate and duration of breastfeeding and their reasons for cessation of breastfeeding. These reasons depended on the child's perceived 'feeding style', for example, barracudas, excited ineffectives, procrastinators, gourmets, and resters. Overall, the most frequently reported reason for ceasing breast feeds in the Mizuno study was due to perceived milk insufficiency. The other reasons varied with the infant's feeding style, but included taking medications, mastitis and other siblings getting angry or jealous (Mizuno et al., 2004). At each developmental assessment in this study, parents were asked to report the drinking methods that they had tried with their infant. Their observations of the infant's feeding skills for drinking liquids by breast, bottle, spout cup, open cup, and straw drinking were recorded on the FAO. However, the reasons for the mother's onset and conclusion of breastfeeding their infants were not collected during this study. Collection of this data would be useful in future studies.

Previous studies have suggested that infants that are exclusively breast-fed until 4 months of age will score a higher intelligence quotient in their first grade of school (Humphrey, 1997). And if breast feeding and speech development are in fact related, then the parent choice, based on maternal characteristics, socioeconomic status, educational level and cultural background may impact feeding and subsequently communication development (Broad, 1972a, 1972b). Therefore, the parent's choice of feeding method adopted and observed in this study could have had an impact on the results collected during this study. They could have also affected the cognitive and communication development of infants in this study.

The Apgar score is a regularly used instrument to assess the condition of the infant at birth and to be a predictive index for the survival or morbidity of infants (Juretschke, 2000; Letko, 1996). A score of ten indicates the best possible outcome for the infant and a low score can represent poor neonatal outcome (Letko, 1996). The tool has been validated on term infants. Mixed accounts have been reported for the sensitivity of the Apgar score with preterm infants, as preterm infants with a high Apgar score will not necessarily predict good developmental and neurological outcomes for preterm infants (Jepson et al., 1991). Preterm infants are likely to experience a poor Apgar score due to the immaturity of their system, such as skin colour, respiration and pulse (Letko, 1996). The preterm infants who participated in the current study did not demonstrated significantly lower Apgar scores at 1 and 5 minutes than term infants. A study of low birth weight infants (500-1800 grams) found 95% sensitivity and 68% specificity for Apgar scores in a preterm population (Carter et al., 1995).

Preterm infants have delayed gross motor skills during the first year of life, and attain motor milestones later than term infants (Bartlett & Piper, 1993). The results of this study did not support the findings of Barlett and Piper (1993) at 4 and 12 months CA, since no significant differences were noted between the motor milestone development of term and preterm infants at 4, 8 and 12 months CA. Moreover, preterm infants demonstrated much greater variability in motor milestone attainment than term infants at all age intervals as indicated by larger variability in standard deviation scores.

*Maternal factors*

This study recorded parent ages during the initial questionnaire when infants were 1-2 weeks chronological age for term infants and corrected age for preterm infants. In the current study, the ages of mothers of preterm infants was statistically higher significant that mothers of term infants. No statistically significant difference was found between the ages of fathers of term and preterm infants. These results conflict with those of Magill-Evans and colleagues (2002) who found that the age of parents of preterm infants was less than the parents of term infants. In the current study, the mean age of mothers (29.86) and fathers (34.43) of term infants was statistically higher than the mothers (28.1) and fathers (30.9) of term infants in the Magill-Evans study (2002). Similarly, the ages of mothers (36.13) and fathers (38.75) of preterm infants was higher than the Magill-Evans and colleagues (2002) study where the mean ages of mothers and fathers of preterm infants were 26.8 and 28.1 respectively.

During the first few months of an infant's life, a special bond develops between the mother and infant during breastfeeding. Renfrew and colleagues (2000) conducted a study to determine the relationship between infant's first breast feed and their emotional attachment and duration of breastfeeding. No significant difference was found for the length taken to breast feed at the first contact of breastfeeding whether within 30 minutes, 4 to 8 hours after delivery. However, a significant association was reported for communication between the mother and infant and earlier introduction of breast feeding (Renfrew et al., 2000). Given that a mother's attitude during pregnancy towards feeding her infant is positively correlated with the mother infant's feeding method on discharge from hospital (Scott et al., 2004), the findings of Renfrew et al (2000) could be indicative of a more engaged and knowledgeable parenting style.

The marital status of mother can have an impact on the infant's environmental score on the HSQ (Pessanha & Bairrao, 2003). In the current study, all parents of term and preterm infants were married or in a defacto relationship. Married mothers ($n$ = 98) had significantly higher HSQ scores than unmarried mothers ($n$ = 22) in the study by Pessanha and Bairrao (2003). In addition, a moderate correlation of 0.62 was found between the mother's educational level and environmental scores on the HSQ (Pessanha & Bairrao, 2003).

The relationship between the mother and infant and infant development may be negatively affected by early maternal employment. This relationship was refuted by Huston and Rosenkrantz Aronson (2005), who found that mothers who worked for a longer duration had higher environmental scores on the Home Observation for Measurement of the Environment (HOME) assessment (Huston & Rosenkrantz Aronson, 2005). Similarly, working mothers had statistically higher environmental scores on the Home Screening Questionnaire (HSQ), compared to non-working mothers (Pessanha & Bairrao, 2003).

Conflicting evidence exists on the impact of socioeconomic status or the poverty level of the family on an infant's development. Abbott and Bartlett (1999) suggested that poverty can confound an infant's intellectual development. They proposed that children are at greater risk of developmental delay from families living in low socioeconomic standards. The environment did not have a significant impact on feeding or communication development in this study. Similarly, no correlation between breastfeeding and socioeconomic home environment has been reported (Broad & Duganzich, 1983).

*Environmental factors*

The HSQ provides a screening evaluation of environmental influences. The HSQ scoring manual indicates a total HSQ score of 32 or below is indicative of a suspect home environment, and a score of 33 and above a non-suspect environment. The HSQ manual reports that it is applicable for children up to 3 years of age. Using the scoring process within the HSQ manual, all infants at all age intervals in the first 12 months of life achieved a score of less than 32 points, meaning that all are considered 'at risk' of environmental deprivation. A more viable explanation could be that the cut-off score of 32 is not appropriate for infants less than 12 months. This study provides a small amount of preliminary data for term and preterm infants at 1-2 weeks, 4, 8 and 12 months CA.

Magill-Evans and colleagues (2002) propose that the environment where a healthy preterm infant lives in the first week of life can affect later language and cognitive development. Infants who received an individualised care program during the neonatal period performed better than preterm controls when assessed at two weeks post term age (Duffy et al., 1990). This could have influenced the results of preterm infants in the current study, as 2 out of 7 term infants and 6 of the 8 preterm infants were seen for a feeding assessment during the neonatal period.

Overall, the results from the current study showed some variation between the preterm and term groups for influencing infant, maternal, and environmental factors. However, none of the infant, maternal, or environmental factors had a significant impact on the rate of feeding and communication development of the term and preterm infants groups. The model proposed by Carpendale and Lewis (2004) provided a useful framework to investigate the relative contribution of influencing infant, maternal and environmental factors on feeding and communication development.

### *9.2.3 Support for related or unrelated motor control processes*

The study provided some evidence to support the integration of communication and feeding development for term infants from birth to 12 months chronological age, and preterm infants corrected age. Ziegler (2003a) proposed a task-dependent and task-independent model to describe motor control of speech and other motor systems. The task-dependent hypothesis suggests that oral motor control, such as the tongue, lips, and laryngeal movement, is controlled differently based on the motor activity. In other words, that feeding and communication are operated from separate control systems or have unrelated functions (Ziegler, 2003a, 2003b). In contrast, the task-independent hypothesis assumes that the motor control of individual oral structures are controlled by a common sensory/motor system, independent of the motor task (Ziegler, 2003a, 2003b). In response to Ziegler (2003a), Ballard et al. (2003) suggested an integrative model of motor control.

The findings of the current study provide preliminary support for the utilisation of an integrative model of control for the feeding and communication motor systems. The trends in the development of feeding efficiency on liquids and solids and communication development were discussed in Chapter 8.0. The results revealed that both term and preterm infants' feeding motor efficiency improved over time with liquids. For example, the duration and frequency for bottle or breast feeds reduced as the infants' feeding motor control systems became more refined. In addition, the infants' feeding efficiency for solids improved as the complexity of solid textures was increased over time. Both term and preterm infants feeding efficiency on solids revealed an increasing trend for the length of mealtimes and the volume of solid feeds.

A similar trend was demonstrated in the development of communication skills for term and preterm infants. Therefore, the study provides preliminary support for integrative motor control mechanisms involved in feeding and communication development. Further research is required to determine whether specific co-morbidities will differentially impact on the processes required for communication as distinct from feeding development. It could be possible that some disorders may impair development in a simultaneous manner, whereas others may have a differential impact on a different aspect. The utilisation of a research design based on theory-driven research within the current study allowed for the impact of influencing factors to be examined, and was found to be beneficial given that most feeding protocols presently lack a theoretical basis.

Evidence from the preterm infant case example provides preliminary support for both the task-dependent and task-independent hypothesis depending on the corrected age when the infant was assessed. The participant demonstrated poor feeding and indicators of communication deficit and motor milestone delays at 4 and 8 months CA, thus supporting the task-independent hypothesis of a common sensory/motor system for feeding and communication (Ziegler, 2003a). The infant continued to have indicators of feeding deficits at 12 months CA, including gagging on liquids, however, his communication skills improved to within the average range by 12 months CA. Therefore, it could appear that the motor control systems for feeding and communication are operating in isolation from one another, supporting unrelated motor control or the task-dependent hypothesis (Ziegler, 2003a). The more probable assumption would be that motor systems for the feeding and communication are developing by integrative means, and development was not necessarily time dependent, thus supporting the theoretical proposition of integrative motor control of Ballard and colleagues (2003). Further evidence is required to confirm or refute these positions.

All infants in this study were introduced to solids earlier than the recommended guidelines. The preterm infants in this study ate solids at an earlier corrected age than term infants at their chronological age. The introduction of solids to participants in this study is interesting and conflict with the WHO recommendations for exclusive breastfeeding until 6 months of age and introduction of solids at 6 months to infants (World Health Organisation, 2003). Six out of 8 (75%) preterm infants and 4 out of 7 (57%) term infants were receiving solids at 4 months corrected and chronological age respectively. An unpublished study of a much greater number of preterm infants in Western Australia revealed the mean age of introduction of solids in preterm infants to be 11 weeks CA (Su, 2005).

