UNIVERSITY OF LIVERPOOL

Early feeding experiences, individual characteristics, and their impact on infant feeding outcomes.

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By

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LIST OF ABBREVIATIONS

EBF	Exclusively Breast feeding
EFF	Exclusively Formula Feeding
Combi	Combination feeding
LBIFS	Laboratory Based Infant Feeding Studies
NCAST	Nursing Child Assessment Satellite Training
NCAFS	Nursing Child Assessment Feeding Scale
FACS	Facial Action Coding System
FIBFECS	Feeding Infants: Behaviour and Facial Expression Coding System
CFQ	Child Feeding Questionnaire
PFSQ	Parental Feeding Styles Questionnaire
BEBQ	Baby Eating Behaviour Questionnaire
CEBQ	Child Eating Behaviour Questionnaire
ICQ	Infant Characteristics Questionnaire
VARSEEK	Variety Seeking Questionnaire
VAS	Visual Analogue Scale
BLW	Baby Led Weaning
PLW	Parent Led Weaning
IFS	Infant Feeding Survey
WHO	World Health Organization
ANOVA	Analysis of variance
ANCOVA	Analysis of covariance
RRR	Relative Risk Ratio
CI	Confidence Interval

ABSTRACT

Early life experiences impose long lasting effects on health and wellbeing. The early development of eating habits and flavour preferences associated with a healthy diet can help to extend and improve the quality of life. A variety of factors contribute to this process and the resulting early feeding choices have an impact on parents and infants alike. Initially, nutritional factors provide the key influence, with maternal diet affecting the flavour profile of amniotic fluid and breast milk. In doing so, these factors shape the type of flavours recognised as "familiar" and "safe" by the infant. Later parental behavioural inputs interact at different levels, and with an increasing influence, to further mould infants' and toddlers' eating related behaviours. This thesis aims to explore elements of the nutrition and behavioural inputs during early life by employing a bi-directional focus.

In a small-scale laboratory study comparing vegetable acceptance between breast-fed and formula-fed infants it was found, contrary to hypotheses that the intake of vegetable puree did not vary with milk feeding type. Maternal ratings of their infant's enjoyment of the vegetables were also comparable between the two groups. With the recognition that mothers likely use multiple means of assessing vegetable preference, the rationale for the enjoyment ratings applied was further explored. Two main categories of cues were derived 'explicit cues' and 'implicit cues, with the first most commonly applied. Finally, the potential for mother-infant interactions to provide insight into vegetable acceptance was explored. Results suggested that mothers might adjust their interactions with their baby during feeding depending on the food familiarity. However, outcomes should be considered with caution due to various methodological limitations and the small sample size.

The focus of subsequent research was guided by the methodological limitations identified in the laboratory based. The final online survey was targeted at weaning practices. Specifically, it demonstrated positive associations between the baby-led weaning approach and the use of health promoting parental feeding practices to achieve positive eating behaviour outcomes in toddlers. Although results were encouraging, as BLW is relatively contemporary in the literature, further research is required to explore the long-term benefits of this weaning method.

Chapter 1
Introduction

The central aim of this thesis is to explore how healthy food preferences develop during infancy (through both milk and complementary feeding periods) and how their development is influenced by maternal eating behaviour and neophobia, mother-infant interaction during feeding and parental feeding practices. This introductory chapter contextualizes later content by providing a narrative of project evolution before identifying the resulting research aims and questions. The subsequent literature review begins with an overview of the importance of early life nutrition to highlight the standing of the thesis' topic. It then progresses to provide an in depth exploration of the specific impact of flavour learning on the development of food preferences, before finally considering various factors that may also impact on nutritional experiences and resulting body weight, putting the present doctoral thesis in context.

1.1 LABORATORY STUDY

The present doctoral thesis was developed from a study that received PhD studentship funding from Liverpool Primary Care trust. The studentship intended to investigate the effects of early vegetable flavour exposure through breast milk on later vegetable acceptance and preference.

The study was initially designed as an intervention with both observational and questionnaire based outcomes during testing and aimed to replicate, enhance and generalise the results of previous research (Mennella, Jagnow, & Beauchamp, 2001). The protocol required the recruitment of exclusively breastfeeding mothers and contained at least five contact points with them, one during screening and four during testing. As the screening session occurred during the early postnatal period, the mothers were offered a home visit to aid convenience. The intervention phase of the study required participants to be randomly allocated to one of three groups, with one group being required to consume 300ml of carrot juice, the second to consume the same volume of mixed vegetable juice (V8) and the final group to consume 300ml of water 4 days a week for 3 weeks (a total of 12 exposures) from the second month of lactation. They were also required to keep a food diary during exposure days to ensure adherence to the protocol. Additionally, the protocol required participants to provide breastmilk samples for chemical analysis at baseline and after the exposure period. Testing was intended to occur four weeks after the introduction of solid foods (as defined by mothers). During testing sessions, mothers were provided with 4 different vegetable purees (carrot, spinach, broccoli, and cauliflower), one in each session, and these were administered in a counterbalanced order. Questionnaire measures of maternal and infant characteristics were also included in the study design. A follow up visit at 15 months was also planned to assess the long-term effects of the exposure. As such, the study required a substantial time commitment from mothers both in the early postnatal period but also the longer-term.

The choice of which vegetables to include in the testing sessions was based on the familiarity and palatability of the vegetables, their suitability for consumption during early weaning and whether they were present in the exposure drinks. Both carrot and spinach were contained within V8. Carrot was selected as a

"positive control" vegetable, as previous research has shown that infants whose mothers consumed carrot juice during the lactation period exhibited greater acceptance of carrot flavoured cereal (Mennella et al., 2001). Spinach was selected as an unfamiliar, unpalatable vegetable. Broccoli and cauliflower were not present in the V8 juice and were selected to test the potential generalizing effect of a mixed vegetable juice.

For the purposes of this study, the social eating laboratory of the University of Liverpool was converted to an infant feeding laboratory, specifically designed to hold the feeding sessions. It was prepared with the necessary equipment to hold an infant feeding session, including highchairs, a waterproof floor mat, an infant bodyweight scale and age appropriate toys. Additionally, the room was fitted with 3 dome cameras connected to a CCTV system which delivered high resolution recordings to the researcher in order to capture maternal and infant interactions and facial expressions for later analysis.

Recruitment was aided by advertisement of the study in family magazines as well as through links with SureStart children centres. However, during the recruitment process a few problems arose which resulted in an unanticipated high dropout rate and prevented the original project from continuing. As the intervention was designed to start relatively soon after birth (during the first 2 months of lactation) volunteers were asked to register their interest prenatally. The initial level of interest was encouragingly high. Yet, postnatally, many of the mothers who had expressed an interest in participating decided that taking part in the study required more time and commitment than originally expected. As such, for some mothers it was not realistic for the limited time available when adapting to a new baby, resulting in their withdrawal from the study. Other mothers who intended to exclusively breastfeed were not able to establish successful feeding at the time of screening, and were similarly unable to continue with the intervention protocol. Unforeseen complications during delivery or immediately after birth also prohibited a number of volunteers from continuing with their study participation.

In response to the recruitment issues encountered, the decision was made to simplify the study's protocol and revise the study's aims. Rather than examining the effect of early flavour exposure through breast milk, the focus of the laboratory study shifted to examining the impact of milk feeding practices (breast or formula feeding), mother-infant interactions during feeding and maternal traits on the intake and acceptance of novel/disliked (spinach, broccoli, cauliflower) and familiar/liked (carrot) vegetables. The revised aims were driven by the available scientific literature which demonstrated that the potential for breastfeeding alone (without supplemental flavour exposure) to facilitate acceptance of novel dietary flavours at weaning, compared to formula feeding, remained equivocal (Hausner, Nicklaus, Issanchou, Mølgaard, & Møller, 2010; Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007; Maier, Chabanet, Schaal, Leathwood, & Issanchou, 2008).

For this study, mothers who either exclusively breastfed or exclusively formula fed their infants were recruited and the testing protocol from the original study design was followed. Mothers who had enquired

about the initial study but were excluded because they were formula feeding from birth were contacted, informed of the new study design, and were given the opportunity to take part.

Reports with recruitment and dropout rates as well as the general progress of the project were provided to Liverpool Primary Care Trust for the whole duration of the studentship to ensure that the funding body was in agreement with the project changes.

1.2 Online study examining methods of introduction to solid foods

During the testing period of the laboratory study, several participants indicated that they were planning to follow, or were already following a new method of solid food introduction distinct from traditional puree-based methods called baby-led weaning (BLW). Through examination of the scientific literature, it was determined that the research related to baby-led weaning was limited. As such, participants who reportedly followed baby-led weaning practices were not excluded from the study and were invited to the laboratory for the testing sessions as normal. Upon observation of the feeding event, however, it was obvious that several infants who were identified as following baby-led weaning exhibited distinctively different behaviours than the remainder of the cohort. In particular, these infants appeared either uninterested in the spoon or abnormally agitated by its presence, pushing the spoon away even before tasting the vegetable puree offered on it. Retrospective inspection of the 3 day infant feeding logs that were provided by the mothers before each testing session clearly demonstrated that these infants had very little or no experience with feeding utensils, including spoons, being fed instead mostly or entirely finger foods. As a consequence of this marked change in infant behaviour, the coding scheme utilised to examine the interactions between mothers and infants during feeding events was considered inappropriate and unreliable. These mother-infant dyads were therefore excluded from the coding aspect.

Given the underexplored nature of BLW and the reported potential beneficial impact this approach has to influence the development of healthy food preferences, an online survey was designed to address gaps in the literature. Specifically, the survey explored the impact of expanding the categorisation of weaning approaches. Previous categorisations failed to distinguish between those who combine BLW and traditional spoon-fed approaches to weaning. As such, it was impossible to determine whether occasional spoon feeding could jeopardize the beneficial effects attributed to BLW or whether occasional finger foods could be beneficial to the longer term eating behaviour of a spoon-fed baby. The survey was also designed to examine whether parental feeding practices are associated with approaches utilised to introduce solid food. To date, BLW has only been linked with controlling feeding practices.

1.3 ONLINE STUDIES EXAMINING THE EMOTIONAL AND PRACTICAL EXPERIENCES THAT MOTHERS ASSOCIATE WITH MILK FEEDING.

The simplified study protocol that evolved from the original intervention study design for the current PhD was not exempt from recruitment related problems. In their vast majority, mothers who expressed an interest in taking part in the study followed health practitioner's recommended feeding practices with exclusive breastfeeding from birth and the intention to continue with this feeding method at least until the introduction of solid food and often beyond. On the contrary, mothers who exclusively formula fed from birth rarely expressed a desire to participate. Discussion of this problem with peers identified data from a qualitative study undertaken by another PhD student within the research group (Miss Victoria Fallon), which suggested that formula feeding mothers may be prone to guilt and feeling stigmatised and unsupported and, in turn, these feelings may dissuade them from participation. To expand on these findings, an online quantitative survey was designed with the aim of exploring the emotional and practical experiences of formula feeding mothers in more detail. The survey was designed, analysed, and written for publication in collaboration with Miss Victoria Fallon.

With the ongoing media debate related to breast feeding in public and the potential for stigmatisation of breast feeding mothers, a comparable survey was undertaken in a breast-feeding population. Again, the survey was analysed and written for publication in collaboration with Miss Victoria Fallon. As the relationship between these online studies and the main aim of the thesis is more diffuse, the publications derived from those two surveys are provided in the appendix.

1.4 RESEARCH AIMS AND QUESTIONS

As stated above, the overall aim of this doctoral thesis is to advance the understanding of factors that influence the development of healthy food choices in infants. Specifically, it examines the impact of early life experiences (milk feeding and introduction to solids), maternal characteristics (eating behaviour, trait neophobia), mother-infant interactions and parental feeding practices on later vegetable acceptance.

The research inquiry is driven by five key research questions developed through a combination of scientific literature and research experiences:

Q1. How do early life experiences (both milk feeding and the introduction of solid food) affect vegetable intake during the early weaning period?

Q2. What criteria do mothers use to assess food liking when feeding familiar and novel vegetables to their infants during the early weaning period?

Q3. How do maternal eating behaviours and neophobia impact on mother-infant interactions during feeding of familiar and novel vegetables during the early weaning period?

Q4. Do parental characteristics influence the approach used to introduce solid food during the early weaning period?

Q5. Does the approach used to introduce solid food have effects on eating behaviour and the liking of vegetables beyond infancy?

1.5 THESIS OUTLINE

Chapter 2 of the thesis provides a review of existing literature. It outlines the importance of early life dietary experiences before establishing the current level of understanding with regard to factors that are known to influence eating behaviour and resulting body weight during infancy and toddlerhood. The review provides the background that subsequent chapters build upon.

Chapter 3 details the methodological approaches, study designs and analytical methods employed throughout the thesis.

Chapter 4 reports the results of the simplified laboratory study, and answers to the first three research questions. Results are presented in four distinctive but inter-related sections. The first examines for differences in vegetable acceptance (in the absence of flavour supplementation) between i) infants with different milk feeding experiences (breast or formula milk) and ii) infants who experience different approaches to the introduction of solid food (experience with spoon, finger foods or mixed experience). The second part recognises the limitations of relying on one measure of acceptance (intake) and explores the criteria applied by mothers when making a judgement about their infant's food enjoyment and liking. The potential of using these criteria as measures of acceptance is discussed in the third part. In particular, the possibility of using mother-infant interactions as a means of examining preference is examined. In the final section, the influence of maternal characteristics, including eating behaviour and neophobia, on various characteristics of an eating event (perception of their infant's liking of a novel and a familiar vegetable such as actual intake of the vegetables). Due to the small scale of the study, the majority of the analysis is exploratory.

Chapters 5 and 6 progress from milk feeding to the weaning period and examine the relatively under-researched topic of baby led weaning (BLW) to answer questions 4 and 5 respectively. The current coarse classification of parents according to the extent they adopt BLW approaches is extended to address all weaning styles. Subsequently, the new categorisation is applied in a survey which extends earlier research in the field by combining previously used questionnaires with other validated measures to explore the relationship between parental characteristics, infant behaviours and the weaning practice followed.

The aim of chapter 7 is to synthesize all the experimental results and discusses their implications, perspectives, limitations and associated future research directions.