### *9.2.4 Summary*

Therefore, feeding and communication skills appeared to develop simultaneously in term and preterm participants in this cohort. The results provided weak evidence to support the proposition of integrative motor control mechanisms for feeding efficiency on liquids and solids and communication development, as proposed by Ballard and colleagues (2003), as the data suggested co-development of the two systems. Support was provided for the integrative development of motor systems with the preterm case example, who exhibited deficits in feeding skills at 4 and 8 months CA, and indicators of speech motor concern at 8 months CA. However, communication skills developed within normal range by 12 months CA, despite the presence of consistent gagging on liquids at this age. Therefore, the data supports the co-occurrence of feeding and communication development for the preterm infant case example that presented with deficits in feeding and speech motor control earlier in life, but caught up and exhibited less symptoms of deficit in both areas later in infant development.

There was more variation in the infant and environmental factors in the preterm infant group than in the term group. However, the factors did not have a significant influence on feeding and communication development between the term and preterm groups over time. The case example of the preterm infant discussed in section 8.5 provides preliminary evidence for the communication development of an infant with feeding difficulties, with some communication concerns identified at 8 months CA, which had resolved by 12 months CA.

## 9.3 Strengths, limitations and future direction

### *9.3.1 Strengths and limitations of the research*

One of the main outcomes of this study was the development of a feeding assessment protocol from a ‘top down’ perspective to address the overall efficiency of an infant’s feeding system whilst controlling and measuring other maternal and environmental factors that could impact on development. As the theoretical model was adapted from an existing sensorimotor framework of speech production, it enabled the assessment of motor control with the same structure to address directly the aims of unified or differentiated motor control systems for feeding and communication (Van der Merwe, 1997). The structure of the assessment protocols was based on this theoretical framework, and individual questions for the FAO and FAQ were connected to phases of the feeding framework.

The current study was unique in its adaptation of a feeding model and the development and implementation of feeding assessment observation and questionnaire protocols based on the framework of sensorimotor control (Van der Merwe, 1997), with consideration for the influences of infant, maternal, and environmental factors (Carpendale & Lewis, 2004). Furthermore, this was the first study to follow the developmental progression of feeding and communication skills in a sample of term and preterm infants from birth to 12 months of age, at corrected ages for preterm and chronological ages for term infants. Further reliability and validity testing with a larger sample size is suggested.

A single author collected all data during the study. This allowed for the development of a good rapport with parents and participants and for detailed observations and contrasts between measures. The study involved a small number of participants due to the logistics of the assessments. Each home visit lasted an average of 2 to 3 hours, plus travel time to and from the home. The assessments conducted during each home visits took around 1½ hours to complete. Parents spent a considerable amount of time sharing stories of other aspects of their infant's development, showing photos, and conducting home duties during the home visit, such as changing nappies, putting out and bringing in washing, preparing meals, and caring for siblings.

The repeated measures research design utilised during this study has inherent benefits and limitations. Examination of patterns of child development provides rich information about individual infant's variability over time (Darrah et al., 2003). However, parents became very familiar with environmental, feeding and communication measures. For example, question 15 on the HSQ asks how often parents read stories and show pictures to their children. This prompted parents to respond by saying that they would try to read to their infants more often, and they proudly reported increased reading to infants at the next review. Therefore, it is difficult to measure the carry-over and familiarisation effects with objective measures.

During the interrater reliability testing stage, a demonstration for completing the FAO tool was provided to students with a 7½ months old dysphagic infant who was not a participant within the main study. Students were then required to complete the FAO protocol individually on a 7 day old term infant without dysphagia or feeding difficulties who was not a participant within the main study. It may have been more useful to provide of an age-matched example of feeding behaviours as a demonstration for students. In addition, interrater reliability testing was conducted on a newborn at 7 days chronological age infant. Further reliability testing of the FAO tool would be useful on term and preterm infants at birth, 4, 8 and 12 months corrected ages for preterm and chronological ages for term infants.

The current study was limited as it consisted of a small sample size, with only 10 term and 10 preterm participants recruited initially, which reduced to 7 term and 8 preterm infants who were seen for all assessments. Parents were required to make a long term commitment to the project over 12 to 15 months from the time of approach in hospital until the child turned 12 months CA. However, the parents who consented to participate in the study could represent a biased sample of parents with good parenting skills. Despite the small number of participants, a large volume of data has been collected for each infant to obtain a comprehensive overview of the infant's development and the context in which this was occurring. This small sample is the first step to explore further these complex areas of infant development.

A further benefit of the current study was the ability to observe the infant feeding within a naturalistic context, in the child's home as suggested by Mathiesen (2001). In Perth, Western Australia, infants requiring a feeding assessment are referred to the sole tertiary paediatric hospital, Princess Margaret Hospital for Children. Referrals are reviewed by an intake team and the child's needs are prioritised by standard criteria. Low priority infants, who live in an area with a feeding service as part of their community clinic, may be seen in the home environment or at the child development clinic. All other infants are seen in the hospital setting.

A considerable amount of time was involved conducting analyses during this study, as the feeding assessments developed for this study were new protocols. Descriptive data were analysed for all individual items on the feeding assessment observation (FAO) and feeding assessment questionnaire (FAQ). Individual questions and confidence ratings were measured and analysed on the FAQ. The level of detail involved for each measurement would be difficult to achieve with large group studies.

The participants recruited for the study were selected from a quasi-random sample. Pair wise matching of infants was not conducted during participant recruitment. One term participant was Indonesian, the family of the infant spoke English only as a second language. The specificity of the participant data is a limitation in the study. All infants participating in the study were recruited through King Edward Memorial

Hospital, the only tertiary perinatal centre in Western Australia that provides services to a multicultural clientele.

As previously highlighted, healthy infants born between 28 and 33 weeks gestation were recruited in the preterm group. Healthy infants were recruited to eliminate the impact of potential confounders associated with preterm morbidity. The results from this study are specific to a healthy preterm population and future studies of preterm infants with abnormalities and diseases are suggested.

### *9.3.2 Further development of this topic*

Suggestions for future studies examining the relationship between feeding and communication development are provided. The current study tracked the feeding, motor, and communication skills of infants from birth until 12 months CA. The study by Motion and colleagues (2001) found that infants with persistent feeding difficulties at 1, 6, and 15 months had delayed motor milestones and language development at 18 months and articulation difficulties at 38 months of age. An additional study found that preterm infants without significant health problems scored significantly lower receptive and expressive language skills and performance intelligence quotient (IQ) at 10 years of age compared to their term counterparts (Magill-Evans et al., 2002).

The current study utilised a sample of healthy preterm and term infants for a prospective design, to evaluate the development of feeding and communication. The findings suggest that maturity of former preterm infants is not a concern as deficits in feeding and communication development would have been apparent during earlier assessment. Future research is strongly suggested to evaluate the feeding and communication development in a disordered population, and to evaluate the impact of feeding difficulties on communication development to enhance our understanding of feeding and communication development in a sample of age and gender matched infants with disorders. The latter question could be first addressed with a retrospective pilot to evaluate factors within the medical history that differentiate infants with feeding and communication deficits to guide the development of a prospective study.

# 10.0 CONCLUSION

The relationship between the development of feeding and communication is an important research area in which limited empirical literature exists. The presence or absence of such a relationship will provide vital information to improve our understanding of infant motor development. The current study proposed the interpretation of feeding skills and development in light of a modified framework of motor speech control, and extended theoretical thinking into the new domain of feeding motor control. Equipped with this novel theoretical framework of feeding, new observation and questionnaire assessment tools were developed. In addition, the normal range of feeding and communication development in preterm and term infants was described.

The current study provided some support for the project hypothesis, and refuted others. The study provided preliminary support for the first hypothesis of integrative motor control and co-occurrence of feeding and communication development, as indicated in the similar trends of development for communication and feeding efficiency on liquids and solids. The study did not support the second hypothesis, as infant, maternal and environmental factors did not significantly influence feeding and communication development. In addition, there was no difference in the impact of influencing factors for the term and preterm groups. The study did not provide evidence to support the third hypothesis, as feeding and communication skills developed at corrected age levels for preterm infants, and not significantly slower as predicted. The fourth hypothesis predicted that delays in feeding development would be accompanied by similar delays in communication development. The results of a single case example supported the prediction of the fourth hypothesis with a preterm participant at 8 months CA, but not at 12 months CA. Whilst the findings of the study do not provide support for integration of motor control systems for feeding and communication development, it provides preliminary evidence of the development of the feeding and communication motor control systems in a healthy term and preterm infant sample. Further investigation of the subsequent communication development of preterm infants with definitive feeding difficulties is suggested.

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APPENDICES

Appendix A. Receptive-Expressive Emergent Language Scale – Second Edition

(REEL-2)

REEL-2 SCALE

**The Bzoch–League Receptive–Expressive Emergent Language Scale Second Edition**

**for the Measurement of Language Skills in Infancy**

**PROFILE / TEST FORM**

**Section I. Identifying Information**

Name ____________________

☐ Boy ☐ Girl ID# ____________

| | Year | Month | Day |
|---|---|---|---|
| Interview Date | ____ | ____ | ____ |
| Date of Birth | ____ | ____ | ____ |
| Age | ____ | ____ | ____ |

Age in Months ________

Interviewer's Name ____________________

Interviewer's Title ____________________

Informant's Name ____________________

Relationship ______ Mother ______ Father ______ Both

Other ____________________ (Specify relationship)

**Section II. Family Information**

Mother or Guardian's Name ____________________ Occupation ____________

Father or Guardian's Name ____________________ Occupation ____________

____________________ ZIP or CODE

Telephone: ( ________ ) ____________________

Siblings' Names and Ages:

____________________

____________________

____________________

Others Interacting with Infant:

____________________

**Section III. REEL-2 Scores**

Receptive Language Age (RLA) ____________

Expressive Language Age (ELA) ____________

Combined Language Age (CLA) ____________ [(RLA + ELA) ÷ 2 = CLA]

To obtain quotients, divide each of the above language ages (RLA, ELA, and CLA) by the child's chronological age and multiply by 100, or see Appendix C in the REEL-2 Manual.

| RECEPTIVE | EXPRESSIVE | LANGUAGE |
|---|---|---|
| ☐ | ☐ | ☐ |
| QUOTIENT | QUOTIENT | QUOTIENT |


12 13 03 02 01

Additional copies of this form (#5127) are available from PRO-ED, 8700 Shoal Creek Boulevard, Austin, Texas 78757 USA 512/451-3246.

## Stage I. PHONEMIC LEVEL DEVELOPMENT—BIRTH TO 3 MONTHS*

**Age Periods****

### 0 to 1 month

Receptive Language†

____ R1. Startle response to loud, sudden noises.
____ R2. Activity arrested when approached by sound.
____ R3. Often quieted by a familiar, friendly voice.

Expressive Language†

____ E1. Frequent crying.
____ E2. Begins random vocalizing other than crying.
____ E3. Vowel-like sounds similar to "E" and "A" predominate.

### 1 to 2 months

____ R4. Frequently gives direct attention to other voices.
____ R5. Appears to listen to speaker.
____ R6. Often looks at speaker and responds by smiling.

____ E4. Has a "special" cry for hunger.
____ E5. Sometimes repeats the same syllable while cooing or babbling.
____ E6. Develops vocal signs of pleasure.

### 2 to 3 months

____ R7. Responds to speech by looking directly at speaker's face.
____ R8. Now regularly localizes speaker with eyes.
____ R9. Frequently watches lips and mouth of speaker rather than whole face.

____ E7. Occasionally responds to sound stimulation or speech by vocalizing.
____ E8. When played with, laughs and uses other vocal expressions of pleasure.
____ E9. Vocalizes occasionally with two or more different syllables.

## Stage II. MORPHEMIC LEVEL DEVELOPMENT—3 TO 9 MONTHS

### 3 to 4 months

____ R10. Now deliberately turns head and eyes toward the source of the voice.
____ R11. Looks about in search of out-of-sight speakers in the room.
____ R12. Usually frightened or disturbed by angry vocal inflection patterns.

____ E10. Often laughs during play with objects.
____ E11. Babbles (regularly repeats series of same sounds, especially when alone).†
____ E12. Often uses sounds like "P," "B," or "M."

* See Appendix A in the REEL-2 Manual for narrative discussion of stages of emergent language development.
** For detailed scoring instructions see the REEL-2 Manual.
† See the glossary in the REEL-2 Manual for definitions of terms.

**4 to 5 months**

____ R13. Regularly localizes source of voice with accuracy.
____ R14. Occasionally seems to recognize and respond to his or her own name.
____ R15. Usually stops crying when someone talks to him or her.

____ E13. Now uses some back vowel sounds similar to "O" and "U."
____ E14. Expresses anger or displeasure by vocal patterns other than crying.
____ E15. Usually stops babbling in response to vocal stimulation, but now may occasionally continue babbling for a short time.

**5 to 6 months**

____ R16. Appears by facial and bodily gestures to be able to distinguish general meanings of (a) warning, (b) anger, and/or (c) friendly voice patterns.
____ R17. Appears to recognize some words like "daddy," "bye-bye," "mama," etc.
____ R18. Stops or withdraws in response to "no" at least half of the time.

____ E16. Takes the initiative in vocalizing and babbling directly at others.
____ E17. Occasionally vocalizes with 3 or more different syllables at one time.
____ E18. Now plays at making sounds and vocal noises whether alone or with others.

**6 to 7 months**

____ R19. Now appears to recognize names of family members in connected speech, even when the person named is not in sight.
____ R20. Responds with appropriate arm gestures to such words as "up," "high," "bye-bye," etc.
____ R21. Gives some attention to music or singing.

____ E19. Begins some frequent 2-syllable babbling (often repeats combinations of 2 or more different sounds).
____ E20. At least half of the time responds with vocalizations when called by name.
____ E21. Uses some word-like vocal expressions (appears to be naming some things in his or her own "language").

**7 to 8 months**

____ R22. Frequently appears to listen to whole conversations between others.
____ R23. Now regularly stops activity when her or his name is called.
____ R24. Appears to recognize the names of a few common objects by localizing to them when their names are spoken.

____ E22. Begins some 2+ syllable sentence-like jargon utterances using only occasional, true recognizable words.
____ E23. Plays speech-gestures games like "pat-a-cake" or "peek-a-boo."
____ E24. Occasionally "sings along" with some familiar song or music without using true words.

### 8 to 9 months

____ R25. Appears to understand some simple verbal requests like, "Come here."
____ R26. More regularly stops activity in response to "No," or "Stop that!"
____ R27. Will sustain interest (up to a full minute) in looking at pictures if they are named by an adult.

____ E25. Uses some gesture language (such as shaking head appropriately for "no," pointing, etc.).
____ E26. Often mimics the sounds and number of syllables used in vocal stimulation by others.
____ E27. Utterances now contain more consonants than at the 6-month stage.

## Stage III. SYNTACTIC LEVEL DEVELOPMENT—9 TO 18 MONTHS

### 9 to 10 months

____ R28. Appears to enjoy listening to the names of new words.
____ R29. Generally able to listen to speech without being distracted by other competing sounds.
____ R30. Often gives toys or other objects to a parent or to others on verbal request.

____ E28. Speaks first words. These are often "da-da," "ma-ma," "bye-bye," or the name of a pet or a toy.
____ E29. Uses some exclamations like "oh-oh."
____ E30. Also uses some jargon (short sentence-like utterances of 4 or more syllables without true words).

### 10 to 11 months

____ R31. Occasionally follows simple commands like "Put that down."
____ R32. Appears to understand simple "where" questions like "Where is the ball?" or "Where is Daddy?"
____ R33. Responds to rhythmic music by bodily or hand movements in approximate time to the music.

____ E31. Usually now vocalizes in varied jargon patterns while playing alone.
____ E32. Initiates speech-gestures games like "pat-a-cake" or "peek-a-boo."
____ E33. Occasionally tries to imitate (repeat) new words heard.

### 11 to 12 months

____ R34. Demonstrates understanding by responding with appropriate head and body gestures to several kinds of verbal requests.
____ R35. Generally shows intense attention and response to speech over prolonged periods of time.
____ R36. Demonstrates understanding by making appropriate verbal responses to some frequent requests (for example, "Say bye-bye").

____ E34. Uses 3 or more words with some consistency.
____ E35. Now, most often "talks" to toys, objects, and people throughout the day, using longer verbal patterns.
____ E36. Frequently responds to songs or rhymes by vocalizing (sings or recites along).

### 12 to 14 months

____ R37. Appears to understand some new words each week.

____ R38. Seems to better understand the psychological feeling and shades of meaning of most speakers.

____ R39. Now will sustain interest for 2 or more minutes in looking at pictures, if they are named.

____ E37. Uses 5 or more true words with some consistency.

____ E38. Attempts to obtain desired objects by using voice and some words in conjunction with pointing and gesturing.

____ E39. Some true words now more frequently occur in jargon utterances.

### 14 to 16 months

____ R40. Demonstrates understanding by carrying out double verbal requests to select and bring some familiar object from another room, and so forth.

____ R41. Recognizes and can identify by pointing to many objects (or pictures of objects when they are named).

____ R42. Clearly recognizes names of various large parts of the body (such as hair, mouth, ears, hands, etc.).

____ E40. Consistently uses 7 or more (up to 20) true single words.

____ E41. More frequent use of consonants like "T," "D," "W," "N," "H," and so forth in expressive vocal utterances.

____ E42. Most communication is now accomplished by using some true words along with frequent gestures.

### 16 to 18 months

____ R43. Comprehends simple questions and can carry out up to two consecutive related directions with a ball or other object.

____ R44. Now learns and associates new words each week in broad categories (such as the names for new items of foods, clothing, animals, etc.).

____ R45. From a single request, identifies 2 or more familiar objects from a group of many familiar objects (e.g., "Pick up the ball *and* the block.").

____ E43. Begins using words rather than gestures to express wants and needs.

____ E44. Begins repeating words overheard in conversation.

____ E45. Evidences a continual but gradual increase in speaking vocabulary (3–4 new words each month).

## Stage IV. SEMANTIC LEVEL DEVELOPMENT—18 TO 36 MONTHS

### 18 to 20 months

____ R46. Upon verbal request points to several parts of the body and various items of clothing shown in large pictures.

____ R47. Demonstrates understanding by appropriate responses to such action words (verb forms) as "sit down," "come here," "stop that," etc.

____ R48. Demonstrates some understanding of distinctions in personal pronouns (such as "give it to her," "give it to me," etc.).

____ E46. Imitates some 2-word and 3-word sentences frequently heard.

____ E47. Imitates environmental sounds (such as motors, animals, etc.) during play.

____ E48. Now has a speaking vocabulary of at least 10 to 20 words.

# Appendix B. Communicative and Symbolic Behavior Scale Developmental Profile Checklist (CSBS DP)

CSBS DP

## CSBS DP Infant-Toddler Checklist

*Child's name:* ______________________ *Date of birth:* ____________ *Date filled out:* ____________

*Was birth premature?* ______________________ *If yes, how many weeks premature?* ______________

*Filled out by:* ______________________ *Relationship to child:* ______________________