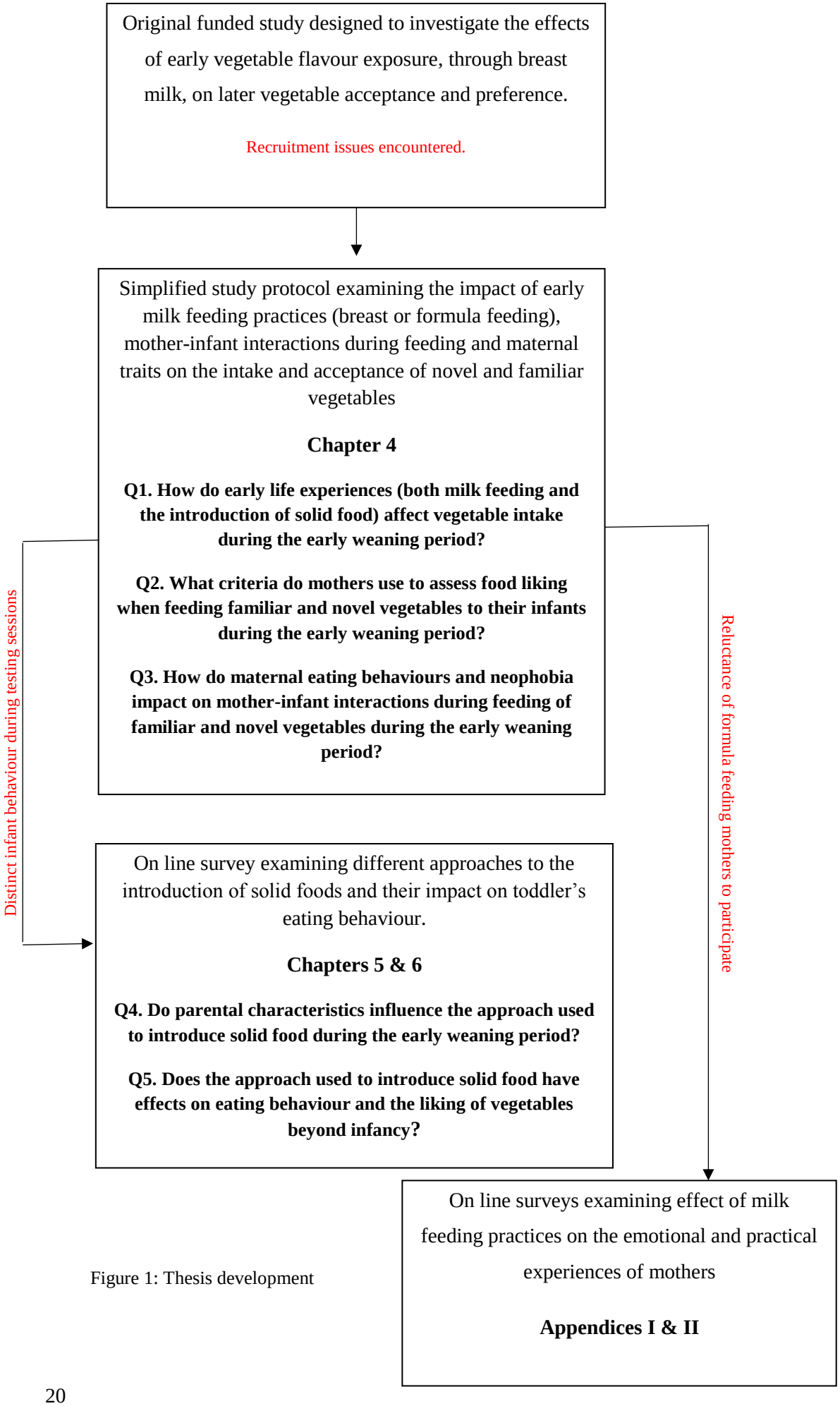

Figure 1: Thesis development

CHAPTER 2
LITERATURE REVIEW

2.1 THE IMPORTANCE OF EARLY LIFE NUTRITION

Historically, the main goal of early life nutrition was to provide sufficient nourishment for an infant's weight to meet pre-defined growth curves. However, with advances in understanding it is now recognised that nutrition and diet during early life can have a profound effect on wide ranging early life outcomes including growth and physical, cognitive and social development. Moreover, clear links between early life nutrition and later health and disease have also been established.

During pregnancy, expectant mothers are advised to follow a healthy balanced diet, defined as one that provides all the required macro and micro nutrients to achieve good health (both physical and mental), illness prevention and maintenance of a healthy weight. During this period, a particular focus is placed on sufficient but not excessive energy intake and the consumption of folic acid, vitamin D and iron is recommended. Postnatally, the World Health Organisation (WHO) recommends exclusive breastfeeding up to 6 months of age with continuation after the introduction of solid food for up to 2 years and beyond (WHO, 2003). The introduction of solid food is recommended from 6 months of age. Traditionally, mothers were advised to start introducing solid foods with starchy, energy dense foods such as rusks and infant cereal. However, in recent years there has been a shift to encourage mothers to offer vegetables first, with a focus on frequency and variety to help infants acquire a variety of sensory experiences (Chambers, 2016; Chambers et al., 2016). Even with the introduction of solid food, breast milk or formula is recommended as the main source of energy until about 12 months of age. Other notable dietary recommendations include avoiding the use of salt, honey and fresh cow's milk until the infant's first birthday.

Whilst a detailed analysis of the impact of early life nutrition is beyond the scope of this thesis, an overview is provided in the next sections to highlight the magnitude of its effect. A synopsis of the acute and longer term effects of early life nutrition on growth, development and physical health is provided. This is followed by a more extensive examination of potential pathways through which early life nutrition has been suggested to influence the development of flavour preferences, laying the foundations for future eating behaviour. Finally, the importance of other parental influences on the formation of eating habits and the determination of body weight in children is described at the end of the review.

2.1.1 ACUTE EFFECTS

2.1.1.1 GROWTH

Maternal diet and foetal nutrition has been shown to have great impact on birth weight and infant growth. Poor maternal nutrition, in particular, low energy, protein and iron intake, has been associated with low birth weight (a baby measuring less than the 10th percentile for gestational age, Kramer et al., 2001). On the other hand, nutrient over supply *in utero,* and more specifically gestational diabetes, or pre-existing type 2 diabetes increases the risk of macrosomia (a baby measuring more than the 10th percentile for gestational age Kramer et al., 2001), although the risk seems to decrease when elevated levels of glucose are under control throughout pregnancy (Leipold et al., 2005).

There are multiple implications of an infant born with either low or large birth weight for the immediate decisions that affect feeding. Low birth weight is associated with parental concern regarding the infant's growth and weight gain (Agras, Hammer, McNicholas, & Kraemer, 2004), and this concern is often apparent even later during childhood. Parents of low birth weight infants report feeling the need to ensure that their baby "catches up" to what is considered the average weight for their age. As breastfeeding fosters a less rapid weight gain, the typically consequence is for parents to deviate from WHO recommendations and to decide to introduce formula feeding in an attempt to increase the rate of weight gain (Redsell et al., 2010).

Infants born large for gestational age have a higher risk of hypoglycaemia during the first 2 hours of life (Hay & Rozance, 2010), although evidence suggest that glucose levels rise even in the absence of nutrient intake (Deshpande & Platt, 2005; Mitanchez et al., 2015). To prevent neonatal hypoglycaemia, frequent breastfeeding is recommended with formula only being provided as the last resort (Mitanchez, 2010). With studies on milk feeding practices concluding that breastfeeding initiation, exclusivity and extended duration provide a protective effect over excess weight gain during infancy (Agostoni et al., 1999; Kalies et al., 2005; Kramer et al., 2004; Lande et al., 2005), toddlerhood (Baird et al., 2008; Griffiths, Smeeth, Hawkins, Cole, & Dezateux, 2009) and early childhood (Grummer-Strawn, Mei, & Centers for Disease Control and Prevention Pediatric Nutrition Surveillance System, 2004) the relevance of this feeding recommendation for large babies is clear. However, mothers whose infants are more likely to develop hypoglycaemia already have risk factors associated with breastfeeding difficulties. As such, the potential for introduction of formula feeding remains high.

2.1.1.2 DEVELOPMENT

Physical and cognitive development are interdependent. Optimal brain and cognitive development is without a doubt imperative to reaching the best potential in life and it is predictive of later school performance (Clark, Pritchard, & Woodward, 2010; Tramontana, Hooper, & Selzer, 1988). Apart from the impact on foetal growth mentioned in the previous section, low birth weight, as a consequence of poor maternal diet and intrauterine nutrient restriction, has been also associated with delayed cognitive development later in life when compared to normal birth weight controls (Aylward, Pfeiffer, Wright, & Verhulst, 1989). Typically, this delay is more distinct in later rather than in early childhood and in children from lower socioeconomic backgrounds (Hack, Klein, & Taylor, 1995). However, with factors such as socioeconomic background, maternal education, nutrition and substance abuse being closely interlinked, research in this area can be biased if all of these relevant aspects are not carefully controlled for during the data analysis. Additionally, it is should be considered whether it is more important to take into account clinical significance, rather than statistical significance when selecting cognitive development measures for use in research (Aylward et al., 1989).

Studies around early life nutrition and cognitive development tend to focus on the impact of milk feeding. A meta-analysis of 20 studies, most of which controlled for covariates, showed that breastfeeding benefits cognitive development and this was measured using IQ scales, in toddlerhood in comparison to formula feeding and with pre-term infants deriving additional benefits (Anderson, Johnstone, & Remley, 1999). However, the ability of IQ scores to accurately measure cognitive function or development is debatable. Consistent with the issue identified above, any differences detected can be statistically significant but their clinical significance is often small. Additionally, more recent publications fail to conclude on the effect of breastfeeding on cognitive and brain development, mainly because variables such as exclusivity and duration are not consistently reported (Drane & Logemann, 2000; Jain et al., 2002; Rey, 2007). However, a small number of studies remain which show a beneficial effect of breastfeeding on brain and neuronal development (Lanting, Huisman, Boersma, Touwen, & Fidler, 1994; Lucas, Morley, Cole, Lister, & Leeson-Payne, 1992).

Specific nutrients, such as omega-3 fatty acids (Martinez, 1992; Schulzke, Patole, & Simmer, 2011) and iron (Akman et al., 2004; Idjradinata & Pollitt, 1993) have also been found to aid optimal brain development. Consequently, formula milk manufacturing has progressed over time by fortifying infant formula with the identified nutrients. However,

studies looking at the effects of fortified formulas report mixed outcomes (Auestad et al., 2001; Auestad et al., 2003; Makrides, Neumann, Simmer, & Gibson, 1999; Makrides, Neumann, Simmer, Gibson, & Pater, 1995; Sachdev, Gera, & Nestel, 2005; J. Williams et al., 1999), with the majority of the beneficial supplementation results identified only in preterm or nutrient deficient infants.

2.1.2 LONG LASTING EFFECTS

2.1.2.1 PHYSICAL HEALTH

Evidence suggests that the common rationale of needing to 'eat for two' during pregnancy can, in fact, be detrimental to the long term health of the baby, with disproportionate weight gain during pregnancy linked with development of cardiac and metabolic issues in adulthood. Birth weight can have lifelong consequences as the intrauterine environment can shape foetal metabolic programming. For example, low birth weight has been repeatedly associated with a number of chronic diseases such as glucose intolerance and type 2 diabetes, higher blood pressure and heart disease later in life (Abu-Saad & Fraser, 2010; Barker, 1996, 1995, 2006; Eriksson et al., 2000; Roseboom et al., 2006). High birth weight has also been associated with adverse effects later in life, namely, higher risk of type 2 diabetes and obesity (Oken & Gillman, 2003).

During early postnatal life, breastfeeding is associated with lower risk of childhood cancer, respiratory illnesses, otitis, non-specific gastroenteritis, atopic dermatitis, asthma, sudden infant death syndrome , diabetes and obesity (Chung et al., 2007; Davis, Savitz, & Graubard, 1988). In the longer-term, breastfeeding occurrence and duration has been shown to have a decreased mortality risk from ischemic heart disease (Fall et al., 1992), however, some evidence also show higher arterial distensibility (stiffness) in young adults (Leeson, Kattenhorn, Deanfield, & Lucas, 2001). Evidence relating to the impact of breastfeeding on total serum cholesterol levels are also conflicting (Fall et al., 1992; Horta, Loret de Mola, & Victora, 2015; Horta & Victora, 2013). Consequently, the role of breastfeeding on heart disease is still unclear. However, breastfeeding does appear to offer a protective effect over elevated levels of systolic and diastolic blood pressure (Horta & Victora, 2013), and the development of type 2 diabetes (Horta et al., 2015) .

Additionally, early life dietary and nutritional factors beyond milk feeding can also impact on long term physical health. A number of lines of evidence demonstrate that high sugar intake can result in increased risk of heart disease (Nicklas et al., 1987) and micronutrient deficiency (Ruottinen et al., 2008), while high salt intake early in infancy can result in high blood pressure during adolescence (Geleijnse et al., 1997).

2.1.2.2 GROWTH

A large number of studies provide evidence linking *in utero* metabolic programming with the development of obesity later in life. It has been suggested that *in utero* nutrient deprivation programmes the developing foetus for a similar environment postnatally (Barker & Osmond, 1986), by redistributing the basic metabolic energy requirements to sustain life. Evidence from the Dutch Famine Study reveals that the effects of energy restriction on later weight gain and obesity are actually more profound if the energy restriction happens during early gestation (Ravelli, van Der Meulen, Osmond, Barker, & Bleker, 1999; Ravelli, Stein, & Susser, 1976). While this is an evolutionary advantage when there is indeed a scarcity of food, it can lead to weight gain and being overweight and obese in later life in cases where there is an abundance of energy and nutrients available in the early postnatal period. This was the case after the Dutch Famine, that lasted only a few months during the winter of 1944-1945. However, evidence from the famine during the Lenningrad Siege that lasted significantly longer (1941–1944), and with food storage continuing after the Siege lifted, demonstrates that infants who are not exposed to an abundance of nutrients in early postnatal life do not have a "catch up" growth trajectory and do not exhibit the same later obesity pattern as the population affected by the Dutch Famine (Stanner & Yudkin, 2001).

In modern society, infants born with low birth weights are put at risk of following an excessive weight gain trajectory as a consequence of parental concern (Fildes et al., 2015) and the resulting overcompensation for small size at birth through provision of more energy than needed. This behaviour is fostered by a lack of definition for an overweight status in infants younger than 2 years of age, which directs parental concern to the clearly defined underweight status (Carnell, Edwards, Croker, Boniface, & Wardle, 2005; Dennison, Edmunds, Stratton, & Pruzek, 2006; Hager et al., 2012).

Similarly, in utero overnutrition can affect future growth in multiple ways. Research suggests that when the foetus is exposed to an oversupply of nutrients in the womb, the epigenetic gene expression adapts to this environment and it affects hypothalamic function (Sookoian, Gianotti, Burgueño, & Pirola, 2013). The hypothalamus plays a critical role in appetite control and individuals with impaired hypothalamic functioning experience issues with satiety responsiveness, excessive weight gain and obesity (Bialik, 2007; Swaab, 1997). A large body of evidence, including large prospective cohort studies, supports the suggestion (Crume, Ogden, West, et al., 2011; Gillman, Rifas-Shiman, Berkey, Field, & Colditz, 2003; Lawlor et al., 2010; Pettitt, Nelson, Saad, Bennett, & Knowler, 1993). However, one prospective study suggests that it is possible

that breastfeeding can have long term protective effects on adolescents who are born with an increased obesity risk due to impaired functioning and, specifically, maternal gestational diabetes (Crume, Ogden, Maligie, et al., 2011).

The outcomes from studies examining the longer term protective effects of breastfeeding on excessive weight gain are not as clear, but findings suggest that benefits persist until at least adolescence in lower socioeconomic status groups (Armstrong & Reilly, 2002; Elliott et al., 1997). The effect of breastfeeding on adult obesity and overweight status is largely underexplored by research, which is potentially due to its complicated nature and vast variety of confounding factors. One study did report that adults who were breastfed had lower BMI after adjustment for multiple variables (Parikh et al., 2009), however, implications are limited as breastfeeding was measured as a binary variable with no information on exclusivity or duration.

The mechanisms through which milk feeding practices influence excessive weight gain are multiple. Formula fed infants have greater protein and calorie intake until at least 6 months of age (de Bruin et al., 1998; Gunnarsdottir & Thorsdottir, 2003; Heinig et al., 1993; Köhler et al., 1984) which can contribute to more rapid weight gain. Among formula fed infants, weight gain during the first weeks of life can be predictive of obesity later in adulthood (Stettler et al., 2005), suggesting that rapid weight gain itself can impact on metabolic programming. Additionally, breastfeeding affords the infant the ability to control intake enabling the development of skills such as satiety responsiveness (Brown & Lee, 2012), which may aid with the regulation of food intake later in life.