**Instructions for caregivers:** This Checklist is designed to identify different aspects of development in infants and toddlers. Many behaviors that develop before children talk may indicate whether or not a child will have difficulty learning to talk. This Checklist should be completed by a caregiver when the child is between **6 and 24 months** of age to determine whether a referral for an evaluation is needed. The caregiver may be either a parent or another person who nurtures the child daily. Please check all the choices that best describe your child's behavior. If you are not sure, please choose the closest response based on your experience. **Children at your child's age are not necessarily expected to use all the behaviors listed.**

| | | | | | |
|---|---|---|---|---|---|
| **Emotion and Eye Gaze** | | | | | |
| 1. Do you know when your child is happy and when your child is upset? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 2. When your child plays with toys, does he/she look at you to see if you are watching? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 3. Does your child smile or laugh while looking at you? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 4. When you look at and point to a toy across the room, does your child look at it? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| **Communication** | | | | | |
| 5. Does your child let you know that he/she needs help or wants an object out of reach? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 6. When you are not paying attention to your child, does he/she try to get your attention? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 7. Does your child do things just to get you to laugh? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 8. Does your child try to get you to notice interesting objects—just to get you to look at the objects, not to get you to do anything with them? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| **Gestures** | | | | | |
| 9. Does your child pick up objects and give them to you? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 10. Does your child show objects to you without giving you the object? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 11. Does your child wave to greet people? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 12. Does your child point to objects? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 13. Does your child nod his/her head to indicate *yes*? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| **Sounds** | | | | | |
| 14. Does your child use sounds or words to get attention or help? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 15. Does your child string sounds together, such as *uh oh, mama, gaga, bye bye, bada*? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 16. About how many of the following consonant sounds does your child use: *ma, na, ba, da, ga, wa, la, ya, sa, sha*? | ❒ None | ❒ 1–2 | ❒ 3–4 | ❒ 5–8 | ❒ over 8 |
| **Words** | | | | | |
| 17. About how many different words does your child use meaningfully that you recognize (such as *baba* for bottle; *gaggie* for doggie)? | ❒ None | ❒ 1–3 | ❒ 4–10 | ❒ 11–30 | ❒ over 30 |
| 18. Does your child put two words together (for example, *more cookie*, *bye bye Daddy*)? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| **Understanding** | | | | | |
| 19. When you call your child's name, does he/she respond by looking or turning toward you? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 20. About how many different words or phrases does your child understand without gestures? For example, if you say "where's your tummy," "where's Daddy," "give me the ball," or "come here," without showing or pointing, your child will respond appropriately. | ❒ None | ❒ 1–3 | ❒ 4–10 | ❒ 11–30 | ❒ over 30 |
| **Object Use** | | | | | |
| 21. Does your child show interest in playing with a variety of objects? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |
| 22. About how many of the following objects does your child use appropriately: cup, bottle, bowl, spoon, comb or brush, toothbrush, washcloth, ball, toy vehicle, toy telephone? | ❒ None | ❒ 1–2 | ❒ 3–4 | ❒ 5–8 | ❒ over 8 |
| 23. About how many blocks (or rings) does your child stack? **Stacks** | ❒ None | ❒ 2 blocks | ❒ 3–4 blocks | ❒ 5 or more | |
| 24. Does your child pretend to play with toys (for example, feed a stuffed animal, put a doll to sleep, put an animal figure in a vehicle)? | | ❒ Not Yet | ❒ Sometimes | ❒ Often | |

**Do you have any concerns about your child's development?** ❒ **yes** ❒ **no** **If yes, please describe on back.**

Appendix C. Communicative and Symbolic Behavior Scale Developmental Profile

Cut-off Scores

CSBS DP Communication and Symbolic Behavior Scales Developmental Profile™

## Cut-off Scores for the CSBS DP Infant-Toddler Checklist

| | | COMPOSITES | | | TOTAL |
|---|---|---|---|---|---|
| | | Social | Speech | Symbolic | |
| **6 months** | ***No Concern*** | 8 to 26 | 2 to 14 | 3 to 17 | 13 to 57 |
| | ***Concern*** | 0 to 7 | 0 to 1 | 0 to 2 | 0 to 12 |
| **7 months** | ***No Concern*** | 8 to 26 | 2 to 14 | 3 to 17 | 14 to 57 |
| | ***Concern*** | 0 to 7 | 0 to 1 | 0 to 2 | 0 to 13 |
| **8 months** | ***No Concern*** | 8 to 26 | 4 to 14 | 4 to 17 | 16 to 57 |
| | ***Concern*** | 0 to 7 | 0 to 3 | 0 to 3 | 0 to 15 |
| **9 months** | ***No Concern*** | 9 to 26 | 4 to 14 | 4 to 17 | 18 to 57 |
| | ***Concern*** | 0 to 8 | 0 to 3 | 0 to 3 | 0 to 17 |
| **10 months** | ***No Concern*** | 12 to 26 | 5 to 14 | 5 to 17 | 23 to 57 |
| | ***Concern*** | 0 to 11 | 0 to 4 | 0 to 4 | 0 to 22 |
| **11 months** | ***No Concern*** | 13 to 26 | 5 to 14 | 6 to 17 | 25 to 57 |
| | ***Concern*** | 0 to 12 | 0 to 4 | 0 to 5 | 0 to 24 |
| **12 months** | ***No Concern*** | 14 to 26 | 6 to 14 | 7 to 17 | 28 to 57 |
| | ***Concern*** | 0 to 13 | 0 to 5 | 0 to 6 | 0 to 27 |
| **13 months** | ***No Concern*** | 15 to 26 | 6 to 14 | 8 to 17 | 29 to 57 |
| | ***Concern*** | 0 to 14 | 0 to 5 | 0 to 7 | 0 to 28 |
| **14 months** | ***No Concern*** | 16 to 26 | 7 to 14 | 9 to 17 | 33 to 57 |
| | ***Concern*** | 0 to 15 | 0 to 6 | 0 to 8 | 0 to 32 |
| **15 months** | ***No Concern*** | 18 to 26 | 7 to 14 | 10 to 17 | 35 to 57 |
| | ***Concern*** | 0 to 17 | 0 to 6 | 0 to 9 | 0 to 34 |
| **16 months** | ***No Concern*** | 18 to 26 | 7 to 14 | 11 to 17 | 36 to 57 |
| | ***Concern*** | 0 to 17 | 0 to 6 | 0 to 10 | 0 to 35 |
| **17 months** | ***No Concern*** | 18 to 26 | 7 to 14 | 11 to 17 | 37 to 57 |
| | ***Concern*** | 0 to 17 | 0 to 6 | 0 to 10 | 0 to 36 |
| **18 months** | ***No Concern*** | 18 to 26 | 8 to 14 | 11 to 17 | 38 to 57 |
| | ***Concern*** | 0 to 17 | 0 to 7 | 0 to 10 | 0 to 37 |
| **19 months** | ***No Concern*** | 18 to 26 | 8 to 14 | 11 to 17 | 38 to 57 |
| | ***Concern*** | 0 to 17 | 0 to 7 | 0 to 10 | 0 to 37 |
| **20 months** | ***No Concern*** | 19 to 26 | 8 to 14 | 12 to 17 | 39 to 57 |
| | ***Concern*** | 0 to 18 | 0 to 7 | 0 to 11 | 0 to 38 |
| **21 months** | ***No Concern*** | 19 to 26 | 9 to 14 | 12 to 17 | 40 to 57 |
| | ***Concern*** | 0 to 18 | 0 to 8 | 0 to 11 | 0 to 39 |
| **22 months** | ***No Concern*** | 19 to 26 | 9 to 14 | 12 to 17 | 40 to 57 |
| | ***Concern*** | 0 to 18 | 0 to 8 | 0 to 11 | 0 to 39 |
| **23 months** | ***No Concern*** | 19 to 26 | 9 to 14 | 13 to 17 | 42 to 57 |
| | ***Concern*** | 0 to 18 | 0 to 8 | 0 to 12 | 0 to 41 |
| **24 months** | ***No Concern*** | 19 to 26 | 10 to 14 | 13 to 17 | 42 to 57 |
| | ***Concern*** | 0 to 18 | 0 to 9 | 0 to 12 | 0 to 41 |
| | | **Social** | **Speech** | **Symbolic** | **TOTAL** |

# Appendix D. Home Screening Questionnaire: 0-3 years

Child's Name____________ Birthdate________ Age________

Parent's Name____________ Phone No.________

Address____________ Date________

## HOME SCREENING QUESTIONNAIRE
Ages 0-3 Years

Please answer all of the following questions about how your child's time is spent and some of the activities of your family. On some questions, you may want to check more than one blank.

FOR OFFICE USE ONLY

1. How often do you and your child see relatives?
   ____never
   ____at least once a year
   ____at least 6 times a year
   ____at least once a month
   ____at least once a week

2. Do you subscribe to any magazines? YES NO If yes, what kind?
   ____home and family magazines
   ____news magazines
   ____children's magazines
   ____other

3. About how many hours each day does your child spend in a playpen, jump-chair, infant swing or infant seat?
   ____none
   ____up to 1 hour
   ____1 to 3 hours
   ____more than 3 hours

4. Does your child have a toybox or other special place where he/she keeps his/her toys? YES NO

5. How many children's books does your child have of his/her own?
   ____0: too young
   ____1 or 2
   ____3 or 4
   ____5-9
   ____10 or more

6. How many books do you own?
   ____0-9
   ____10-20
   ____more than 20

   Where do you keep them?
   ____in boxes
   ____on a bookcase
   ____other -- explain ________

FOR OFFICE USE ONLY

7. How often does someone take your child into a grocery store?
   ____hardly ever; prefer to go alone
   ____at least once a month
   ____at least twice a month
   ____at least once a week

8. How many different babysitters or day care centers have you used in the past three months?________

9. Do you have any pets? YES NO (include dog, cat, fish, birds, etc.)

10. About how many times in the past week did you have to spank or slap your child to get him/her to mind?
    ________

11. Did you start talking to your child when he/she was
    ____0-3 months?
    ____3-9 months?
    ____9-15 months?
    ____when he/she was old enough to understand?

12. Most of the time do you feel that your child
    ____is usually smiling and pleasant
    ____prefers to be by himself/herself
    ____responds readily to affection
    ____gets angry when he/she doesn't get his/her way
    ____is often cranky

13. Do you talk to your child as you are doing the housework? YES NO TOO YOUNG

FOR OFFICE USE ONLY

14. When your child gets a new toy do you usually
    ____explore it with him/her?
    ____let him/her explore it on his/her own
    ____save it for a special occasion?

15. How often does someone read stories or show pictures to your child?
    ____hardly ever
    ____once or twice a month
    ____at least once a week
    ____at least 3 times a week
    ____at least 5 times a week

16. What do you usually do when your child gets bored?
    ____give him/her a cookie or something to eat
    ____put him/her to bed for a nap
    ____offer him/her a toy
    ____encourage him/her to keep himself/herself busy
    ____play with him/her

17. Which of the following do you let your child play with?
    ____water ____food
    ____mud ____fingerpaints
    ____dirt ____none of the above
    ____sand

18. How often does your child eat a meal at the table (or sit at the table during a meal) with both mother and father (or father figure)?
    ____never
    ____at least once a month
    ____at least once a week
    ____at least 3 or 4 times a week
    ____at least once a day

19. Do you have any plants in your house? YES NO

20. About how often do you take your child to the doctor? ____________

21. Do you have any friends with children about the same age as your child? YES NO

22. Do you sometimes try new recipes that you find in the newspaper or in magazines? YES NO

FOR OFFICE USE ONLY

23. Does the father (or other adult male) provide some caregiving (such as babysitting, feeding, putting to bed, etc.) for the child? YES NO If Yes, how often?
    ____at least once a month
    ____at least once a week
    ____at least 3 or 4 times a week
    ____everyday

24. How often does your child get out of the house (backyard, for a walk, to the store, etc.)?
    ____at least once a month
    ____at least once a week
    ____at least 4 times a week
    ____at least once a day

25. Check the things which you (or other adult or older child in the home) have helped your child to learn.
    ____rolling over
    ____crawling
    ____feeding himself/herself
    ____walking
    ____colors
    ____saying new words
    ____song, prayers, or nursery rhymes
    ____none of the above
    Other:____________

26. Is anyone in the family presently taking a class at the college level? YES NO

27. Who does the grocery shopping for your family? ____________

28. Most of the decisions about how the family income is to be spent are made by
    ____Mother ____Grandparent
    ____Father ____Friend
    ____Mother and Father

29. How often do you actively play with your child at this age?
    ____hardly ever; too young
    ____at least once a week
    ____at least 3 or 4 times a week
    ____everyday

30. Do you have a T.V.? YES NO
    a) About how many hours is the T.V. on each day? ______
    b) About how many hours does your child watch T.V. each day? ______

We are interested in finding out what kinds of toys children have in their homes. The items listed below are for children of different ages.