The timing of solid food introduction and the type of food offered has also been associated with weight gain, at least in late infancy. Early food introduction, before the 4th month of age, has been repeatedly associated with greater infant weight gain, especially in non-breastfed infants (Baker, Michaelsen, Rasmussen, & Sørensen, 2004; Forsyth, Ogston, Clark, Florey, & Howie, 1993; Sloan, Gildea, Stewart, Sneddon, & Iwaniec, 2008). However the pattern is less clear after 18 months of age. While a number of studies fail to detect any associations in toddlerhood (Forsyth et al., 1993; Morgan, Lucas, & Fewtrell, 2004), breastfeeding for more than 4 months has been reported to have a protective effect on excessive weight gain in 3 year olds who were introduced to solids before 4 months of age (Huh et al., 2011).

2.2 DEVELOPMENT OF EATING HABITS - CRITICAL LEARNING WINDOWS

As previously shown, maternal nutrition and infant feeding choices have an impact on both the immediate and future health of the infant. These choices lay the foundations of both metabolic processes and eating habits. It is therefore important to foster positive eating behaviours at an early stage. Pregnancy and the first months of life provide a myriad of opportunities that can influence the development of healthy eating habits. The following section provides a review of some of those opportunities.

With the neurons and brain rapidly developing, the first years of life is a period with an abundance of learning opportunities that can have lifelong impact. There is convincing evidence for the existence of critical learning widows, which appear to be co-ordinated with periods of brain development. A number of these learning opportunities are related to the development of eating preferences and habits, with both pre and postnatal critical windows of food preference and eating habits development identified (Cooke et al., 2004; Mennella, Griffin, & Beauchamp, 2004; Mennella et al., 2001; Mennella, Lukasewycz, Castor, & Beauchamp, 2011; Schwartz, Chabanet, Lange, Issanchou, & Nicklaus, 2011; Schwartz, Issanchou, & Nicklaus, 2009). Some of these eating behaviours have been shown to persist in later life, even in adulthood (Coulthard, Harris, & Emmett, 2010; Möller, de Hoog, van Eijsden, Gemke, & Vrijkotte, 2013; Nicklas, Webber, & Berenson, 1991; Nicklaus, Boggio, Chabanet, & Issanchou, 2005; Skinner, Carruth, Bounds, Ziegler, & Reidy, 2002).

The most probable mechanistic explanation for the formation of taste preferences is the transmission of vital information from mothers to the foetus and, later on, to the infant, about flavours which constitute part of her usual diet. This provides a form of guidance with regard to foods that are safe for consumption. Unfamiliar flavours are considered uncommon and are therefore rejected.

Prenatally, the foetus experiences certain flavours through the amniotic fluid. While in uterus, the foetus' mouth and nostrils are usually filled with amniotic fluid within which are different flavour molecules which reflect the flavours of the mother's usual diet. These molecules provide the first sensory experience to the sensors in mouth and nose by chemically irritating them (Bautista et al., 2006, Liman, 2007). A number of studies have been shown that this exposure can affect odour and flavour preferences in both the early postnatal life (Schaal, 2000), and later on during solid feeding (Mennella et al., 2001).

Postnatally, two routes of early flavour exposure have been explored – milk feeding and weaning. Early infant feeding (milk feeding) before weaning contributes to flavour programming and whether breast or formula feeding is followed. Breastfeeding reflects the maternal diet in a similar manner to amniotic fluid. Both chemical analysis of breast milk and sensory experiments have shown that distinct flavours are discernible in the milk (Mennella & Beauchamp, 1996, Mennella and Beauchamp, 1991a). Breast milk's taste and viscosity can change every day, or even within a feeding, depending on maternal diet. Contrastingly, formula-fed infants are exposed to the sole flavour of the formula they are fed, which usually stays unaltered. However, differences in flavour between formula types are evident. Randomized control trials using specific formulas, with distinct flavours (hydrolyzed and non-hydrolyzed formulas), reveal that the most probable critical period for the postnatal flavour programming covers the first two months of life (Mennella et al., 2004).

The age around which the introduction to solid food typically occurs appears to be another opportunity to establish healthy eating habits that are likely to track later in life. Research has shown that although preference for sweet and salty is higher than sour and bitter during the first year of life (Schwartz et al., 2009), between 5-7 months of age infants equally accept sweet, salty, umami, sour and bitter tastes when added to water (Schwartz et al., 2011). As such, the introduction of sour and bitter tasting food (such as green vegetables and citrus fruit for example) during this specific weaning period could be beneficial. Indeed, fruit and vegetable introduction in general, during the early weaning period has been found to result in higher consumption of fruit and vegetables later during childhood (Coulthard et al., 2010; Möller et al., 2013).

In addition to flavour learning, evidence also supports the existence of a specific post-natal learning window related to food texture. Introduction of complex texture at the right time (around 10 months of age) is reported to increase acceptance of foods with complex textures whilst also decreasing food fussiness and other feeding related problems during toddlerhood and childhood (Coulthard, Harris, & Emmett, 2009; Northstone, Emmett, Nethersole, & ALSPAC Study Team. Avon Longitudinal Study of Pregnancy and Childhood, 2001). The introduction of more textured food also aids with the development of oral motor skills that are important in food consumption and have also been linked with speech development (Reilly, Skuse, Mathisen, & Wolke, 1995).

It is possible that throughout infancy, toddlerhood and childhood, there are more critical windows related to the development of eating behaviours that are yet to be discovered. Continued research on this topic has the potential to inform interventions and public

health guidelines in relation to the optimal strategies to follow to maximise the capacity for the development of healthy eating habits.

2.2.1 IN UTERO FLAVOUR EXPOSURE AND FLAVOUR LEARNING

Since the beginning of the 1980s the effects of flavour exposure *in utero* on later odour aversion have been examined and described in rodent models (Smotherman, 1982). However, as studies examined the impact of compounds artificially introduced to amniotic fluid, outcomes were not initially interpreted in terms of distinct flavours arising from the maternal diet. A few years later, a link between a maternal diet component (garlic) and rat pup preference to this component was described (Hepper, 1988), with rat pups being drawn more often to garlic than to onion odour at 12 days old when their mothers consumed garlic during gestation. Similar findings were also described in other mammal species such as rabbits (Bilkó, Altbäcker, & Hudson, 1994; Semke, Distel, & Hudson, 1995) and sheep (Orgeur, Arnould, & Schaal, 1995), with the effect lasting until at least the weaning age of each animal.

The first indication of a similar mechanism in humans was shown in a series of 4 case studies where odours of curry, fenugreek and cumin were identified on infants and in amniotic fluid of women who consumed meals containing those spices before giving birth (Hauser, Chitayat, Berns, Braver, & Muhlbauer, 1985). An experimental study confirmed the speculation that volatile molecules from maternal diet can pass through the placenta barrier and end up in the amniotic fluid (Mennella, Johnson, & Beauchamp, 1995). In this experimental study 5 pairs of mothers ingested either a garlic flavoured or placebo capsule before a routine amniocentesis procedure and their amniotic fluid odour was blindly sensory evaluated by 8-11 panellists. Results revealed that in four out of every five cases, panellists indicated that the amniotic fluid taken from mothers who ingested the garlic flavoured capsule smelled more strongly of garlic (Mennella et al., 1995).

While the results of those studies are consistent with the pattern of flavour transmission through the amniotic fluid that was first described in animal models, the evidence to support *in utero* flavour learning in human foetuses were not published until a few years later. The progression of studies to human infants allowed for alternative odour and flavour acceptance and aversion measures, such as facial expressions, mouth movements and behaviours such as head turning, to be utilised. In an experimental study, 24 women in their last trimester of pregnancy were randomly assigned to two groups with one group

being supplied anise flavoured sweets, cookies and syrup to consume *ad libitum*, while the control group was asked not to consume any anise flavoured foods until delivery (Schaal, 2000). Infants whose mothers consumed anise flavour food showed far less negative facial expressions and for a smaller duration and they displayed mouthing action more frequently and for longer when they smelled an anise flavoured swab. They also turned their head more often to the anise smelling swab in comparison to the non-anise smelling swab when tested within 8 hours after their birth. When the testing was repeated at the fourth day after delivery, while infants of both groups displayed similar facial expressions and mouthing actions, the infants in the anise exposure group continued to display an increased head orientation towards the anise smell. This difference was attributed by the study researchers to the theory that facial responses (such as facial expressions and mouthing actions) might be more stimuli bound and, thus, more sensitive to the more recent sensory experiences of milk feeding than the *in utero* sensory experiences (Lipsitt, 1977; Soussignan, Schaal, & Marlier, 1999; Soussignan, Schaal, Marlier, & Jiang, 1997; Steiner, 1979). Additionally, the authors suggested that the anise exposure in the first day of testing might be enough to familiarise the infants to the odour and mask the effects of the *in utero* manipulation. In contrast, the literature suggests that head orientation reflects a sensation seeking and memory mechanism (Kuhl, 1985), and is therefore a more accurate indicator of longer-term effects during the first days of life.

While the short term effects of *in utero* flavour exposure provide an insight of flavour learning, it is only viable to link such flavour exposure to the development of long term flavour preferences if there is evidence of effects lasting beyond the initial time after birth. The longer term effects of *in utero* flavour exposure, that last until the introduction to solid feeding, were demonstrated by a dietary interventions study in which pregnant mothers were instructed to consume either 300ml water or carrot juice 4 times a week and for 3 weeks during the last trimester of their pregnancy. Infants were tested about a month after their introduction to solid food and they were offered either plain cereal or cereal prepared with carrot juice. Infants whose mothers consumed carrot juice during pregnancy exhibited less negative facial expressions and their mothers rated their perceived enjoyment significantly higher (Mennella et al., 2001). However, while this provides an indication of carrot flavour acceptance, the use of cereal prepared with carrot juice, instead of carrot puree or carrot in their whole form, could potentially cloud the study's conclusions.

A possible mechanism, proposed to explain the sensory programing *in utero*, is related to the learned pairing of the flavour compound with an increase of available glucose, which

signifies both the presence of energy and a food source safe to consume. As previously mentioned, flavour volatile molecules from the maternal diet are present in the amniotic fluid. Normal foetuses swallow a significant amount of the amniotic fluid they are surrounded with through both the mouth and airways. Consequently both glucose and the volatile molecules within the amniotic fluid are concurrently placed in those cavities providing concurrent chemosensory stimulation to the nasal receptors and creating a functional link to the brain, signalling the presence of glucose (Gold, 1986) in the presence of stimuli. In this way, the positive signal of the presence of glucose is linked with the specific odour or flavour molecule enhancing positive responses, such as the head orientation and constraining the negative responses, such as the negative facial expressions (Schaal, 2000).

Combining the results of those studies, there is an indication of a chemosensory mechanism that programmes the foetuses of mammals to show a greater preference to odours and flavours present in the maternal diet during gestation. This preference can be demonstrated in both animal and human models until the respective weaning age. However, it is difficult to establish links beyond weaning age due to the involvement of more complex confounding factors.

2.2.2 POSTNATAL FLAVOUR EXPOSURE THROUGH MILK FEEDING

Postnatally, flavour acceptance is usually measured by observing the facial responses of the infant, the duration of the feeding or the time the infants are attached to their mother's nipple and in some cases the amount of food / milk that the infant consumed. Food preference, in contrast, is usually measured using the ratio of food intake or the length of the feeding event of one food in contrast with another. Food preference and acceptance can also be measured indirectly using questionnaires assessing maternal perceptions.

In the literature, there are several types of intervention studies examining postnatal flavour exposure. The most significant of the methods used are the one session exposure and the repeated exposure to the taste through breast milk. One session exposure aims to examine for flavour transfer. Such experiments can be used to derive information about volatiles which can be found in breast milk and identify appropriate food stimuli to use in experiments with repeated exposure methodology. Those experiments aim to examine the flavour learning and programming mechanisms in more detail.

2.2.2.1 ONE TIME EXPOSURE METHODOLOGY

In the literature there are a limited number of studies examining the effect of acute, maternal one-time ingestion of specific foods with distinct flavours on flavour preference of the infant. Studies with such a methodology cannot predict the long term effects of the exposure. However, they provide sufficient evidence for the transmission of volatile food molecules in breast milk.

Experiments of this design usually take place over two days (one for experimental and one for placebo exposure) with a week-long washout period between them. In the experimental sessions, mothers are asked to consume either an extract of the food under investigation, or a placebo. Approximately 2 to 3 hours after ingestion they express milk for sensory evaluation by a panel of adults to assess the strength of the milk's odour. Mothers also evaluate the test of the milk and breastfeed their infants, usually on demand, and the total consumption, the suckling behavior and the time attached to the nipple are used to measure the acceptance of the new taste.

Following maternal ingestion of 1.5g garlic extract, sensory evaluation panelists were able to detect a stronger smell of garlic in breast milk samples 2 hours after the ingestion, while mothers observed a stronger taste 3 hours following the ingestion. Although they disagreed on the exact time point of the peek smell/taste, both panelists and mothers agreed that they could detect sensory differences after the mother's exposure to the garlic volatile. A similar procedure has also been used to examine the influence of carrot juice on the smell and taste of breast milk. Breast-feeding women were asked to consume either 500ml of carrot juice or 500ml of water and they expressed milk samples every hour for the next 3 hours. Again, the sensory evaluation panel indicated a peak in the odour of the breast milk 2 hours after the ingestion of the carrot juice and mothers reported a stronger taste 3 hours later (Mennella & Beauchamp, 1999). Whilst these findings follow a distinct pattern, the timing difference between the odour and taste evaluations is not as clear. It is possible that taste compounds are expressed later than odour compounds, or that their molecules differ in size and structure (hydrophobic or hydrophilic). When panelists were provided with milk samples collected 30 minutes, 1 ,2 and 3 hours after consumption of a small amount of alcohol (0,3 g/kg for body weight) their sensory evaluation followed the same trend with the actual ethanol concentration. This finding demonstrates the reliability of the panelist in detecting odour differences in breast milk, and it confirms that the elevated ethanol content is actually perceived by the human's receptors (Mennella & Beauchamp, 1991b).

Looking at infant behavior, when mothers consumed 10ml of vanilla extract, infants spent 25% more time attached to their mother's nipple, and they drank 20% more milk when they nursed within three hours after the ingestion (Mennella & Beauchamp, 1996). Similarly, when mothers ingested garlic extract capsules, infants spent significantly more time attached to their mothers nipple, but the amount they actually drank didn't differ significantly (Mennella & Beauchamp, 1991a). Again, while these studies provide an indication of an effect of flavor exposure on the sensory properties of breast milk and on the infants' feeding behavior, it is important to note that they use flavor extracts in doses that are not typically consumed in reality. Therefore, the conclusions drawn must be interpreted with caution as it is not clear whether the amount typically consumed in daily diet would actually have an impact on both breast milk's sensory properties and the infants' feeding behaviours.

Finally, after a small amount of alcohol consumption, infants were observed to make more sucks during the first minute of feeding. However, the total amount of milk consumed was significantly less. The reduced milk consumption cannot solely be attributed to the difference in the odour of the milk, as the infants actually sucked more times. It is possible that alcohol inhibited the production of the breast milk (Cobo & Quintero, 1969), so the total amount of available milk might have been less.

2.2.2.2 FLAVOUR COMPOUNDS RESPONSIBLE FOR FLAVOUR TRANSMISSION TO BREAST MILK.

Whilst sensory experiments indicate the potential for infants to detect changes in the taste and smell of breast milk, chemical analysis is required to provide evidence for the transmission of flavour molecules. A number of studies report such analyses for a distinct array of potential flavour molecules. However, there are no articles to date that report such analyses in conjunction with infant sensory perception.

One study, focusing on specific aromatic compounds was completed over 4 sessions, separated by at least 3 days, with testing occurring in the home setting (Hausner et al., 2008). Lactating mothers were asked to ingest capsules containing 100mg of either trans-anehole (found in anise, fennel and liquorice candy), d-carvone (found in caraway, dill and spearmint), 3-methylbutyl (used for banana and pear flavouring), or l-menthol (major compound of mint flavour). Mothers provided milk samples every two hours for 8 hours after the ingestion and the milk samples were analyzed with chromatographic techniques to determine the concentration of each molecule in the breast milk samples at each time

point. Only 3 of the 4 compounds ingested were found in breast milk with 3-methylbutyl acetate being absent from the milk samples. Of the flavor molecules that were detected in breast milk, trans-anethole was present in the highest concentration and concentration followed by d-carvon and l-methol. The peak of the concentration of trans-anethole and d-carvone was observed at 2 hours after ingestion and with l-menthol levels plateaued between 2, 4 and 6 hours. Due to the study protocol there were no measurements taken atr 3h, when mothers observed a stronger taste in sensory experiments.

The exact compounds transmitted in breast milk following vanilla extract ingestion have not been identified yet. However, chemical analysis of human urine after synthetic vanilla flavouring (vanillin or 4-hydroxy-3-methoxybenzaldehyde) ingestion revealed that 3-ethoxy-4-hydroxybenzoic and 3-ethoxy-4-hydroxymandelic acids (Mamer et al., 1985) could be detected. Vanillin is the major volatile for the vanilla, however, natural vanilla extract contains various volatile molecules of different structure and size (Sostaric et al., 2000) that could also potentially be transmitted through the breast milk.

There is some evidence that sulfates are able to alter the flavour of cow's milk (Bassette et al., 1986), but there is no evidence of the transmission of these flavor molecules from garlic to breast milk. Sulfates are present in a great variety of different vegetables (e.g. broccoli, spinach, onions Block, 2010) with distinct flavor, and it is possible that they are responsible for this flavour too. By contrast, the metabolism of allyl methyl sulphide molecules from garlic has been investigated in the human body. It was established that the molecule is not digested but transmitted to the lungs producing the distinct garlic breath and also to the skin causing the same smell in the sweat (Block, 2010) . Garlic also contains Malliard reaction products, usually responsible for certain flavours (Block, 2010). As such, the potential for flavor molecules arising from garlic to be transmitted via breast milk remains high.

The chemical compounds that are suggested to contribute to carrot taste (as well as citrus taste) are terpens (Hausner et al., 2008). However, to date, chemical analysis of their transmission has not been examined. Yet, as recognised by Hausner et al., (2008), there are various flavor molecules that have the potential to be transmitted to breast milk. Detailed chemical analysis of breast milk samples after ingestion of the flavours examined in sensory studies (natural vanilla extract, garlic or carrot ingestion), is therefore required to obtain a greater understanding of the actual molecules that take part in flavour transmission and their associated characteristics.

2.2.2.3 REPEATED EXPOSURE THROUGH BREAST MILK INTERVENTION METHODOLOGY

Experiments employing the repeated exposure paradigm tend to involve consumption of carrots (Mennella & Beauchamp, 1999, Mennella et al., 2001), although caraway (Hausner et al., 2009) and garlic have also been examined (Mennella & Beauchamp, 1993).

2.2.2.3.1 *CARROT JUICE*

In the previous section it was shown that flavour and odour molecules in carrot juice can be detected in human breast milk. Following on from these single exposure studies, there are two studies using carrot juice in a repeated exposure protocol, both by the same research team. In the first study (Mennella & Beauchamp, 1999), thirty eight mothers who were already breastfeeding, and had just started to wean their infants with cereals, were asked to consume 300ml of either water or carrot juice daily for one week. Two testing sessions with plain and carrot flavoured cereals took place on the baseline and after the exposure. Regardless of the exposure group the mothers were in, all infants ate more cereal after the exposure period. Interestingly, infants whose mother consumed carrot juice ate less carrot flavoured cereal than cereal prepared with water. Infants whose mothers had just water during the intervention week ate about the same amount of carrot flavoured and plain cereals.

In the second study (Mennella et al., 2001), forty six pregnant women in the last trimester of pregnancy were recruited and allocated to one of 3 groups. One group received 300ml carrot juice during the last trimester of pregnancy, another received the same volume of carrot juice during the first month of lactation and the third group didn't receive any carrot juice at all. Group's were asked to refrain from eating any other carrot flavoured foods. After the first month of weaning, and while none of the infants were fed any carrot flavoured food, mothers and infants underwent two testing sessions separated by 4 days. Infants were fed either plain cereal or cereal prepared with carrot juice. Infants whose mothers were exposed to carrot juice showed greater acceptance (less negative facial expressions) and greater intake of carrot flavoured cereal than infants whose mothers were not exposed at all. Also, mothers from the group exposed to juice during pregnancy showed greater response than infants whose mothers were in the exposure group during lactation, but this difference was not significant. The results of this study advance the field by demonstrating that both pre-and post-natal exposure have the potential to sufficiently familiarize an infant with a flavour to impact at weaning. However, as discussed previously, the use of cereal prepared with carrot juice instead of

actual carrot, offers a distinctly different texture and flavour profile and is therefore a clear limitation of the study design. Additionally, the sample size of the study is very limited. Although this is generally typical for laboratory based infant feeding studies due to their nature (requiring a lot of commitment from a population that has limited time and convenience), as it will be discussed at the conclusion of this thesis, this continues to be a limitation that could potentially affect the findings.

The contrast in results between those two studies, with exposure reducing intake in the first but increasing it in the second, can be explained by the sensory specific satiety theory. According to the theory, testing immediately after the exposure period can decrease intake due to overfamiliarity of the sensors with the flavour (Rolls et al., 1982). Leaving adequate time between exposure and testing appears to eliminate this effect and increase the response of the infants to the targeted food. Additionally, the infants in the first study were older when their mothers received the carrot juice supplementation. Consequently, if favour programming occurs earlier in life, it is possible that these infants missed the critical phase for flavour learning.

2.2.2.3.2 *GARLIC*

Similarly to carrot juice, garlic flavour and odour molecules have been detected in human breast milk approximately 2-3 hour after a single exposure to garlic extract. In an experiment using a repeated exposure protocol (Mennella & Beauchamp, 1993), thirty mothers were initially asked to consume a bland diet without any sulfur containing food. On the fourth day mothers ingested a placebo capsule and breastfed their infants as usual. Subsequently, mothers were randomized to 3 groups. In one, mothers didn't consume garlic extract (group 1). In the second they consumed 1.5g of garlic extract for 3 days following the initial testing session (days 5-7), (group 2) and in the third, mothers consumed garlic extract a further three days later (days 8-10), (group 3). At the end of the exposure period (day 11), mothers and infants attended another testing session where all mothers consumed a capsule containing 1.5g garlic extract.

Consistent with the single exposure study, infants in group 1 spent more time attached to their mother's nipple. However, infants in groups 2 and 3 spent significantly less time attached to their mother's nipple after the exposure than when compared to the infants in group 1. Regardless of the time spent attached to their mother's nipple though, all three groups consumed the same amount of milk either between sessions, or between groups in each session. Again, sensory specific satiety may explain the lack of apparent response to the exposure, particularly for those in group 3. Moreover, it is important to note that the garlic extract was used in quantities much larger than typical consumption.

2.2.2.3.3 *CARAWAY*

After the observation that d-carvone is transmitted in breast milk, a larger scale interventional study was conducted using caraway seeds, which contain d-carvone (Hausner et al., 2009). In group 1, twenty breast feeding mothers consumed 75g humus containing 30mg d-carvone 10 times in a period of 28 days (once every 3 days). In group 2 twenty breast feeding mothers consumed the same amount of unflavoured humus over the same period. Finally, in group 3, eight non-breastfeeding mothers followed the same regiment as the first group. Mothers consumed the purees around the end of fourth month postpartum. Exactly after the exposure period, infants underwent 2 testing sessions on 2 different days in which they were fed either plain potato puree or potato puree containing caraway seeds.

The two breastfeeding groups demonstrated no difference in intake between plain and caraway flavoured potato puree. Interestingly, formula fed infants consumed significantly less caraway flavoured puree than plain puree. It is notable that that amount of d-carvone used during the exposure period (30g) was much less than that previously used (100g) to examine for flavor transfer. Consequently, it is unclear whether infants actually detected a difference in the sensory properties of the breast milk.

2.2.2.4 REPEATED EXPOSURE THROUGH FORMULA MILK METHODOLOGY.

Whilst different formulas vary in taste, parents usually choose one brand for their infants, limiting the flavor profile they are exposed to. In some cases, though, infants may experience health problems such as an allergy to milk protein or phenylketonuria, a genetic metabolic condition in which the amino acid phenylalanine cannot be metabolized. In these conditions, formulas with hydrolyzed proteins are required for infant feeding. These types of formula have a very characteristic taste and smell, which are typically unpleasant to adults, mainly because of the free sulfur containing amino acids.

This unique sensory experience offered by such hydrolyzed formula has been experimentally explored in a number of studies with comparison to regular formula and breast milk. With the formulas being routinely fed to the infants, the designs are all characteristic of a study with a repeated exposure methodology. Some studies were randomized, with infants without a health problem receiving hydrolyzed formulas, others included infants fed hydrolyzed formulas because of a specific health problem.

In one study, 49 infants, 5-11 months old, were split into 3 groups according to the type of formula they were routinely receiving. In the first group were 20 infants who were fed

Nutramigen, in the second 13 who were fed Alimentum while in the third 16 infants who were fed non hydrolyzed formula were recruited. The infants fed hydrolysed formula demonstrated a preference for their familiar type of formula when comparing the two brands of hydrolyzed formulas with different flavour profiles (Alimentum was judged by sensory panelists to be sweeter and less bitter than Nutramigen). Moreover, infants fed milk based formula, rejected both brands of hydrolyzed formulas when were offered in a taste test (Mennella & Beauchamp, 2005).

There is only one randomized trial using both milk based and hydrolyzed formula in a repeated exposure protocol over 7 months. (Mennella et al., 2004). Infants were allocated to one of four groups, at 2 weeks of age. Group 1 received non-hydrolyzed milk based formula for the whole duration of the study. Group 2 received hydrolyzed formula during the first 3 months of the study and non-hydrolyzed milk based formula for the 4 remaining months. Group 3 received non-hydrolyzed milk based formula during the first 2 months, hydrolyzed formula the following 3 months and again non-hydrolyzed milk based formula for the last 2 months. Finally, group 4 received hydrolyzed formula for the whole duration of the study. Each month, infants underwent testing sessions where they were fed with the formula which they consumed during the month before the testing session. At the end of the seven-month period, infants had three different testing sessions, in three different days, within a week. On these days, infants were fed either the hydrolyzed formula, the non-hydrolyzed milk based formula or a different brand of hydrolyzed formula. Infants who were fed hydrolyzed formula accepted both hydrolyzed formulas easier than those who were fed non-hydrolyzed formula. Infants who consumed the hydrolyzed formula for longer (7 months) demonstrated an even greater acceptance than those who were exposed at some point within the first 3 months of their life. This finding indicates both a “flavour programming” period during the first months of life and a strong “repeated exposure” effect on general taste preference.

Acceptance differences between infants fed with hydrolyzed formula and infants fed milk based formula have also been detected during weaning. In one study, the taste preferences of 4-9-month-old infants who were breast fed or fed with hydrolyzed or non-hydrolyzed formula, were compared using cereals which contained a small amount of either d-lactose for sweet taste, sodium chloride for salty taste, urea for bitter taste, citric acid for sour taste or monosodium glutamate for savory taste. The testing took place over 6 different testing sessions. Infants were also categorized based on whether they typically consumed table foods or just baby cereal. Infants who were fed hydrolyzed formula and did not experience table foods ate significantly more savory, bitter, sour and plain cereals than infants who were breast fed or fed with a milk based formula. Among infants who

were typically fed table foods other than baby cereals, this result was present only for savory and sour cereals (Mennella et al., 2009). Some associations were also found between the table foods the infants experience at home and the type of cereals they consumed in greater amounts. For example, infants who ate cheese at home ate more salty cereal, and infants who had bitter vegetables at home ate more bitter cereals than other infants within the formula fed group.

In contrast, 8-9-month-old infants who were either fed milk based or hydrolyzed formula, were tested for their preference of either carrot puree or broccoli/cauliflower puree. Infants in the hydrolyzed formula group consumed significantly less broccoli/cauliflower puree, and their mothers appeared to be aware of this difference (Mennella et al., 2006). As discussed previously, hydrolyzed formulas share some flavour characteristics with bitter green vegetables like broccoli. Consequently, the results of this study may be explained by sensory specific satiety.

Later, during early childhood, children who were fed hydrolyzed formulas demonstrated a significant preference for sour apple juice (Mennella & Beauchamp, 2002, Liem &Mennella, 2002). One study demonstrating this result (Mennella & Beauchamp, 2002) recruited an additional group who were fed soy based formula during infancy. Soy based formulas are usually described as more sweet, more sour and bitter and with a distinct "beany" odour. In contrast, children fed soy based formula preferred the bitter tasting apple juice. However, older children, aged 6-7 years old, who were fed with hydrolyzed formula demonstrated a preference for the sweeter apple juice rather than the sour one (Liem & Mennella, 2002). These findings suggest an age-limited ceiling effect for hydrolyzed and soy formulas flavour profiles on later flavour preferences. While younger children accept and prefer sour and bitter taste, older children reject them, possibly due to a greater exposure to sweet taste.

To summarize, additional studies have investigated the effect of hydrolyzed formulas on weaning and food preferences (Mennella & Beauchamp, 2002; Mennella & Beauchamp, 2005; Mennella et al., 2006, Mennella et al., 2001, Liem & Mennella, 2002). These formulas contain sulfur volatiles, the properties of which were discussed previously, and which are generally disliked by children (Mennella & Beauchamp, 1991a). At the weaning stage, infants fed hydrolyzed formula ate significantly less broccoli/cauliflower puree than infants fed with milk based formula. This result has been attributed to sensory specific satiety occurring as a consequence of repeated exposure to similar tastes (Mennella et al., 2006). Also, infants who were fed hydrolyzed formula ate significantly more sour or bitter cereals than breastfed or milk-based formula fed infants (Mennella et

al., 2009). In the long term, 5 year old children who were fed hydrolyzed formula as infants were more likely to prefer sour apple juice (apple juice with added lemon juice) and had a heightened preference for the hydrolyzed formula compared to children who were fed milk based formula (Liem & Mennella, 2002). Children who were fed hydrolyzed formula also demonstrated a preference to a wider variety of flavours (Mennella & Beauchamp, 2002). The latter study demonstrates that despite no short term effect of taste exposure, a long term effect appears later in childhood.