PLEASE CHECK ANY OF THE FOLLOWING THAT YOU HAVE IN YOUR HOME AND THAT YOUR CHILD IS ALLOWED TO PLAY WITH. DO NOT CHECK THE ONES THAT YOU DO NOT HAVE NOW OR ONES THAT ARE BROKEN.

WE DO NOT EXPECT A CHILD TO HAVE ALL OF THESE ITEMS.

1. ____dolls with clothes or paper dolls
2. ____stuffed animals, animal toys or animal books
3. ____dress-up clothes or costumes
4. ____tricycle, bicycle or scooter
5. ____stroller or walker
6. ____wagon
7. ____Big Wheel or child-size car
8. ____pull or push toy
9. ____mobile
10. ____child-size furniture
11. ____high chair
12. ____playpen
13. ____puzzles - at least three
14. ____alphabet toy, alphabet game or alphabet book
15. ____number toy, number game or number book
16. ____coloring book
17. ____dot-to-dot or color-by-number book
18. ____scissors
19. ____pegboard
20. ____toy telephone
21. ____plastic snap-together beads
22. ____musical toys or music box
23. ____children's books
24. ____ball
25. ____shape ball or box
26. ____crib gym
27. ____jumpseat or door swing
28. ____squeeze toys
29. ____rattles
30. ____T.V.
31. ____Busy Box
32. ____gun
33. ____clay or play dough
34. ____real or toy musical instruments
35. ____sand box
36. ____homemade building toys
37. ____blocks
38. ____Tinker Toys, Lego or Lincoln Logs
39. ____record player
40. ____children's records
41. ____chalkboard
42. ____swings
43. ____jungle gym
44. ____car, truck or train
45. ____measuring cups
46. ____pots and pans
47. ____toy dishes
48. ____doll carriage
49. ____plastic tools and workbench
50. ____crayons, paints or pencils

*FOR OFFICE USE ONLY*

See the HSQ Reference Manual for scoring instructions.

Questions Subtotal ____________

Toy Checklist Subtotal _________

TOTAL HSQ SCORE __________

HSQ Results ____________________

Scorer's Name ___________________________

# Appendix E. Feeding Assessment Observations

Participant number: _______________ Age: _______________ Date: _________________

*Rooting reflex*
Turn head to source of food Observed / Not observed

| | | | | |
|---|---|---|---|---|
| Symbolic planning (Intentionality) | Infant cries for food | Observed / Not observed / Unsure | | |
| Sensorimotor planning | Liquids observed<br>Presentation<br><br>* Temperature<br>* Teat flow | Thin L / Thick L / Nil<br>Breast / Bottle / Spout cup<br>Open cup / Straw / Other<br>Cold / Room / Warm / Hot / Unsure N/A<br>Slow / Med / Fast / Variable /Unsure N/A | Solids observed<br><br><br>* Presentation<br>* Temperature<br>Taste | Puree / Thicken P / Lumpy P / Mixed<br>Soft FF / Hard FF / Chewy FF /<br>Nil / N/A<br>Spoon / Finger food / N/A<br>Cold / Room / Warm / Hot/ Unsure N/A<br>Sweet / Savoury / Bland / Other |
| Motor programming | Gagging<br>Coughing<br>Gurgling<br>Breathiness | Y / N / Unsure<br>Y / N / Unsure<br>Y / N / Unsure<br>Y / N / Unsure | Gagging<br>Coughing<br>Gurgling<br>Breathiness | Y / N / Unsure<br>Y / N / Unsure<br>Y / N / Unsure<br>Y / N / Unsure |
| Execution | Lip seal<br>Mouth open<br>Tongue for teat<br>Teeth | Sealed / Leak / L/R/Both<br>Y / N / N/A<br>Bottom lip / Not observed / N/A<br>Lower CI / Upper CI / Not observed N/A | Lip seal<br>Mouth open for spoon | Sealed / Leak / L/R/Both<br>Y / N / N/A |
| | Duration of feed observed: ____ minutes | | Duration of feed observed: ____ minutes | |

Total duration of feed observed: _____ minutes

* - Ask parent/s during observation

# Appendix F. Feeding Assessment Questionnaire

Participant number: __________Age: ___________ Date: ___________

1. Does he/she cry to when he/she is hungry?

Never — Consistently

a. How confident are you about this answer?

Very unsure — Very sure

2. Does he/she turn his/her head to bottle/breast before feeding?

Never — Consistently

a. How confident are you about this answer?

Very unsure — Very sure

3. When touched around mouth, does he/she start to suck?

Never — Consistently

a. How confident are you about this answer?

Very unsure — Very sure

**Drinks**

4. What texture drinks does he/she drink? Thin L / Thick L / Nil
5. Can he/she drink from ___? Breast / Bottle / Spout cup / Open cup / Straw / Other
6. What texture drinks does he/she prefer? Thin L / Thick L

a. How confident are you about this answer?

Very unsure — Very sure

7. What temperature drinks does he/she prefer? Cold / Room / Warm / Hot

a. How confident are you about this answer?

Very unsure — Very sure

**Food**

8. What texture food/s has he/she tried? Puree / Thicken P / Lumpy P Soft FF / Hard FF / Chewy FF / None / N/A
9. Can he/she eat from ____? Spoon / Finger food / N/A
10. What texture food does he/she prefer? Puree / Thicken P / Lumpy P Soft FF / Hard FF / Chewy FF / None / N/A

a. How confident are you about this answer?

Very unsure — Very sure

11. What taste food does he/she prefer? Sweet / Savoury / Bland / Other / N/A

a. How confident are you about this answer?

Very unsure — Very sure

12. What temperature food does he/she prefer? Cold / Room / Warm / Hot /N/A

a. How confident are you about this answer?

Very unsure — Very sure

| | |
|---|---|
| 13. 1 Does he/she gag on certain food? | N/A<br>Never ___ Consistently |
| a. How confident are you about this answer? | Very unsure ___ Very sure |
| 13.2 Does he/she gag on certain drinks? | Never ___ Consistently |
| a. How confident are you about this answer? | Very unsure ___ Very sure |
| 14.1 Does he/she cough on certain food? | N/A<br>Never ___ Consistently |
| a. How confident are you about this answer? | Very unsure ___ Very sure |
| 14.2 Does he/she cough on certain drinks? | Never ___ Consistently |
| a. How confident are you about this answer? | Very unsure ___ Very sure |
| 15. 1 Does he/she sound gurgly during and after food? | N/A<br>Never ___ Consistently |
| a. How confident are you about this answer? | Very unsure ___ Very sure |
| 15. 2 Does he/she sound gurgly during and after drinks? | Never ___ Consistently |
| a. How confident are you about this answer? | Very unsure ___ Very sure |
| 16.1 Does he/she sound more breathy after food? | N/A<br>Never ___ Consistently |
| a. How confident are you about this answer? | Very unsure ___ Very sure |
| 16.2 Does he/she sound more breathy after drink? | Never ___ Consistently |
| a. How confident are you about this answer? | Very unsure ___ Very sure |

17. Does he/she open his/her mouth for food/drink?

Never Consistently

a. How confident are you about this answer?

Very unsure Very sure

18. Does he/she have teeth? Y / N If yes, how many? _____
a. How confident are you about this answer?

Very unsure Very sure

19. Do you think he/she is teething? Y / N

a. How confident are you about this answer?

Very unsure Very sure

20. What is the average time for his/her bottle/breast feeds? _______ Minutes
a. How confident are you about this answer?

Very unsure Very sure

21. How many bottle/breast feeds does he/she have each day? _______
a. How confident are you about this answer?

Very unsure Very sure

22. How much fluid does he/she drink most days? N/A _______ Milliliters
a. How confident are you about this answer?

Very unsure Very sure

23. What is the average time for his/her solid feeds? N/A _______ Minutes
a. How confident are you about this answer?

Very unsure Very sure

24. How many solid feeds does he/she have each day? N/A _______
a. How confident are you about this answer?

Very unsure Very sure

25. How much solids does he/she eat most days? N/A _______ Grams
a. How confident are you about this answer?

Very unsure Very sure
Very sure

Appendix G. Initial Questionnaire

## Infant Development

*Background information*
Surname: First name:
Est DOB: DOB:
Gender:

*Birth details*
Weight: Height:
Head circ: Apgars: 1 5

*Current details*
Weight: Height:
Date taken:

*Medical details*
Ventilation: Y/N Days:
IVH: Y/N Grade:
NEC: Y/N
RDS: Y/N
BPD: Y/N

*Feeding details*
At birth Non-oral/Oral/Combination
(If oral) Breast/Bottle/Other

Age oral feeds introduced: ___ days/weeks
Full oral feeds achieved: ___ days/weeks

Seen for feeding assessment/therapy? Y/N
Location: PMH/KEMH/Other: ________
Service: Assessment/Therapy/Other: __
Provider: SP/OT/PT/Lactation consultant/ Midwife/Other: ____
Number of sessions:
Est. time of sessions: mins

## Maternal Factors

*Family details*
Marital status:
Married/Defacto/Single/Other:____
Mother's age: Father's age:
Children: Y/N Ages:

*Pregnancy details*
Previous pregnancies: Y/N Number:
Medical & pregnancy history:
- Medication Y/N
Type:

*Birth details*
Delivery method: Vaginal/Caesarean
Baby position: Normal/Breech/Other: ____
Instruments used: Nil/Vacuum/Forceps/Other:
Complications: Nil/Haemorrhage/High blood pressure/Other: _
Medications: Y/N Type:

*Post natal details*
Post natal depression: Y/N Treatment:

*Language*
Primary language: English
Other language: _________

*Education & Geography*
M - Education: Yr 10/Yr 12/TAFE/ Undergrad/Postgraduate/PhD
Employment: F/T, P/T, Casual, Nil
F - Education: Yr 10/Yr 12/TAFE/ Undergrad/Postgraduate/PhD
Employment: F/T, P/T, Casual/Nil
Postcode: ______

## Environmental Factors

*At Birth*
No. days in intensive care:
No. days in special care:
Family/friends/relatives visits ___/day or week

*At Home*
Number of adults at home:
Number of children at home:

# Appendix H. Information Sheet

## PURPOSE

This sheet contains information about the study on feeding and communication in babies from birth to their first birthday.