Another study examined the differences in acceptance of two age groups (4-5 year old and 7-8 year old) of children, who either had or hadn't experienced hydrolyzed formulas (Liem & Mennella, 2002). The results demonstrated that the 7-8 year old children who were fed hydrolyzed formula preferred sour taste significantly less than younger children (4-5 year old) fed with the same type of formula (Liem & Mennella, 2002). There was no difference in the preference of sour taste between the two age groups in the milk based formula fed group. Also there was no difference in preference of sweet taste between the two age groups or between the different types of formula. Those findings suggest that the effects of milk flavour exposure are likely to peak around 4-5 years of age and start to decline after that.

2.2.2.5 STUDIES EXAMINING DIFFERENCE BETWEEN FOOD ACCEPTANCE OF BREAST AND FORMULA FED INFANTS.

As discussed in previous sections, early flavour exposure through breast milk has been shown to have a positive effect on later flavour acceptance and liking. It would therefore be expected that formula fed infants could be at a sensory disadvantage. Yet, in the limited number of studies comparing vegetable acceptance in breast fed and formula fed infants before and after a repeated exposure of the target vegetable, this distinction is not so well defined.

In one study, nineteen breast fed and seventeen formula fed infants aged 4-6 months were offered green vegetables (peas and beans) in a laboratory feeding session at baseline and after they have been repeatedly exposed to those vegetables in home settings for 10 times within 26 days (Sullivan & Birch, 1994). Although there was no difference in the baseline consumption, breast fed infants consumed significantly more vegetables after the exposure period than formula fed infants. Similar results were observed in another study by Maier et al. (2008) which compared 45 breast fed to 27 formula fed infants at 5 months of age. After 10 exposures of tomato-zucchini or pea purees, breast fed infants had a higher intake of the target vegetable. Both of these

studies indicate a potentially synergistic effect of sensory exposure during milk feeding and exposure intervention, supporting a beneficial effect of breastfeeding.

However, in other studies, the pattern of effect was reversed. The distinction between breast fed and formula fed infants was obvious at baseline, suggesting an initial disadvantage inferred by milk feeding practice. However intake of the groups converged following repeat exposure. In one study twenty four breast fed and twenty five formula fed babies, 6-8 months of age, were tested at baseline and after 8 exposures of an initially disliked vegetable (Maier, Chabanet, Schaal, Issanchou, et al., 2007). The disliked vegetable was not determined by the researchers but by mothers and it was not the same for all the infants. At baseline breast fed infants consumed significantly more of the disliked vegetable and their mothers rating the liking significantly higher than formula fed infants. This effect, however, disappeared after the repeated exposure to the disliked vegetable. Another study compared eight formula fed infants to twenty breast fed infants whose mothers consumed caraway flavoured hummus during pregnancy and twenty breastfed infants whose mothers consumed unflavoured hummus during pregnancy. Although the number of formula fed infants in the study was low, they exhibited statistically significant lower acceptance of a novel flavour, consuming more of a "plain" potato puree in comparison to a caraway flavoured one when tested at baseline (Hausner et al., 2010). Again, this difference disappeared after 10 exposures to caraway flavoured potato puree. These results suggest that breastfeeding provides a route for exposure to the flavours of the maternal diet which initially enhances acceptance of novel flavours by infants, but which doesn't confer an advantage in the longer term.

2.2.3 SUMMARY AND CRITIQUE OF THE EFFECTS OF FLAVOUR EXPOSURE ON FOOD PREFERENCE.

From the literature described above, key points can be extracted and limitations identified. First, it is clear that there are certain foods the flavour of which can be transmitted via breast milk, and can be perceived by infants when they breast feed. Also, there is evidence for the existence of sensory specific satiety, with infants exposed recently to a certain flavour presenting with different feeding behaviours to infants who experienced a period of delay between exposure and testing. However, the amount of time needed to actually overcome the sensory specific satiety phase still needs to be identified. Clarification of this detail may allow testing protocols to become more consistent, facilitating a more direct comparison of the results obtained.

Regarding the examination of flavour exposure via formula feeding, an association has been identified between consumption of hydrolyzed formulas and the preference of sour taste in young children (4-5 years old). Whilst the nature of the flavour molecule underlying this preference is unclear, it has been proposed that the sulfurs which are present in these types of formula play a role. It has also been noted that this sour preference is lost a few years later (7-8 year olds, Liem and Mennella, 2002). It is possible that this reflects the duration of effect of flavour exposure during milk feeding or, alternatively, the point when the impact of initial flavour exposure is dominated by the multitude of other flavour experiences provided by the child's daily diet. However, food preferences are not only a matter of taste, but also a matter of habit and peer pressure and it is possible that children's preferences are further moulded when the start to attend nursery or primary school (Renner et al., 2012).

Considering methodological limitations, studies evaluating the effects of milk flavor exposure where the impact of exposure on the intake of actual vegetable puree is assessed are very restricted in number. Apart from the one study examining the acceptance of broccoli/cauliflower puree in formula fed infants (Mennella et al., 2006), intake of vegetable flavoured cereals is typically examined and cereal texture is clearly very different from vegetable puree. Additionally, the taste profile of the juices used to flavour the cereal may differ from that of the vegetable itself. Thus, the results from such studies cannot be generalized to real vegetable consumption. Finally, it is unclear whether the quantities typically consumed in the maternal diet are sufficient to achieve the same sensory and behavioural impacts observed in experimental exposure paradigms.

Other methodological limitations relate to the instructions provided to mothers in initial studies in the field examining the impact of flavour exposure through milk feeding at weaning. In some studies mothers were required to wear a mask whilst feeding her infant in the laboratory (Gerrish & Mennella, 2001; Mennella et al., 2001), while others imposed restrictions in terms of their ability to vocalize, make facial expressions or encourage consumption in other ways (Hausner et al., 2010). When mothers cover their faces, or eliminate their interactions, infants are being deprived of vital information to respond to and, as such, the results of studies should be interpreted with caution. As the field advances, research approaches that recognize the opportunity offered through examination of mother infant interactions require development and validation.

Additionally, due to the nature of development, infants' liking of specific foods can only be assessed indirectly. Typically, this is achieved by asking mothers to rate their perception of their infant's liking. However, the factors and cues that impact on maternal

judgment of infants' preferences have not been fully explored, introducing the potential for the formation of biased or flawed views. Further research is needed to identify the plethora of signals available to mothers and to determine which of those are routinely employed when assessing food preference.

It should also be noted that experimental studies examining the effects of flavour exposure consistently fail to provide key demographic information. Ethnicity is often reported, with studies largely conducted in white American or European populations. However, aspects such as parity or socioeconomic status are rarely defined. Whilst parity has been shown to influence breast feeding duration, any impact on the development of food preferences remains to be defined. It could be argued that parity may offer little impact on biological outcomes (the presence of flavor molecules in breast milk or its sensory characteristics), or more objective measures of infant's feeding behavior (time attached on the nipple, milk or food consumed etc.). Yet, until adequately examined it should not be ignored. By contrast, socioeconomic status has the clear potential to influence the outcome of studies as mothers of high socioeconomic groups have the potential of a generally healthier and more flavour varied diet, regardless of the experimental manipulation.

2.3 PARENTAL EFFECTS ON EATING BEHAVIOR AND CHILDREN'S BODY WEIGHT.

While flavour exposure can provide an opportunity for the development of heathy eating habits, it is not the only factor influencing eating behavior in infants and children. Family environment plays a very important role in the formation of healthy eating habits in children, with its effect starting shortly after birth. Parents function as role models, and their lifestyle choices strongly determine those of their offspring. Apart from the environmental characteristics, direct parental influences also guide first preferences in early life.

The terms "parenting style", "parental feeding style" and "parental feeding practices" are often confused in the literature. When referring to them it is important that the definition followed is consistent and accurate to allow for direct comparisons between studies' methodology and findings. To ensure the clear distinction of the terms, all three of these concepts will be presented in the following section.

"Parenting style" is an umbrella term used for the attitudes and behaviors parents use when interacting with their children (Darling & Steinberg, 1993) and it is not

interchangeable with the term "parental feeding style". Parenting styles are generally categorized in four main domains, along two different dimensions, namely, the demandingness of the child and the responsiveness of the parent (Maccoby & Martin, 1983).

Authoritative parents are highly responsive to their child's high demandingness and they are characterized by reasonable expectation, warmth in the parent-child interactions and autonomy fostering. Authoritarian parents are less responsive to their child's high demandingness and they are characterized by strict demands irrespective of their child's maturity or ability and impervious to the child's opinions. Permissive or indulgent parents are highly responsive to their child's low demandingness. The term characterizes non-demanding parents, low in control, which are respectful to the child and provide warmth. While this parenting style appears to foster the child's developmental needs, it can also be characterized by inconsistencies and inability to apply rules and boundaries, jeopardizing the child's ability to self-regulate their behaviors. Finally, neglectful or uninvolved parents are less responsive to the child's low demandingness and they are non-demanding but also not aware of their child's opinions or needs (Maccoby, 1992). While these terms may be perceived as judgmental, this model is widely used in both research and practice. (Table 1)

Table 1: Parenting styles according to (Maccoby, 1992)

		Child's Demandingness	
		High	Low
Parent's Responsiveness	High	Authoritative	Permissive
	Low	Authoritarian	Neglectful

The term "parental feeding style" describes the collection of parental attitudes and behaviors used by parents when interacting with their children during feeding, or in a food related context (Hughes, Power, Orlet Fisher, Mueller, & Nicklas, 2005). Note that the term is not interchangeable with the term "parental feeding practices" (see below). The taxonomy of parental feeding styles is similar to the one given for parenting styles, with responsiveness and demandingness dimensions still present but now focused on the specific context of feeding.

Table 2: (Maccoby, 1992) ***model*** **adaptation for parental feeding styles**

		Child's Demandingness	
		High	Low
Parent's Responsiveness	High	Authoritative	Indulgent
	Low	Authoritarian	Uninvolved

The term "parental feeding practices" refers to the behaviors that parents use to achieve specific food related goals for their children (LeVine, 1988), and, therefore, can vary across age, gender, weight status, culture and eating behaviour. These include controlling practices, such as pressure to consume healthy foods, like fruit and vegetables, and restriction on access to or the consumption of unhealthy but palatable food choices (Birch et al., 2001). They also include non-controlling practices such as monitoring intake, modelling and encouragement of healthy behaviors, nutrition teaching, and instrumental feeding (offering food as a reward or pacifier; Musher-Eizenman & Holub, 2007).

2.3.1 PARENTING STYLES

There are numerus cross-sectional studies linking parenting styles with children's diet and weight. While some questionnaires use different terminology, following Maccoby's model (Maccoby, 1992) it is possible to draw study similarities based on the description of the alternative terminology. In this section, studies which make associations between parenting styles and healthy eating and weight status outcomes will be presented.

Authoritative parenting style, particularly when it is practiced by mothers, was found to be positively associated with higher fruit and vegetable intake (Lytle et al., 2003; Park & Walton-Moss, 2012; Rodenburg et al., 2012) and negatively associated with fat and sugar intake (Chen & Kennedy, 2005; Pearson, Atkin, Biddle, Gorely, & Edwardson, 2010; van der Horst et al., 2007) for both children and adolescents. Additionally, individual studies have linked authoritative parenting with more frequent family meals (Berge et al., 2010b), while it has also been negatively associated with fast food meals (McIntosh et al., 2011), obesogenic environment at home (Johnson, Welk, Saint-Maurice, & Ihmels, 2012) and emotional eating (Topham et al., 2011) in children and increased weight in adolescents (Kim et al., 2008).

Authoritarian parenting style has been linked with higher availability of high fat and sugar food at home (Gable & Lutz, 2000), but it has also been inversely associated with high intake of such foods (Pearson et al., 2009). This discrepancy is explained as a function of the higher control that parents following authoritarian parenting exercise (Ventura & Birch, 2008). Regardless, results from both longitudinal and cross sectional studies consistently link this parenting style to higher body weight (Berge et al., 2010; Berge et al., 2010a; Fuemmeler et al., 2012; Lane et al., 2013; Rhee, 2006).

Permissive and neglectful parenting styles have both been repeatedly associated with higher child's BMI regardless of the age of the examined population (Fuemmeler et al., 2012; Humenikova & Gates, 2008; Johnson et al., 2012; Lane et al., 2013; Olvera and Power, 2010; Rhee, 2006; Rodenburg et al., 2012; Topham et al., 2010; Wake et al., 2007).

Specific associations, according to which parent practices a certain style or the gender of the affected child, have also been identified in the literature. A combination of an authoritative mother and a neglectful father was found to be positively associated with body weight, but only in boys (Berge et al., 2010). All except for authoritative styles practiced by fathers have been positively associated with higher fruit and vegetable consumption (Berge et al., 2010a; Lytle et al., 2003), while non-authoritative styles practices from mothers increase the risk of the child being overweight up to two years later in school aged children (Rhee, 2006).

From the above it is evident that an authoritative parenting style is linked with more healthy and beneficial eating practices and patterns. Authoritarian and permissive styles were associated to both healthy and unhealthy behaviors while neglectful parenting seems to foster only unhealthy behaviors.

2.3.2 PARENTAL FEEDING STYLES

There is a dearth of studies examining the effect of different parental feeding styles on eating behaviour and weight status. However, the results do not diverge considerably from the parenting style's effect on those outcomes.

Due to the nature of authoritative style, being high in demandingness of the child to follow a healthy diet, one might expect such parents to make sure that healthy food choices are available in their households. Indeed, authoritative feeding style was associated with higher availability of fruit and vegetables at home settings and lower intake of food with poor nutrient profile (Patrick, Nicklas, Hughes, & Morales, 2005). All but authoritative feeding styles were associated with lower fruit and vegetable intake

(Hoerr et al., 2009; Hughes et al., 2007). At the same time, however, an authoritative feeding style might jeopardize the child's autonomy and their reliance on internal cues (like hunger). As mentioned in the previous section, adolescents whose parents follow an authoritative parenting style in general were found to have increased weight (Kim et al., 2008). This suggests that long-term exposure to high controlling parenting practices can have negative effects overtime.

The indulgent (equivalent to permissive) feeding style was associated with increased intake of high energy, sugar sweetened beverages, fats and low nutrient food (Hennessy, Hughes, Goldberg, Hyatt, & Economos, 2012; Hoerr et al., 2009) and increased body weight (Hennessy, Hughes, Goldberg, Hyatt, & Economos, 2010; Hughes et al., 2005; Hughes, Shewchuk, Baskin, Nicklas, & Qu, 2008; Tovar et al., 2012). Conversely, an indulgent feeding style practiced by the child's care provider was associated with an increased consumption of fruit and vegetables (Hughes et al., 2007).

For parents practicing uninvolved (equivalent to neglectful) feeding style the literature is unclear, as the two studies examining its effect on child's eating have contradictory results (Hennessy et al., 2012; Hoerr et al., 2009).

2.3.3 PARENTAL FEEDING PRACTICES

2.3.3.1 FEEDING PRACTICES IN INFANCY AND TODDLERHOOD

Studies examining milk feeding practices, such as restriction or pressure to eat, in the first year of life, are very limited. However, food restriction in infancy has been associated with bottle feeding and increased appetite, while pressure to eat has been associated with low birth weight, maternal concern about underweight and lower infant appetite in infants as young as 8 months (Fildes, van Jaarsveld, Llewellyn, Wardle, & Fisher, 2015). Despite the initial speculation, no link has been established between pressure to eat and bottle feeding. Additionally, breastfeeding has been associated with lower maternal control over feeding (Brown, Raynor, & Lee, 2011c) in the first 6 months post-partum and with longer duration of breastfeeding in the first year (Taveras et al., 2004). None of those studies provide sufficient evidence to make assumptions for the long term effects of restriction, pressure or control over feeding.

Toddlers, up to 2 years of age, for whom unhealthy foods such as cakes, cookies, soft drinks, chocolate and crisps were restricted at home, consumed less of the restricted food items. The amount of restriction they received was also associated with their temperament; more stubborn, demanding and jealous toddlers received stricter rules

(Gubbels et al., 2009). A prospective study revealed that the level of pressure and restriction used at one year of age can predict the child's BMI z-score one year later, with both pressure and restriction having a protective effect on higher BMI (Farrow &Blissett, 2007).

2.3.3.2 PRESSURE TO EAT

Pressure to eat is a frequently followed strategy parents use to increase consumption of food. Commonly, it is used to increase desired food consumption in children who are perceived as picky eaters or underweight. Various cross sectional studies have associated the practice with lower weight status and parental concern about the child's weight (Francis, Hofer, & Birch, 2001; Keller, Pietrobelli, Johnson, & Faith, 2006; Matheson, Robinson, Varady, & Killen, 2006; Powers, Chamberlin, van Schaick, Sherman, & Whitaker, 2006), as well as food pickiness and poor diet quality (Campbell, Crawford, & Ball, 2006; Fisher, Mitchell, Smiciklas-Wright, & Birch, 2002; Galloway, Fiorito, Lee, & Birch, 2005).

In experimental settings, twenty seven pre-schoolers (3-5 year old) made more negative comments and decreased their preference and consumption of a soup when a mild pressure was applied by researchers (Galloway, Fiorito, Francis, & Birch, 2006). Interestingly, in this study, children who received high levels of pressure at home were less likely to be affected by pressure in experimental settings. Another experimental study included 22 pre-schoolers (3-5 year old) in a conditioning trial over 6 weeks. The study demonstrated that, over time, children became more responsive to external cues (such as pressure to clean their plates) than internal cues (such as hunger, Birch et al., 1987b). Combining the results, a definite picture emerges; children seem to initially respond to the pressure, but they desensitize overtime, making pressure to eat ultimately an unsuccessful feeding practice to increase food intake.

2.3.3.3 RESTRICTION

Food restriction is positively associated with child's weight status for older children in the majority of cross sectional and longitudinal studies (Francis et al., 2001; Joyce & Zimmer-Gembeck, 2009; Lee & Birch, 2002; Powers et al., 2006; Santos et al., 2009).

Restriction has been shown to increase the preference for the targeted foods on pre-schoolers (Liem, Mars, & De Graaf, 2004) and it doesn't prohibit their consumption (Rollins, Loken, Savage, & Birch, 2014). These findings are additionally supported by experimental studies, in which restriction led to increased restricted food desirability,

preference and intake in children up to 5 years of age (Fisher & Birch, 1999; Jansen et al., 2007).

Restrictive practices were associated with eating in the absence of hunger in a few experimental studies (Birch et al., 2003; Fisher & Birch, 2000; Fisher & Birch, 1999; Francis & Birch, 2005). Eating in the absence of hunger is assessed by a simple protocol where the participants are initially preloaded with a generous, age appropriate, amount of food and their level of hunger is measured at the end of the meal to confirm satiety. Then, participants are asked to do a different, unrelated task in the presence of food. Additionally, children who received very small or very big amount of restriction at home, had greater energy intake in the free food access procedure, while those who received moderate restriction at home had a much smaller energy intake in the lab (Jansen et al., 2007). This shows that a mild food restriction at home can actually have protective effect over increased food consumption in the absence of hunger. On the contrary, for children who are naive to food restriction or they are accustomed to it because of their routinely parent's behavior, its effects can be very potent.

In pre-school aged girls, parental food restriction was associated with higher dietary restraint and disinhibition measured through questionnaires (Carper, Orlet Fisher, & Birch, 2000). While these two factors seem to have a contradictory effect, both can be precursors of disturbed relationship with food. In a self-reported online study which included 611 mothers of children 2-7 years old higher restriction was associated with more frequent unhealthy snacks consumption, with the lower levels or restrictions being associated with healthy snack intake (Boots, Tiggemann, Corsini, & Mattiske, 2015). Another experimental study showed that restriction can increase the consumption not only of forbidden sweets in comparison to non-forbidden sweets, but also of forbidden fruit compared to another non-forbidden fruit (Jansen et al., 2008).

The effects of food restriction have been shown to be dependent on the child's age and familiarity with specific foods. While restricting access to an already known food is proven to be counterproductive, as mention above, restricting access to unhealthy food (i.e. chocolate, crisps, cakes, etc.) in younger age, when the child has little or no experience with it, seems to have the desired effects. A different explanation can be rooted in the development of cognitive ability of desire in infants. In an experimental study, it was concluded that infants around 18 month of age (and not younger) start to develop reasoning for food specific desire (Repacholi & Gopnik, 1997), and, around the same age, they develop the ability to engage in conversations about absent objects or objects that are out of their sight (Goodwin, 1985; Sachs, 1983). It is plausible, therefore,

to assume that the counterproductive effects of restriction begin at the same time, given that the toddlers are familiar with the restricted food, as they are able to form and articulate their food-related desires and to relate with the food even if it is not present.

2.3.3.4 MODELING AND PARENT'S FOOD PREFERENCES.

Parents are the primary role models in the first years of children's lives. Through their daily interactions, children learn skills and behaviors crucial to their development. Food choice and eating behavior are among those behaviors learned through modeling.

Modeling of healthy food behaviors was associated with lower child weight in one cross sectional study (Matheson et al., 2006), but there is no longitudinal data available to support any causal relationship. There is a large body of literature showing the positive effect of healthy eating modeling by adults on children's healthy food consumption (Fisher et al., 2002; Galloway, Lee, & Birch, 2003; Kratt, Reynolds, & Shewchuk, 2000; Reynolds, Hinton, Shewchuk, & Hickey, 1999; Wardle, Carnell, & Cooke, 2005; Wind et al., 2006), as well as on their acceptance of novel foods (Addessi et al., 2005; Harper and Sanders, 1975; Hendy & Raudenbush, 2000a, 2000b; Jansen & Tenney, 2001). Evidence from longitudinal studies further supports the relationship of modeling and healthier diets in children over time (Cullen et al., 2003; Fisher, Mitchell, Smiciklas-Wright, Mannino, & Birch, 2004).

On the other hand, children's unhealthy eating habits and attitudes can be also traced to their parents. In a number of studies, the link between parental and offspring unhealthy eating habits is clearly demonstrated. Young children's consumption of unhealthy snacks, such as crisps, chocolate and biscuits, are correlated to their parents consumption of those snacks in cross sectional studies (Brown & Ogden, 2004; Wardle, 1995). Similarities between parental and young children's diet were also found at the nutrient level (Oliveria et al., 1992). Parent-children similarities were also identified in regard to eating related attitudes such as body perception and weight concern, especially between mothers and daughters (Brown & Ogden, 2004).

During infancy and early childhood, parents are solely responsible for the food available to their children and therefore, it is possible that their own liking and consumption of food will affect the choices they offer to their children. It is expected that parents who dislike specific foods will not be willing to purchase or offer them to their children. While there are no studies looking at the effect of parental liking on consumption in infants, the effect has been demonstrated in toddlers. Mothers liking for either fruit or vegetables has been shown to be positively associated with their 2 year old children's

liking for the respective food and inversely associated with the number of 'never tried' fruits and vegetables from a list of 23 vegetables and 17 fruits. Similar associations were found for non-core foods (Howard, Mallan, Byrne, Magarey, & Daniels, 2012). This finding confirms the speculation that parental food liking has an effect on the range of foods children are offered and like themselves. It also shows that the effect extends to non-core, unhealthy food. Similarly, the reported parental consumption of fruit and vegetables was found to be a strong predictor of 2-6 year olds fruit and vegetable consumption (Cooke et al., 2004) with the effect also persisting in older, school aged children (Falciglia, Pabst, Couch, & Goody, 2004). As children get older, parents are no-longer the exclusive providers of food choices; their eating behavior continues, however, to affect children's eating behavior and outcomes through modeling and home food availability.

2.3.3.5 Associations between parenting styles and practices.

While the concepts of parenting styles and parental feeding practices are not interchangeable, a limited relation can be detected between them. In a sample of 239 participants comprised mainly by mothers of children around 7 years old, 21% of the variance in authoritative parenting was predicted by responsibility, restricting, monitoring, and modeling feeding practices, 15% of the variance of authoritative parenting was predicted by restricting, pressuring, and monitoring practices and 8% of the variance in permissive parenting was predicted by restricting and modelling feeding practices (Hubbs-Tait, Kennedy, Page, Topham, & Harrist, 2008). In a recent review of observational studies of mealtimes between mothers and pre-schoolers, parenting style was associated with parental feeding practices, but not with the child's eating behaviors (Bergmeier, Skouteris, & Hetherington, 2015). These results demonstrate the partial but consistent relationship between general parenting styles and specific feeding practices. However, insufficient data is available to support an effect on the eating behavior outcomes.

In another study with a smaller sample but with measures of both feeding practices and parenting styles from both fathers and mothers of younger children (mean age 42 months), authoritarian parenting was not significantly related to any specific feeding practice. For mothers, permissive parenting style was associated with higher levels of restriction. For fathers, authoritative parenting style was significantly associated with lower levels of pressure, while authoritative style was significantly associated with increased levels of pressure. Permissive parenting style was significantly associated with lower levels of monitoring practices for both parents (Blissett & Haycraft, 2008). These

findings indicate that feeding practices are not directly related to the parenting styles, but also that the same parenting style can be translated to different practices depending on whether they are coming from the mother or the father.

2.3.3.6 PARENTAL EATING BEHAVIOR.

The interactions between the maternal eating behaviour and her infant feeding behaviour, including her responsiveness to the infant during the feeding, is a very complex concept that has been largely overlooked in the literature. Available data suggests that maternal eating behaviour can affect several factors associated with child feeding. One of the most popular tools to measure eating behaviour is the Dutch Eating Behaviour Questionnaire (DEBQ). The questionnaire measures 3 dimensions of eating behaviour; external, emotional, and restrained eating. All of these dimensions describe eating as a result of factors unrelated to hunger cues. External eaters are more likely to consume food due to external cues, like smell or visual cues, emotional eaters are more likely to consume food as a response to their emotions and restrained eaters are more likely to inhibit food consumption, typically for dieting reasons, despite the internal hunger cues.

Mothers who score high on any of those dimensions have been found to be more controlling and monitoring of their offsprings' eating and concerned about their child's weight (Brown & Lee, 2011a). Additionally, mothers who are external and restrained eaters tend to follow a more mother led than baby led approach to feeding, with that having an impact on the breastfeeding initiation and duration. More specifically, mothers who score higher on these subscales introduce formula earlier (Brown, 2014). Recent findings show that they are also more likely to offer more unhealthy and less healthy food choices (Shloim, 2014). This association illustrates that while it is assumed that monitoring and controlling techniques are used from parents to reinforce healthier eating behaviours on their children, this might not be the case when maternal eating behaviour is relying on external rather than internal cues.

During feeding both mother and infant exchange subtle, non-vocal information that is the foundation of communication. The caregiver and the infant learn to adapt, modify and change their behaviours in response to the other A number of factors related both to the mother and the infant, such as maternal mental health and infant physical and cognitive development, have been shown to impact on the information exchange. For example, depressed mothers might refrain from stimulating the infant by limiting the repertoire of their behaviours such as smiling and talking. Similarly, Preterm infants or infants with cognitive delays are likely to be less responsive to their mother's cues (Barnard, Bee, & Hammond, 1984). Other influencing factors, such as the interaction between maternal

eating behaviour and infants temperamental characteristics and the impact of this on the quality of the mother infant interactions during feeding, are currently underexplored.

2.3.3.7 FAMILY MEALTIMES

There is no clear definition of the term "family mealtimes". As highlighted by a recent review, available studies inconsistently define the term, with some accepting a "family mealtime occasion" when at least one parent and one child is present, while others require most or all of the family to be present (Martin-Biggers et al., 2014).

While the vast majority of the research on family meal times has been conducted on adolescents, the limited evidence looking at the impact of frequent family mealtimes on young children's weight and eating behaviors highlight their importance in the family routine.

The importance of children eating the same meal with their parents is highlighted in a study showing that pre-school aged children (2-5 years old) had an increased vegetable liking and consumption when they frequently ate approximately the same food with their parents (Sweetman, McGowan, Croker, & Cooke, 2011). A large cross-sectional study using data from the special supplementation nutrition program for women infant and children in the US associated more frequent family meals with higher fruit and vegetable consumption from toddlers when parents served more than 2 portions of fruit and 2 portions of vegetables a day (FitzPatrick, Edmunds, & Dennison, 2007). Regarding weight status, longitudinal data from the kindergarten cohort of the Early Childhood Longitudinal Study showed that pre-school aged children who had less frequent family meals were more likely to be overweight a few years later, at the third grade (Gable, Chang, & Krull, 2007) and household routines, including family mealtimes, were negatively associated with higher BMI status in four year old children (Anderson & Whitaker, 2010). Frequent family mealtimes are possible to have a long term trans-generational effect, with parents who reported they had more than six family meals a week as children being likely to report significantly more frequent family mealtimes with their own children (Friend et al., 2015). The mechanisms through which shared family mealtimes may enhance healthy eating behaviours and help towards a healthier weight status in younger children are not clear. There is a dearth of research on possible mediating factors such as parent child interactions during mealtimes (Bergmeier et al., 2015), the effect of different parents feeding styles and practices and within meal communication (Boles & Gunnarsdottir, 2015) or source of preparation of those meals (home or commercially prepared, Boles and Gunnarsdottir, 2015). On the other hand, an interesting idea rises from a recent systematic review which examines the effects of

eating in the absence of hunger (Lansigan, Emond, & Gilbert-Diamond, 2015). It could be argued that eating at pre-arranged, non-flexible occasions might lead to insensitivity to internal cues, such as hunger.

A potential protective mechanism linked with shared family mealtimes is the development of healthier patterns of caregiver-infant and, later, caregiver-child interactions. For example, it has been shown that infants whose mothers are less sensitive to infant cues gain more weight during their first year of life (Worobey, Lopez, & Hoffman, 2009). However, it is possible that when the caregiver and the infant are eating at the same time, the caregiver's sensitivity to the cues increases because they are not distracted by other tasks, but they are more focused on the eating and feeding process. It is unknown, however, whether decreased sensitivity to cues, or any other aspect of mother infant interaction during feeding directly affects food intake. Furthermore, as previously stated, the cues that mothers use are also unclear.

2.3.3.8 COMPLEMENTARY FEEDING PRACTICES

The method parents use to introduce solid food to their infant's diet has received a lot of interest recently. In the past, the most popular method dictated the gradual introduction of more complex textures. Purees, which were spoon fed by an adult, were introduced first (Seaman, D'Alessandro, & Swannie, 1996), followed by more lumpy and solid food a little later when the parent considered it to be appropriate (Parent Led Weaning, PLW). Recently, however, an alternative approach has been gaining attention among both parents and researchers. Baby Led Weaning (BLW) skips puree and spoon feeding and it gives the infant a central role in the feeding process by letting them self-select and self-feed rather than passively receive the food (Sexton, 2009).