## PROJECT AIMS

1. To see how feeding and communication skills develop in babies born prematurely and those born at term.
2. To investigate whether early feeding skills affect communication (speech and language) skills.

## PARTICIPANTS

A member of the research team will visit you and your baby for a single visit or four visits 1-2 weeks after birth, then at 4, 8 and 12 months post term age. The visit will last for ~1-1½ hours. You must live within the Perth metropolitan area to be eligible for the study. The researcher will collect information on your pregnancy, your baby's birth and development. They will observe and videotape your babies eating and drinking skills during breast or bottle-feeding, and eating solids in older children. They will also observe your babies communication skills during mealtimes. Your participation is completely voluntary, and you may withdrawal at any time without prejudice or negative consequences. If you choose not to participate in this study, the care of you and your baby and your access to other services will not be affected.

## CONFIDENTIALITY

If you take part in the study, you and your child's details will remain confidential. The research team will require access to some on your child's details, e.g. your child's date of birth, expected birth date, birth weight, birth height and head circumference details from your child's yellow health book or medical chart. All information will be kept in a locked cupboard during the project. After the project, all information identifying your child (name, date of birth and contact details) will be destroyed. The Chief Investigator will keep other data from the study in a secure place for a period of 7 years. After this time, it will be destroyed.

## ETHICAL CONSIDERATIONS

The KEMH/PMH Scientific Advisory Committee, Ethics Committee and Curtin University of Technology Human Research Ethics Committee have approved this project. Should you wish to discuss the ethical basis of this project, please contact the Secretary of the Human Research Ethics Committee at Curtin University on 9266 2784 or email t.lerch@curtin.edu.au

## FURTHER INFORMATION

If you would like further information regarding the project, please contact Sharon Massey (Chief Investigator) on 9266 3437, Kathryn Hird from Curtin University on 9266 3473 or Karen Simmer from King Edward Memorial Hospital on 9340 2050.

# Appendix I. Consent Form

I ……………………………………………………….. have read the information explaining

(Given Name) (Surname)

the study entitled 'The Relationship between Early Feeding and Communication Development in Preterm and Term Infants: Birth to 12 months'.

I have read and understood the information given to me. Any questions I have asked have been answered to my satisfaction. I agree to allow

………………………………………………………………………………………………
……

(Full name of child and relationship of child to you)

to participate in the study and to be videotaped as part of the project.

☐ *Please tick if you allow the videotape or photos to be used for research and education purposes.*

I understand my child may withdraw from the study at any stage and withdrawal will not interfere with routine care.

I agree that research data gathered from the results of this study may be published, provided that names are not used.

Dated ………………… day of …………………………………….. 20 …………...

Parent or Guardian's Signature …………………………………………..

I …………………………………………….. have explained the above to the signatories

(Chief Investigator's full name)

who stated that he/she understood the same.

Signature ……………………………………………. Date …………………………………….

# Appendix J. Contact Details

Surname: ____________________________________

Child's name: ____________________________________

Parent/Guardian's name: __________________________

Relation to child: ____________________________________

Home Address: ____________________________________

____________________________________

____________________________________

Home phone no: ____________________________________

Work phone no: ____________________________________

Mobile phone no: ____________________________________

Do you intend moving from this address within the next 12 months?

YES / NO (please circle)

New Address: ____________________________________

____________________________________

____________________________________

Home phone no: ____________________________________

Work phone no: ____________________________________

Mobile phone no: ____________________________________

Do you have preferred days/times for the research team to visit your child?

YES / NO (please specify)

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

# Appendix K. Ethical Considerations

## Ethical Issues

Ethical approval was granted by Curtin University of Technology Human Research Ethics Committee, and the Women and Children's Health Service Human Ethics Committee. Given that this was an observational study of infant behaviours, there were no advantages or disadvantages for the participants. If the research team identified feeding or communication problems in a term infant, the Chief Investigator will notify the infant's parents who will be advised to obtain a referral from their general practitioner for a referral to their local community clinic. If difficulties are identified in a preterm infant, the coordinators of the neonatal follow-up program (Dr Noel French & Ms Helen Benninger) will be contacted and a decision will be made in consultation with the infants' parents after discharge about the appropriate referral. The participant Information Sheet states that participation in the project is completely voluntary and the participant may withdraw from the study at any time without prejudice or negative consequences. It also states that if the participant does not participate in this study, their and their baby's care and access to other services will not be affected.

Following the data collection period, all identifiable information will be removed from analysis, e.g. names, addresses and the child's date of birth to ensure privacy and confidentiality of the children involved. Only non-identifiable information will be kept and used during data analysis, e.g. child's gestational age, chronological age, weight, height and outcome measures. Videotapes will be marked immediately following assessment. All contact details, personal information and video tapes collected during the study will be kept in a locked cupboard in the Ph D room in the Psychology Building at Curtin University. The Chief Investigator and Supervisor will be the only personnel with access to the locked cupboard. On completion of the project, data will be stored at Curtin University for a 7-year period.

Appendix L.  4 month developmental review

Participant no: ___________ Age: _________ Date: ______________

**Maternal**

Mother's health ______________________________

______________________________

______________________________

**Infant Development**

Child's health ______________________________

______________________________

______________________________

Feeding issues/changes ______________________________

______________________________

______________________________

Motor milestones:
Smiling ______________________________
Laughing ______________________________
Kick legs ______________________________
Lift head & chest ______________________________
Rolls front to back ______________________________
Grasps and plays with toes ______________________________
Swipes at dangling objects ______________________________
Plays with fingers ______________________________
Hold object ______________________________
Searches for sounds – turns head

**Environment**

Changes: ______________________________

______________________________

______________________________

**Other significant**

Changes: ______________________________

______________________________

______________________________

Weight: Length: Date taken:

Appendix M. 8 month developmental review

Participant no: ___________ Age: _________ Date: ______________

**Maternal**

Mother's health

**Infant Development**

Child's health

Feeding issues/changes

Motor milestones:

Rolls both ways (6 mo)

Grasps and plays with toes

Swipes at dangling objects

Plays with fingers

Hold object

Favours one hand (6 mo)

Sit with support (4 mo)

Sit without support (6 mo)

Reach for & hold objects (8 mo)

Crawling or bottom shuffling (8 mo)

Points (8 mo)

Pincer grip (8 mo)

**Environment**

Changes:

**Other significant**

Changes:

Weight: Length: Date taken:

Appendix N. 12 month developmental review

Participant no: ____________ Age: __________ Date: _______________

**Maternal**

Mother's health

**Infant Development**

Child's health

Feeding issues/changes

Motor milestones:

Crawling or bottom shuffling (8 mo)

Points (8 mo)

Pincer grip (8 mo)

Standing with support

Standing without support

Walking with support

Walking without support

**Environment**

Changes:

**Other significant**

Changes:

Weight: Length: Date taken:

Appendix O. Tables of efficiency on liquid and solid function and reflexes on the FAO and FAQ.

Table O1. *Duration in minutes of Liquid and Solid Observations, and Total Duration of Meal Time Observations for Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA*

| | *1-2 weeks CA* | | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|---|---|
| | Term | Preterm | Term | Preterm | Term | Preterm | Term | Preterm |
| Duration of liquid | n=6 | n=8 | n=6 | n=6 | n=5 | n=7 | n=5 | n=8 |
| observation in minutes | 13.50 (2.81) | 14.88 (0.35) | 5.83 (5.60) | 6.42 (5.62) | 1.60 (4.55) | 1.36 (1.28) | 1.00 (0.00) | 1.81 (2.12) |
| Duration of solid | n=0 | n=0 | n=4 | n=6 | n=7 | n=7 | n=6 | n=8 |
| observation in minutes | | | 13.50 (4.44) | 7.42 (3.71) | 15.00 (6.43) | 15.86 (4.45) | 13.00 (4.45) | 14.63 (8.24) |
| Total duration of feed in | n=6 | n=8 | n=7 | n=7 | n=7 | n=7 | n=7 | n=8 |
| minutes | 13.50 (2.81) | 14.88 (0.35) | 12.71 (6.60) | 12.07 (4.81) | 12.07 (4.81) | 16.29 (6.10) | 11.86 (6.23) | 16.44 (7.86) |

Mean score and standard deviation in brackets

Table O2. *Parent report: Duration, Frequency and Volume of Liquids on the FAQ for Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA*

| | *1-2 weeks CA* | | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|---|---|
| | Term | Preterm | Term | Preterm | Term | Preterm | Term | Preterm |
| Duration in | n=7 | n=8 | n=7 | n=8 | n=7 | n=8 | n=7 | n=8 |
| minutes | 40.36 (20.74) | 35.00 (14.14) | 19.61 (12.37) | 20.00 (6.29) | 10.86 (6.43) | 10.94 (4.21) | 6.71 (4.35) | 7.94 (7.39) |
| Number of | n=7 | n=8 | n=7 | n=8 | n=7 | n=8 | n=7 | n=8 |
| feeds in 24 hrs | 8.79 (1.80) | 7.5 (1.54) | 6.50 (2.26) | 6.25 (1.40) | 4.21 (1.32) | 4.13 (1.22) | 3.64 (0.63) | 4.50 (2.20) |
| Volume in | n=0 | n=4 | n=2 | n=5 | n=4 | n=5 | n=7 | n=8 |
| millilitres * | 0.00 (0.00) | 597.50 (109.66) | 750.00 (70.71) | 745.00 (423.88) | 730.00 (73.94) | 698.00 (327.52) | 746.43 (408.01) | 603.00 (317.44) |