BLW stresses the right timing for the introduction to solid feeding as parents are encouraged to start introducing solids only when infants show "signals of readiness" such as hand and eye coordination and infant's ability to sit with no or little support (Sexton, 2009). Parents attribute a considerable amount of benefits to BLW, from health benefits to improved coordination, temperament and even speech development. However, the vast majority of the benefits claimed by the parents have not been confirmed in the literature. Published studies are limited in number and focus only on the feasibility of BLW, the experiences and the opinions of the mothers and health professionals and quantitative experimental results.

There are 2 published reports on the feasibility of BLW, which show that, indeed, full term healthy babies, without developmental delays, are ready to start BLW at

approximately 6 months of age (Cameron, Taylor, & Heath, 2013; Wright, Cameron, Tsiaka, & Parkinson, 2011). This is in line with the current recommendations of solid feeding introduction and prohibits the early solid introduction. Early solid introduction has been associated with greater obesity risk, especially in formula fed infants (Huh et al., 2011), and higher risk of eczema development (Fergusson & Horwood, 1994; Tarini et al., 2006) in a limited number of studies. Qualitative studies show that both mothers and health professionals believe that allowing the infant to be in control of its eating results in a less fussy child with better appetite control (Arden & Abbott, 2015; Brown & Lee, 2013; Cameron et al., 2012). Possible challenges that can discourage parents from adopting BLW include the fear of choking, the mess and food waste (Brown & Lee, 2013), as well as inadequate nutrient intake (Arden & Abbott, 2015). Health professionals tend to be more wary about the method than parents as they are more concerned about choking incidents (Cameron et al., 2012). So far, however, there is only one study that found no significant difference in gagging and choking incidents between infants following BLW and PLW. Note that the incident frequency was self-reported and, thus, the distinction between gagging and choking might have been biased (Cameron et al., 2013). Parents who use BLW usually wait for developmental signs that the infant is ready to handle solid food in order to do it safely (Brown & Lee, 2013), and, as mentioned above, this is unlikely to happen before 6 months of age (Cameron, Taylor, & Heath, 2013; Wright, Cameron, Tsiaka, & Parkinson, 2011).

Studies have shown the beneficial effects of BLW. The method is associated with greater satiety responsiveness and lower rates of overweight and obesity, when compared to traditionally weaned, spoon fed infants and toddlers in cross sectional studies from UK (Brown & Lee, 2015; Townsend & Pitchford, 2012). There are no studies giving more long-term associations between complementary feeding methods and eating behaviours or weight status in later childhood, mainly because the topic is novel and the research is rather limited. BLW is also associated with factors that are linked to better eating habits (Brown & Lee, 2015), longer duration of breastfeeding (Cameron et al., 2013), delayed introduction of complementary feeding (Brown & Lee, 2015; Cameron et al., 2013), lower parental control over feeding (Brown & Lee, 2011b, 2015), family mealtimes (Brown & Lee, 2011c; Cameron et al., 2013) and less commercial/more home prepared meals (Cameron et al., 2013).

The literature around complementary feeding styles, however, is affected by limitations, mainly due to relative novelty of the research field and limited number of studies. From an experts' practice roundtable published recently (Rapley, Forste, Cameron, Brown, & Wright, 2015), it is apparent that there is not a clear definition of BLW. The lack of a

concise definition by researchers leads to inconsistencies in scientific methodologies and may confuse parents looking for advice on complementary feeding. Although all authors used the concepts of self-selection, self-feeding and signals or readiness, there was generally a lack of a quantitative approach to the definition, which would help eliminate the inconsistencies in the literature. Parents might follow the general philosophy of BLW, however they might use a combination of spoon feeding by an adult and self-feeding in different occasions as a result of multiple familial need, for example, when caring for multiple children at the same time or eating out, making sure the child gets the appropriate nutrient intake, or when the child is having meals in nursery or with other carers (Arden & Abbott, 2015).

The only clear, numerical cut off point introduced in the literature is 10% spoon feeding in addition to the general concepts (Brown & Lee, 2011b, 2015). Many families, however, choose a combination approach to accommodate a modern lifestyle, with PLW possibly being the preferred method when eating meals out of the house, or when there is limited time at mealtimes. Although caregivers might use spoon feeding more than 10% of the time, they can still predominantly practice BLW. So far, the literature has not examined the impact of those combination practices in eating behaviour or children's weight.

Despite the lack of clear definition, however, there is consistent evidence that demonstrates beneficial effects of BLW on various health outcomes. More long term studies examining for different confounding factors are needed in the literature to provide a clearer picture of the long term effects of complementary feeding styles.

2.3.3.9 Repeated exposure and dietary variety

In previous section, repeated exposure was mentioned as a methodology to achieve long lasting flavour exposure effects, both in uterus and in milk feeding, through chemosensory stimulation. The method has been proven successful in both critical periods. Here, repeated exposure to the taste or as a visual cue is examined as a technique to increase the infants' and toddlers' familiarity with a target food.

Repeated exposure is a method that has repeatedly shown to increase food liking and intake of target foods. The majority of parents try novel foods up to 3-5 times before they decide whether infants like or dislike them (Carruth, Ziegler, Gordon, & Barr, 2004; Maier, Chabanet, Schaal, Leathwood, & Issanchou, 2007). The number of exposures required to significantly increase the intake of an initially disliked food, on the other hand, is unclear, but it may be more than what evidence suggest parents are willing to

try, and in the range from 8 to 10 times, with older children needing up to 15 exposures to increase their preference. The liking of an initially disliked vegetable (chosen by mothers) linearly increased after 8 home exposures, with the effects persisting for the majority of the sample after 9 months. For the liked vegetables (carrot in all occasions), the consumption was not increased further as a result of the repeated exposure (Maier, Chabanet, Schaal, Issanchou, et al., 2007).

In a recent study, 101 infants aged between 4-7 months old were divided in 4 groups. The first 2 groups received 9 exposures of vegetables puree (artichoke or green beans) while the other two groups were exposed for 9 occasions to fruit puree (apple or plum;Barends et al., 2013). Infants were tested for vegetable or fruit acceptance, depending on the group they were assigned to, with both vegetables and fruits at baseline and after the exposure. After 9 repeated exposures, the intake of green beans and plums significantly increased but not for apple or artichoke purees (Barends et al., 2013). The initial liking of the target vegetables and fruit might be responsible for this difference. On one hand, apple puree initially had the highest consumption out of the 4 purees and it is possible that repeated exposure did not affect the consumption of an already liked food showing a ceiling effect. On the other hand, artichoke puree initially had the lowest consumption out of all 4 purees. It is possible that additional exposure is needed to increase the liking of a strongly disliked food.

As mentioned earlier, milk feeding experiences can influence the efficacy of the repeated exposure as a method to increase vegetable consumption because of the influence of the flavour exposure through breast milk. After a 10 day exposure, infants aged 4-5 months of age significantly increased their intake of green peas and green beans regardless of their milk feeding practices. A possible explanation for this could be that those infants might have been quite young and inexperienced with solids at the beginning of the study and their intake was increased as a result of improved eating skills and intake capacity. Nevertheless, breast fed infants showed a greater increase than formula fed infants (Sullivan & Birch, 1994). Although other studies report no difference between breast fed and formula fed infants after a period of repeated exposure (Maier et al., 2007a; Hausner et al., 2010)

Ten days of repeated exposure to a food with similar flavour characteristics to an unexposed target food can also increase the intake of the target food (as well as the food the infant is exposed to; Birch et al., 1998). Two year olds necessitate between 5 to 10 exposures to increase their taste preference for novel foods, with taste exposures being more effective than visual exposures (Birch et al., 1987a; Birch & Marlin, 1982). For

older children, it is possible that more exposures are needed, as the food preferences are more established and neophobia peaks. A study conducted on children aged 3-4 years revealed that up to 15 exposures are required in order to increase children's preference for unflavored tofu, which was a novel food item (Sullivan & Birch, 1990).

A few studies explored the combined effects of repeated exposure and dietary variety at weaning. Exposure to a single vegetable (carrot) or variety of vegetables was significantly more effective in increasing carrot and novel food (chicken) puree intake than exposure to potato puree after 9 exposures (Gerrish & Mennella, 2001). Similarly, both exposure to pear puree and variety of fruit over 8 days increased the consumption of pears (Mennella, Nicklaus, Jagolino, & Yourshaw, 2008). The same effect is apparent in more "disliked" foods, like green beans. In a similar protocol, infants were fed either green beans or a variety of vegetables either between meals or between and within meals for 8 days. In all 3 groups, the intake for green beans increased after the exposure. In addition, the group which received variety of vegetables both between and within meals further increased their intake for carrot and spinach puree (Mennella et al., 2008). Daily alternation of 3 different vegetables for 9 days (10 changes in total) significantly increased the intake of a novel vegetable puree in comparison to vegetable monotony or limited variety (exposure of the same 3 vegetables for 3 consecutive days each, 4 changes in total), with breast feeding further enhancing the effect (Maier et al., 2008).

These findings show that, at the beginning of solid introduction, repeated exposure to single fruits and vegetables and a limited variety in flavours can increase the intake of both target and novel foods. Additionally, offering increased variety with frequent flavour changes can be even more beneficial for both target and novel foods. The effects of variety were shown to persist beyond infancy. In toddlerhood, greater variety of fruit and vegetable tried at 14 months of age predicted significantly higher preference for fruit and vegetables at 3.7 years of age, while the number of vegetables tried at 14 months predicted significantly lower food fussiness score at 3.7 years, independently from confounding factors (Mallan, Fildes, Magarey, & Daniels, 2016).

In conclusion, in order to achieve greater acceptance for fruits and vegetables, a prolonged exposure period (Skinner et al., 2002) and a great diversity and variety (Pelchat & Pliner, 1986) are also needed. These methods, however, are often too demanding for mothers both emotionally and financially. Thus, they are disinclined to try them, arguing instead that the child does not like the food in question (Skinner et al., 2002, Carruth & Skinner, 2000, Birch et al., 1987)

2.3.4 SUMMARY OF THE EFFECTS OF PARENTAL INFLUENCE ON CHILDREN'S EATING BEHAVIOUR

Research into the effects of parental feeding styles and practices on the eating behaviour of infants and toddlers is very limited. From the literature available, controlling feeding practices appear to exert favourable impacts on eating behaviour and body weight. However, as children get older, factors beyond parental control that may be linked with the cognitive development of the child also have an impact on their eating behaviours.

When considering the actual strategies employed to influence intake at weaning, ensuring an infant's personal involvement with the food, providing access to a variety of foods and offering repeated exposure to foods are key to increase food acceptance and constrict feeding difficulties. However, in older children, less controlling practices have better outcomes long-term. Additionally, modelling, as a method of healthy eating encouragement, seems to be more successful in establishing healthier eating habits and body weight across all ages.

To summarize, the relationship between parental feeding practices and children's eating behaviour is amphidirectional. Parental feeding practices may influence a child's weight and eating behaviour. However, if the outcomes are considered unhealthy or undesirable they may in turn feedback and moderate future parental practices. Whether parental feeding practices are able to exert benefical effects depends on a number of factors, including the consistency of the practice, the feeding style of the parent, the age of the child and whether the input derives from the mother or father.

2.4 LATE INFANCY AND TODDLERHOOD BLIND SPOT

Examining the mechanisms associated with the formation of healthy eating habits early in life is clearly important. However, at present, the majority of the literature focuses on the very early postnatal period and its associated milk feeding practices, or later in childhood focusing on eating behaviour of nursery and school aged children. This is understandable considering the sample recruitment difficulties. Mothers can be targeted and recruited relatively easy through antenatal classes, hospitals and maternity wards. Furthermore, pregnancy and early postnatal records are usually kept in maternal and infant medical history, enabling location of relevant information from this period. Similarly, nurseries and schools can provide an easily accessible and assembled sample, and school-aged children are usually keen on participating in studies and experiments. However, after discharge from midwives' care and before children start attending

nursery or school, there is a considerable dearth of experimental and observational studies and most of the available knowledge to date is based on surveys. Given that the first years of life represent the period of most rapid and dramatic development across the whole lifespan and contains numerous critical periods of metabolic programming and behavioural learning, key information is being missed. The fact that literature saturation around this age is disproportionate to the age significance has also previously been addressed in a neuro development context (Rosales, Reznick, & Zeisel, 2009). The present thesis therefore focuses on the development of healthy eating habits during this less explored period of life. The introduction to solid feeding acts as a focal point of the thesis. From here, factors influencing vegetable acceptance during this introductory period are examined. Additionally, consideration is given to the longer-term consequences of the methods followed to introduce solids and, specifically, how they track into and impact on feeding behaviour in toddlerhood.

CHAPTER 3
METHODOLOGY

3.1 ETHICAL APPROVAL

3.1.1 LABORATORY- BASED STUDY

The laboratory based study gained ethical approval from the physical interventions Ethics Sub-Committee of the University of Liverpool. Approval number: RETH000603 Approval date: 12th of March 2013

3.1.2 ON-LINE SURVEYS

All 3 on-line surveys gained ethical approval from the Ethics Committee of the Institute of Psychology, Health and Society of the University of Liverpool.

Approval numbers:

IPHS-1314-290-Parent-led or baby-led? Associations between complementary feeding styles and the development of healthy food preferences. (Weaning experiences and food preference) (Approval date: 21st of March 2014)

IPHS-1415-110-An online study to investigate the opinions and experiences of mothers who formula feed their infants (Formula Feeding Mothers: Opinions and Experiences) (Approval date: 30th of January 2015)

IPHS-1415-LB-197-An online study to investigate the opinions and experiences of mothers who breastfeed their infants (Approval date: 30th of March 2015)

3.2 RECRUITMENT AND SCREENING

3.2.1 LABORATORY-BASED STUDY

3.2.1.1 RECRUITMENT

Mothers (and their infants) were recruited from the Merseyside area via study advertisements placed in the local press, via posters displayed in public areas relevant to mothers and flyers distributed at appropriate locations around the region (e.g. nurseries, play groups, sports centres and community centres offering activities for pregnant women or women and young children) and via personal researcher visits to local community centres, council run Children's centres and other relevant groups.

Volunteers who were interested in participating contacted the researchers either via phone or email. They were given full information on the study, including detail relating to the amount of commitment participation required from the mother. The researcher

answered any questions volunteers might have before asking simple screening questions to assess basic eligibility.

3.2.1.2 Screening Procedure and eligibility criteria

During a brief telephone screen pregnant mothers were asked information about their current health status, any pregnancy complications and food allergies. Mothers with health conditions affecting eating, pregnancy complications or food allergies were excluded from the study. Post-partum mothers were also asked for the baby's birth date, the gestational week of birth and if there were any complications during pregnancy/labour. Infants born before the 38th week of gestation or with an Appearance (skin color), Pulse (heart rate), Grimace (reflex irritability), Activity (muscle tone), and Respiration (APGAR) score less than 3 were excluded from the study.

Following the telephone screening, individuals who were found to be suitable were forwarded the relevant information sheet (e-mail or paper copies) with a request that they contact the researcher again if they remain interested after reading the study information. For those who expressed interest an appointment for further screening was arranged at a convenient place and time for mother.

At the full screening visit the process of informed consent was completed. Prior to the signing of the consent form no further information was taken other than that obtained at initial contact. The details obtained at full screening are described in the Methods and Tools section below.

One month after birth (or at screening for mothers recruited after this time, but prior to weaning), the mothers were contacted to determine their success in establishing a feeding approach. Infants fed non-hydrolysed milk-based formulas with little or no experience with breastfeeding (<3 weeks) were recruited to the formula fed group. Any unable to successfully establish breastfeeding by this point were excluded from the breastfeeding group. Mothers intending to breastfeed will not always be able to exclusively breast feed to the point of weaning. Therefore, mothers able to feed infants predominantly breast milk (breast milk plus a maximum of 2 feeds of any other food or liquid in a 7 day period; Breastfeeding definitions. Breastfeeding Committee for Canada, 2006) for most other times were retained.