Mean score and standard deviation in brackets

* For bottle-fed infants

Table O3. *Duration, Frequency and Volume of Solids on the FAQ for Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA*

| | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|
| | Term | Preterm | Term | Preterm | Term | Preterm |
| | n=4 | n=6 | n=7 | n=8 | n=7 | n=8 |
| Duration in minutes | 18.75 (8.54) | 19.17 (8.65) | 20.00 (11.46) | 10.56 (4.79) | 18.57 (8.77) | 15.00 (13.89) |
| Number of feeds in 24 hrs | 1.75 (0.96) | 1.86 (0.69) | 3.57 (0.73) | 3.50 (0.76) | 3.50 (1.04) | 4.31 (0.80) |
| Volume in millilitres | 120.00 (81.65) | 138.00 (153.08) | 360.00 (182.21) | 435.00 (262.02) | 490.00 (275.24) | 548.00 (164.90) |

Mean score and standard deviation in brackets

Table O4. *Descriptive Data for Infant Reflexes on the FAQ for Term and Preterm infants at 1-2 weeks, 4, 8 and 12 months CA*

| | *1-2 weeks CA* | | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|---|---|
| | Term<br>n=7 | Preterm<br>n=8 | Term<br>N=7 | Preterm<br>n=8 | Term<br>n=7 | Preterm<br>n=8 | Term<br>n=7 | Preterm<br>n=8 |
| Turn head to breast/bottle | 5.93 (0.17) | 5.78 (1.00) | 5.81 (0.50) | 5.64 (1.13) | 4.52 (2.09) | 6.05 (0.18) | 2.86 (2.77) | 4.41 (2.65) |
| Open mouth to touch around mouth | 5.18 (1.48) | 5.18 (1.12) | 4.06 (2.63) | 5.83 (0.44) | 1.70 (1.08) | 4.25 (2.64) | 0.68 (0.59) | 1.31 (2.38) |

Mean score and standard deviation in brackets

Appendix P. Tables of motor planning function on the FAO and FAQ

Table P1. *Type of Liquids Observed in Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA on the FAO*

| | *1-2 weeks CA** | | *4 months CA#* | | *8 months CA^* | | *12 months CA∞* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=6) | Preterm (n=8) | Term (n=6) | Preterm (n=7) | Term (n=5) | Preterm (n=7) | Term (n=5) | Preterm (n=8) |
| Thin liquids | 6 | 8 | 6 | 7 | 5 | 6 | 5 | 8 |
| Thick liquids | | | | | | 1 | | |
| Not applicable | | | | | | | | |

* One term infant was not observed feeding liquids at this assessment

# One term and one preterm infant were not observed drinking liquids

^ Two term infants and one preterm infant were not observed drinking liquids

∞ Two term infants were not observed drinking liquids

Table P2. *Presentation of Liquids Observed in Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA on the FAO*

| | *1-2 weeks CA** | | *4 months CA#* | | *8 months CA^* | | *12 months CA∞* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=6) | Preterm (n=8) | Term (n=6) | Preterm (n=7) | Term (n=5) | Preterm (n=7) | Term (n=5) | Preterm (n=8) |
| Breast feeding | 6 | 6 | 5 | 3 | | 1 | | |
| Bottle feeding | | 2 | 1 | 4 | 1 | 2 | 1 | 2 |
| Spout cup | | | | | 3 | 3 | 4 | 4 |
| Other | | | | | 1 | 1 | | 2 |

* One term infant was not observed feeding liquids at this assessment

# One term and one preterm infant were not observed drinking liquids

^ Two term infants and one preterm infant were not observed drinking liquids

∞ Two term infants were not observed drinking liquids

Table P3. *Temperature of Liquids Observed in Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA on the FAO*

| | *1-2 weeks CA** | | *4 months CA#* | | *8 months CA^* | | *12 months CA∞* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=6) | Preterm (n=8) | Term (n=6) | Preterm (n=7) | Term (n=5) | Preterm (n=7) | Term (n=5) | Preterm (n=8) |
| Cold | | | | | 3 | 4 | | 2 |
| Room | | | 1 | | 2 | 2 | 4 | 5 |
| Warm | | 2 | | 4 | | 1 | 1 | 1 |
| Not applicable | 6 | 6 | 5 | 3 | | | | |

* One term infant was not observed feeding liquids at this assessment

# One term and one preterm infant were not observed drinking liquids

^ Two term infants and one preterm infant were not observed drinking liquids

∞ Two term infants were not observed drinking liquids

Table P4. *Teat Flow Rate Observed in Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA on the FAO*

| | *1-2 weeks CA** | | *4 months CA#* | | *8 months CA^* | | *12 months CA∞* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=6) | Preterm (n=8) | Term (n=6) | Preterm (n=7) | Term (n=5) | Preterm (n=7) | Term (n=5) | Preterm (n=8) |
| Slow | | 2 | 1 | 3 | | | | |
| Medium | | | | 1 | | 3 | | |
| Fast | | | | | 1 | 1 | 1 | 2 |
| Unsure | | | | | 1 | | 1 | |
| Not applicable✶ | 6 | 6 | 5 | 3 | 3 | 3 | 3 | 6 |

* One term infant was not observed feeding liquids at this assessment

# One term and one preterm infant were not observed drinking liquids

^ Two term infants and one preterm infant were not observed drinking liquids

∞ Two term infants were not observed drinking liquids

✶ This includes infants who are breastfed or offered a spout cup where the flow rate cannot be measured

Table P5. *Type of Solids Observed in Term and Preterm Infants at 4, 8 and 12 months CA on the FAO*

| | *4 months CA** | | *8 months CA^* | | *12 months CA#* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=6) | Term (n=7) | Preterm (n=7) | Term (n=6) | Preterm (n=8) |
| Puree | 3 | 5 | 2 | 1 | | |
| Thick purees | 1 | | 1 | 1 | | 1 |
| Lumpy purees | | | 2 | | 2 | |
| Soft finger food | | 1 | | 3 | | 1 |
| Hard finger food | | | 1 | | 1 | |
| Chewy finger food | | | 1 | 3 | | 3 |
| Mixed textures | | | | | 3 | 3 |

* Four term and 6 preterm infants were observed eating solids

^ One preterm infant was observed drinking liquids only and not on solids at 8 months CA

# One term infant was observed drinking liquids only and not on solids at 12 months

Table P6. *Presentation of Solids Observed in Term and Preterm Infants at 4, 8 and 12 months CA on the FAO*

| | *4 months CA** | | *8 months CA^* | | *12 months CA#* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=6) | Term (n=7) | Preterm (n=7) | Term (n=6) | Preterm (n=8) |
| Spoon | 4 | 5 | 4 | 5 | 2 | 2 |
| Finger food | | 1 | 3 | 3 | 3 | 6 |
| Other | | | | | 1 | |

* Four term and 6 preterm infants were observed eating solids

^ One preterm infant was observed drinking liquids only and not on solids at 8 months CA

# One term infant was observed drinking liquids only, and not on solids at this assessment

Table P7. *Temperature of Solids Observed in Term and Preterm Infants at 4, 8 and 12 months CA on the FAO*

| | *4 months CA** | | *8 months CA^* | | *12 months CA#* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=6) | Term (n=7) | Preterm (n=7) | Term (n=6) | Preterm (n=8) |
| Cold | 1 | | | | | |
| Room | 3 | 6 | 4 | 5 | 4 | 5 |
| Warm | | | 3 | 2 | 2 | 3 |

* Four term and 6 preterm infants were observed eating solids

^ One preterm infant was observed drinking liquids only and not on solids at 8 months CA

# One term infant was observed drinking liquids only, and not on solids at this assessment

Table P8. *Solid Tastes Observed in Term and Preterm Infants at 4, 8 and 12 months CA on the FAO*

| | *4 months CA** | | *8 months CA^* | | *12 months CA#* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=6) | Term (n=7) | Preterm (n=7) | Term (n=6) | Preterm (n=8) |
| Sweet | 4 | 6 | 2 | 2 | | 1 |
| Savoury | | | 5 | 5 | 6 | 7 |

* Four term and 6 preterm infants were observed eating solids

^ One preterm infant was observed drinking liquids only and not on solids at 8 months CA

# One term infant was observed drinking liquids only, and not on solids at this assessment

Table P9. *Texture of Fluids Accepted by Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA on the FAQ*

| | *1-2 weeks* | | *4 months* | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Thin | 7 | 7 | 7 | 8 | 7 | 8 | 7 | 8 |
| Thick | | 1 | 0 | 1 | 3 | 4 | 3 | 6 |

Table P10. *Presentation of Fluids Reported by Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA on the FAQ*

| | *1-2 weeks* | | *4 months* | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Breast | 7 | 3 | 6 | 4 | 4 | 4 | 1 | 3 |
| Bottle | | 3 | 3 | 5 | 5 | 5 | 6 | 7 |
| Breast & bottle | | 2 | | | | | | |
| Spout cup | | | | 2 | 5 | 4 | 6 | 6 |
| Open cup | | | | | | 3 | 3 | 3 |
| Straw | | | | | | 2 | 2 | 5 |
| Other | | | 1 | 1 | | | 1 | 2 |

Table P11. *Liquid Temperature Preference of Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA on the FAQ*

| | *1-2 weeks* | | *4 months* | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Cold | 1 | | | | | | | |
| Room | 1 | 2 | 1 | 4 | 3 | 2 | 2 | 4 |
| Warm | 5 | 6 | 6 | 3 | 4 | 4 | 3 | |
| Hot | | | | 1 | | | | |
| No preference | | | | | | 2 | 2 | 4 |

Table P12. *Texture of Solids Accepted by Term and Preterm Infants at 4, 8 and 12 months CA on the FAQ*

| | *4 months** | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=7) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Puree | 4 | 7 | 7 | 8 | 7 | 8 |
| Thick purees | 1 | 4 | 7 | 8 | 7 | 8 |
| Lumpy purees | | 2 | 7 | 8 | 7 | 8 |
| Soft finger food | | 1 | 4 | 8 | 7 | 8 |
| Hard finger food | | | 3 | 4 | 7 | 8 |
| Chewy finger food | | | 1 | 1 | 4 | 5 |

* Four term and 7 preterm infants were reported to be eating solids

Table P13. *Presentation of Solids Reported for Term and Preterm Infants at 4, 8 and 12 months CA on the FAQ*

| | *4 months** | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=7) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Spoon feeds | 4 | 7 | 7 | 8 | 7 | 8 |
| Finger foods | | | 4 | 8 | 7 | 8 |

* Four term and 7 preterm infants were reported to be eating solids

Table P14. *Solid Texture Preference of Term and Preterm Infants at 4, 8 and 12 months CA on the FAQ*

| | *4 months** | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=7) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Puree | 3 | 5 | 3 | 3 | | 1 |
| Thick puree | | 2 | 3 | 2 | 1 | 3 |
| Lumpy puree | | | | 2 | | |
| Soft finger foods | | | | | 4 | 1 |
| Hard finger foods | | | 1 | 1 | 2 | 3 |
| Chewy finger foods | | | | | | |
| No preference | 1 | | | | | |

* Four term and 7 preterm infants were reported to be eating solids

Table P15. *Solid Temperature Preference of Term and Preterm Infants at 4, 8 and 12 months CA on the FAQ*

| | *4 months** | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=7) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Cold | 1 | | | | 1 | |
| Room | 1 | 2 | 5 | 1 | 2 | 2 |
| Warm | 1 | 5 | 1 | 7 | 2 | 6 |
| No preference | 1 | | 1 | | 2 | |

* Four term and 7 preterm infants were reported to be eating solids

Table P16. *Solid Taste Preference of Term and Preterm Infants at 4, 8 and 12 months CA on the FAQ*

| | *4 months** | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=7) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Sweet | 2 | 6 | 3 | 7 | 2 | 6 |
| Savoury | 1 | | 4 | | 3 | 2 |
| Bland | | 1 | | 1 | | |
| No preference | 1 | | | | 2 | |

* Four term and 7 preterm infants were reported to be eating solids

Table P17. *Gagging, Coughing, Gurgliness and Breathiness on Liquids of Term and Preterm Infants at 1-2 weeks, 4, 8 and 12 months CA on the FAQ*

| | *1-2 weeks CA* | | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Gagging | 1.79 (2.40) | 1.12 (2.40 | 0.79 (1.18) | 0.96 (1.15) | 0.47 (0.56) | 0.29 (0.44) | 1.03 (1.08) | 1.01 (2.09) |
| Coughing | 1.90 (1.30) | 0.52 (0.69) | 0.89 (0.84) | 0.95 (1.11) | 1.43 (1.80) | 0.45 (0.80) | 1.03 (0.58) | 0.32 (0.51) |
| Gurgling | 0.65 (0.61) | 1.82 (2.16) | 1.46 (2.16) | 0.72 (1.55) | 0.51 (0.54) | 0.76 (1.18) | 0.30 (0.14) | 0.33 (0.17) |
| Breathiness | 1.25 (1.25) | 2.24 (2.61) | 0.19 (0.11) | 0.58 (1.11) | 0.91 (1.24) | 0.14 (0.14) | 0.14 (0.08) | 0.33 (0.12) |

Mean score and standard deviation in brackets

Table P18. *Gagging, Coughing, Gurgliness and Breathiness on Solids of Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA on the FAQ*

| | *4 months** | | *8 months* | | *12 months* | |
|---|---|---|---|---|---|---|
| | Preterm (n=4) | Term (n=7) | Preterm (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Gagging | 1.54 (1.43) | 2.71 (2.42) | 3.37 (1.81) | 2.11 (1.66) | 0.99 (1.66) | 1.09 (1.12) |
| Coughing | 0.10 (0.00) | 0.22 (0.43) | 1.83 (2.18) | 0.35 (0.46) | 0.96 (1.05) | 0.32 (0.37) |
| Gurgliness | 0.65 (1.17) | 0.23 (0.26) | 1.17 (2.25) | 0.14 (0.13) | 0.16 (0.26) | 0.08 (0.07) |
| Breathiness | 0.08 (0.10) | 0.56 (1.21) | 0.99 (2.30) | 0.20 (0.29) | 0.23 (0.24) | 0.11 (0.16) |

Standard deviation in brackets

* Four term and 7 preterm infants were reported to be eating solids

Appendix Q. Parent confidence ratings on the FAQ

Table Q1. *Confidence Ratings by Parents for the Efficiency of Feeding on Liquids and Solids on the FAQ for Term and Preterm Infants at 4, 8, and 12 months CA*

| | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|
| | Term | Preterm | Term | Preterm | Term | Preterm |
| Liquids | n=2 | n=3 | n=0 | n=3 | n=2 | n=7 |
| | 65.33 (1.14) | 87.63 (18.16) | 0.00 (0.00) | 70.25 (22.44) | 84.95 (19.67) | 85.64 (14.53) |
| Solids | n=2 | n=3 | n=0 | n=3 | n=1 | n=6 |
| | 84.01 (18.44) | 95.16 (3.53) | 0.00 (0.00) | 89.78 (13.08) | 94.62 (0.00) | 95.79 (2.79) |

Table Q2. *Confidence Ratings by Parents for Rooting Reflex Behaviours on the FAQ for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA*

| | *1-2 weeks CA* | | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|---|---|
| | Term | Preterm | Term | Preterm | Term | Preterm | Term | Preterm |
| | (n=7) | (n=8) | (n=7) | (n=8) | (n=7) | (n=8) | (n=7) | (n=8) |
| Rooting reflex | 92.51 (7.24) | 94.76 (8.53) | 95.51 (5.51) | 95.97 (4.37) | 90.21 (9.55) | 96.27 (3.42) | 94.01 (3.95) | 91.23 (16.71) |

Mean score and standard deviation in brackets

Table Q3. *Confidence Ratings by Parents for Intentionality on the FAQ for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA*

| | *1-2 weeks CA* | | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Intentionality | 86.18 (17.52) | 89.34 (1.49) | 91.47 (9.48) | 92.40 (11.01) | 94.93 (6.28) | 94.96 (6.76) | 90.32 (9.08) | 96.37 (1.67) |

Mean score and standard deviation in brackets

Table Q4. *Confidence Ratings by Parents for Sensorimotor Planning of Liquids on the FAQ for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA*

| | *1-2 weeks CA* | | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) | Term (n=7) | Preterm (n=8) |
| Sensorimotor planning for liquids | 97.18 (3.99) | 99.08 (0.98) | 94.89 (4.44) | 97.98 (0.46) | 97.74 (2.64) | 96.17 (7.62) | 79.21 (20.38) | 81.22 (22.38) |

Mean score and standard deviation in brackets

Table Q5. *Confidence Ratings by Parents for Sensorimotor Planning on Solids on the FAQ for Term and Preterm Infants at 4, 8, and 12 months CA*

| | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|
| | Term (n=4) | Preterm (n=6) | Term (n=6) | Preterm (n=8) | Term (n=6) | Preterm (n=8) |
| Sensorimotor planning for solids | 95.16 (3.73) | 92.20 (9.19) | 74.96 (23.03) | 96.98 (3.21) | 66.22 (28.14) | 89.05 (14.78) |

Mean score and standard deviation in brackets

Table Q6. *Confidence Ratings by Parents for Motor Programming on Liquids on the FAQ for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA*

| | *1-2 weeks CA* | | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=7) | Term (n=7) | Preterm (n=7) | Term (n=7) | Preterm (n=8) | Term (n=6) | Preterm (n=8) |
| Motor programming on liquids | 89.60 (5.83) | 94.64 (7.08) | 95.42 (2.02) | 93.38 (11.19) | 95.82 (3.11) | 97.93 (1.96) | 97.28 (1.70) | 98.39 (1.49) |

Mean score and standard deviation in brackets

Table Q7. *Confidence Ratings by Parents of Motor Programming for Solids on the FAQ for Term and Preterm Infants at 4, 8, and 12 months CA*

| | *1-2 weeks CA* | | *4 months CA* | | *8 months CA* | | *12 months CA* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=7) | Term (n=7) | Preterm (n=7) | Term (n=7) | Preterm (n=8) | Term (n=6) | Preterm (n=8) |
| Motor programming on liquids | 89.60 (5.83) | 94.64 (7.08) | 95.42 (2.02) | 93.38 (11.19) | 95.82 (3.11) | 97.93 (1.96) | 97.28 (1.70) | 98.39 (1.49) |

Mean score and standard deviation in brackets

Table Q8. *Confidence Ratings by Parents for Execution on the FAQ for Term and Preterm Infants at 1-2 weeks, 4, 8, and 12 months CA.*

| | *1-2 weeks CA** | | *4 months CA* | | *8 months CA* | | *12 months CA^* | |
|---|---|---|---|---|---|---|---|---|
| | Term (n=7) | Preterm (n=7) | Term (n=7) | Preterm (n=4) | Term (n=6) | Preterm (n=5) | Term (n=6) | Preterm (n=7) |
| Execution | 96.35 (2.60) | 99.31 (0.74) | 91.97 (6.35) | 98.66 (1.28) | 94.76 (5.77) | 96.77 (5.73) | 96.68 (2.58) | 99.39 (0.65) |

Mean score and standard deviation in brackets

* Statistically significant difference between groups $t(12) = 2.897$, $p = 0.013$

^ Statistically significant difference between groups $t(11) = 2.693$, $p = 0.021$

Appendix R. Syntax to calculate cluster, composite and total scores on the CSBS DP

```
COMPUTE SocialComposite = csbs1 + csbs2 + csbs3 + csbs4 + csbs5 + csbs6 +
csbs7
  + csbs8 + csbs9 + csbs10 + csbs11 + csbs12 + csbs13 .
EXECUTE .
COMPUTE SpeechComposite = csbs14+ csbs15 + csbs16+ csbs19 + csbs20.
EXECUTE .
COMPUTE SymbolicComposite = csbs17+ csbs18 + csbs21+ csbs22 + csbs23 +
csbs24.
EXECUTE .
COMPUTE CSBSTotal = SocialComposite + SpeechComposite +
SymbolicComposite .
EXECUTE .
COMPUTE Emot_Gaze = csbs1 + csbs2 + csbs3 + csbs4 .
EXECUTE .
COMPUTE Comm = csbs5 + csbs6 + csbs7 + csbs8 .
EXECUTE .
COMPUTE Gest = csbs9 + csbs10 + csbs11 + csbs12 + csbs13 .
EXECUTE .
COMPUTE Sounds = csbs14 + csbs15 + csbs16 .
EXECUTE .
COMPUTE Underst = csbs17 + csbs18 .
EXECUTE .
COMPUTE Words = csbs19 + csbs20 .
EXECUTE .
COMPUTE Objects = csbs21 + csbs22 + csbs23 + csbs24 .
EXECUTE .
```