3.2.2 On line studies

3.2.2.1 Recruitment

For all on line studies participants were recruited through social media specifically parenting, infant feeding and baby item sales Facebook groups. Where appropriate,

consent from the group administrators was obtained prior to posting the relevant advertisement. The advertisement included a brief description of the study, the estimated time for completion and a direct link to the study where participants could read the information sheet. Where questions from mothers were raised, the researcher replied either through the comment section of the advertisement post, or, if the answer could create biases to the rest of the participants, via direct message.

3.2.2.2 ELIGIBILITY CRITERIA

Detailed eligibility criteria for each study are presented in the method sections of chapters 5 and 6. In addition, all participants were required to have knowledge of the English language to a degree where they were able to understand the written information provided.

3.3 DATA COLLECTION:

3.3.1 LABORATORY BASED STUDY

3.3.1.1 LABORATORY SET UP

The Infant feeding laboratory in the Eleanor Rathbone building of the University of Liverpool was decorated and equipped with appropriate instruments in order to create a "baby friendly" environment and make mothers and infants feel as comfortable as possible in laboratory feeding conditions. This was necessary to minimise any impact on feeding behaviour caused by the unfamiliar environment.

The laboratory consisted of two connected rooms as shown in the figure 9, an observation and a testing room. These were separated by a 2 way mirror to allow the researcher to observe the feeding session without interrupting or obscuring events. The testing room contained three dome cameras capable of recording high resolution close-ups images of mothers' and infants' faces as well as the whole feeding event.

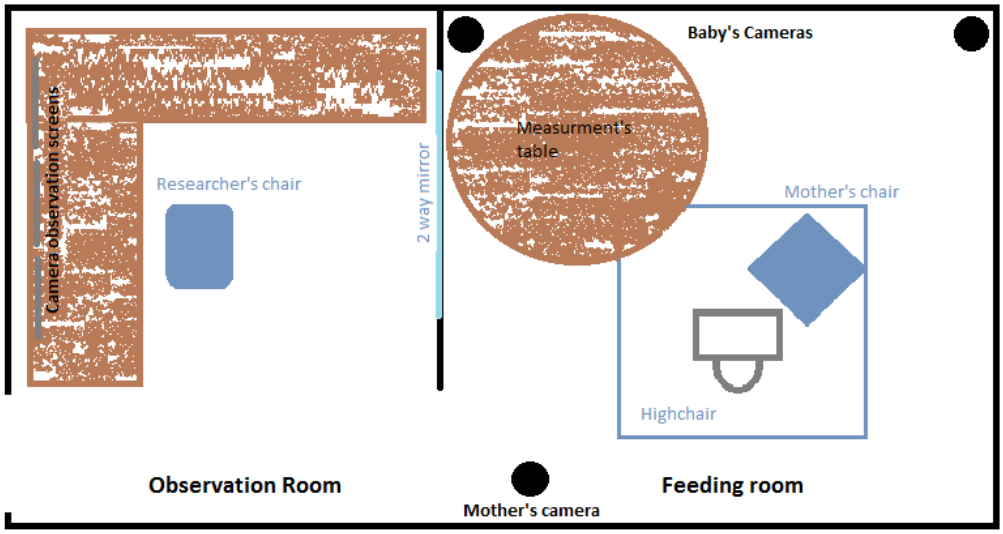

Figure 2: Infant feeding laboratory set up

3.3.1.2 VEGETABLE PUREE PREPARATION

Vegetable puree preparation took place in the Kissilleff laboratory of the Eleanor Rathbone building of the University of Liverpool and was undertaken by the food and hygiene trained researcher.

Frozen vegetables were initially steamed before being blended with sterilized water in amounts presented in table 20 to create an appropriate consistency for consumption. For each session 200g of each puree was prepared, but only 150g were served to the infants. The purees were made in batches of 3-4 portions each time and retained at -20oC after their preparation until they were consumed or for a maximum of 3 months from the preparation date. On the testing day the frozen purees were thawed covered in the microwave oven, to retain moisture and were allowed to cool to room temperature prior to service

Table 3: Recipes for vegetable puree used for testing and estimation of vegetable, water and caloric content at the served puree.

Ingredients	Carrot Puree		Spinach puree		Broccoli puree		Cauliflower puree	
	Prepared (200g)	Served (150g)	Prepared (200g)	Served (150g)	Prepared (200g)	Served (150g)	Prepared (200g)	Served (150g)
Vegetable (frozen)	200g	150g	200g	150g	300gr	225gr	300gr	225gr
Steaming time	10 minutes		16 minutes		25 minutes		25minutes	
Vegetable (steamed)	156g	117g	200g	150g	180g	135g	180g	135g
Water	44 g	33g	0g	0g	20g	15g	20g	15g
Total calories	71.8kcal	54.3kcal	64 kcal	48kcal	50.4kcal	37.8kcal	34.2kcal	25.7kcal

3.3.1.3 LABORATORY TESTING PROTOCOL

For mothers who were recruited during pregnancy, telephone contact was made one month after the expected due date to establish whether they were still interested in study participation. Regular telephone contact from the researcher was maintained during the period between screening and weaning, aiding both compliance and retention. Telephone calls were also used as a means of reminding mothers to notify the laboratory (by telephone call, text message or e-mail) when weaning commenced and on every occasion a novel food item was presented during weaning.

Mothers were familiarised with the laboratory at or shortly after screening to allow them to feel more comfortable when they return for testing. To familiarise the infants with aspects of the testing procedure, prior to testing each mother was provided with a bib, spoons and bowls for her infant's home use. Their use began 3 days before the first test day and continued until the completion of testing. Mothers were provided with instructions detailing how to incorporate the items into their infant's normal daily feeding routine.

Testing began approximately 4 weeks after weaning commenced. Test sessions were spaced approximately 4 days apart and began at approximately the same time of day that the infants were usually fed. Mothers were asked to feed their baby approximately 2hr before the test session such that behaviours observed could not be attributed to hunger or satiety.

On entering the laboratory, mothers and infants were given a period to re-familiarise themselves with the laboratory set up. Toys were available. The researcher remained with the mother and infant, talking to them, playing with the child and answering any

remaining queries. Once the infant was comfortable, the mother placed them in the highchair where the infant again had the opportunity to play with toys. The study began once the infant was at ease. The researcher left the room, the toys were removed and the food was provided to the mother. When signalled, the mother fed the infant in her usual way, maintaining as natural an interaction as possible. Mothers were able to mimic consumption of the food but not permitted to consume it. The feeding session ended when mothers indicated through removal of the infant's bib.

Infants were presented with 4 different vegetable purees (carrot, spinach, broccoli and cauliflower) in counterbalanced order, on separate test days, to prevent order effects. In addition to measuring intake, infant feeding behaviour was observed (via a 2 way mirror and video cameras) and recorded via CCTV system (Everfocus ECOR264-4X1). Validated and standardised tools were used to assess the quality and content of mother-infant feeding interactions observed (see section 1.3.3).

3.4 MEASURES AND TOOLS

All the materials and tools used for both studies, apart from the NCAST scoring sheet can be found on line following this link: http://tinyurl.com/PhDmaterial. NCAST scoring sheet has a copy write and its reproduction and distribution is illegal. A copy will be available for the examiners to view during viva examination.

3.4.1 LABORATORY BASED STUDY

3.4.1.1 ANTHROPOMETRIC MEASURES

Maternal and child anthropometric measures were obtained in the first feeding session. Mothers were weighted on a Seca 888 compact digital floor scale with 2 decimals accuracy and their height was measured on Seca 213 Portable Height Measure. Infants' weight was measured on a Seca 384 Baby and Toddler scale and their length on a Seca 417 portable measuring board.

3.4.1.2 QUESTIONNAIRES

At screening mothers completed a questionnaire to identify any medical problems and family allergies and to obtain descriptive data on socio-economic status, birth order, gestational age at birth and birth weight of their youngest child in order to confirm that they meet the eligibility criteria for the study. Participants who fulfilled the study criteria were recruited to the study and assigned a code number.

After screening, eligible mothers completed a pack containing questionnaires on their eating habits and behaviours.

The Dutch Eating Behaviour questionnaire (Strien & Frijters, 1986) consists of 33 items scored on a 5 point likert scale. It assesses 3 dimensions of eating behaviour; emotional eating, externally induced eating and restrained eating. The scale has high reliability, with Cronbach's α coefficient 0.88 for the restrictive eating, 0.98 for the emotional eating and 0.80 for the external eating subscale in this sample.

The adult neophobia scale (Pliner & Hobden, 1992) was designed to assess trait food neophobia. It contains 9 items rated on a 7 point scale with options labelled "disagree strongly", "disagree moderately", "disagree slightly", "neither agree nor disagree", "agree slightly", "agree moderately" and "agree strongly". The scale was found to have satisfactory internal consistency (Cronbach's α 0.79) in this sample.

A researcher developed questionnaire assessing maternal liking for 21 vegetables and 12 fruits commonly used in UK households was also used. The items were rated on a 5 point scale ranging from 'like a lot' to 'dislike a lot', with a never tried option available.

Before the first visit, mothers were sent a further questionnaire pack to complete and return at the visit. This included:

The Baby eating behaviour questionnaire (Llewellyn, van Jaarsveld, Johnson, Carnell, & Wardle, 2011) consists of 18 items scored on a 5 point likert scale and assessing 4 dimensions; satiety responsiveness, food responsiveness; Enjoyment in food and slowness in eating. Internal consistency of this scale was found moderate, with Cronbach's α ranging between 0.7 and 0.58 depending on the dimension.

The infant characteristics questionnaire for infants aged up to 6 months (Bates & Bayles, 1984) consists of 28 items scored on a 7 point likert scale and assessing the infants temperament and characteristics across 4 dimensions; Fussy – Difficult, Unadaptable, Dull and Unpredictable. Internal consistency was medium to satisfactory depending on the dimension with α=0.79 for the fussy/difficult factor, α=0.48 for the unadaptable factor and α=0.55 for the unpredictable factor.

A researcher developed questionnaire assessing infant liking for fruits and vegetables commonly used in UK households, and comparable to the maternal questionnaire completed at screening.

Prior to each-testing session mothers were also asked to complete a 3 day infant feeding diary as reductions in normal levels of intake may reflect underlying conditions that could confound the study findings.

After each feeding sessions, mothers rated their infant's enjoyment, fullness and satisfaction on visual analogue scales (VAS) and their overall assessment of the feeding session on a 9-point Likert scale. Free answer space was available for mothers to provide justification for the ratings given. To avoid bias, mothers were unaware of the exact amount eaten.

3.4.1.3 VEGETABLE INTAKE

The vegetable intake was measured for each feeding session. After thawing, and before serving, the bowl with the vegetable puree weight was measured in grams on a Sartorius CPA4202S (Data weighting Systems) scale with 2 decimals accuracy. After the feeding session, all the remaining puree was collected back to the bowl and the weight was measured again on the same scale. The vegetable puree intake was calculated by subtracting the weight of the remaining vegetables from the pre-serving weight.

3.4.1.4 PARENT-CHILD INTERACTION FEEDING SCALE

The mother-infant interactions during feeding were coded with the Nursing Child Assessment Satellite Training (NCAST) tool, which contains the Nursing Child Assessment Feeding Scale (NCAFS). Coding was completed by the researcher trained in the assessment and with more than 85% reliability with the scale standard scoring.

NCAFS is a validated measure of caregiver/parent-child interactions during feeding based on the Barnard model of caregiver-infant relationship. According to this model both caregivers and infants have definite responsibilities in order to maintain the flow of the interaction. For the caregiver, the responsibilities are to respond to the infant's cues, alleviating infant's distress and provide opportunities for Social-Emotional and Cognitive growth fostering. The infant is responsible for providing clear cues and being responsive to the caregiver. In order for the interaction to run smoothly, these responsibilities interact with each other and adapt accordingly. When, however, this adaptation is interrupted the interaction can be seen as maladaptive.

The scale consists of 76 items organized in 6 subscales. Each item is scored binary with a yes score if the behaviour appears during the feeding session and no if the behaviour is absent. The subscales are presented in the table 21. The coder scored the interactions through the video recordings of the infant feeding sessions. Each session was viewed as many times as appropriate to provide the most accurate scoring. After scoring, the scores for each subscales and the whole scale were calculated.

Table 4: NCAST feeding scale subscales.

I. Sensitivity to Cues
II. Response to Child's Distress
III. Social Emotional Growth Fostering
IV. Cognitive Growth Fostering
V. Clarity of Cues
VI. Responsiveness to Caregiver

3.4.2 ON LINE SURVEYS

3.4.2.1 QUALTRICS PLATFORM

The three on line surveys were created on the Qualtrics platform, which enables data collection and storage. All data was anonymised. Any personal data collected (such as email address for contacting the winner of a prize draw offered in reimbursement for participation) was stored in a separate database which was not linked to the survey responses.

3.4.2.2 COMPLEMENTARY FEEDING SURVEY QUESTIONS

Demographic characteristics were asked in the first part of the survey. These included self-reported maternal and paternal weight and height, ethnicity and occupation (according to National Statistics Socio-economic 8 option Classification). The child's age, weight at birth and birth order were also obtained along with limited information about breastfeeding initiation and duration.

Parents where asked about the type (baby cereal/fruit/vegetable/other) and the texture (puree/finger food/other) of the first food item, besides milk, that was offered to the child. Additionally, the age of solid and finger food introduction in weeks was requested.

To assess the complementary feeding style followed, parents were asked to use a sliding scale from 0% of the time to 100% of the time to indicate the time their child fed themselves at one month after the first solid introduction. Participants were subsequently grouped into four categories; strict BLW (self-feeding 90% or more of the time (Brown & Lee, 2011a, 2011b, 2013a, 2013b; Brown, 2015)); predominant BLW (self-feeding between 50% and 90% of the time); predominant PLW (self-feeding between 50% and 10% of the time) and strict PLW (self-feeding less than 10% of the time).

Family mealtime habits were assessed using 3 questions previously applied in a similar study (Cameron et al., 2012) ;"Currently, how often do you eat with your child?" "Currently, how often your child has the same meal you are eating (modified or at a different time)?" and "How often your child eats commercially prepared food (ready-made meals, food in restaurant and packaged snacks)?" with response options presented on a 5 point likert scale.

Child's eating behaviour was assessed using the child eating behaviour questionnaire (CEBQ) (Wardle, Guthrie, Sanderson, & Rapoport, 2001).It includes 35 items in eight dimensions which are associated with either underweight or overweight in later life (Food responsiveness α=0.77, Emotional over-eating α=0.72, Enjoyment of food α=0.81, Desire to drink α=0.72, Satiety responsiveness α=0.70, Slowness in eating α=0.65, Emotional under-eating α=0.79 and Food fussiness α=0.87). Slowness in eating was not included in this analysis due to the lower chronbach's α value

The Parental Feeding Styles Questionnaire (PFSQ; (Wardle, Sanderson, Guthrie, Rapoport, & Plomin, 2002) was used to assess the parental feeding practices. The PFSQ is a 27 item scale assessing four different dimensions recognised as potential contributors to the development of obesity (emotional feeding α=0.84, instrumental feeding i.e. using food as a reward α=0.84, prompting/encouragement to eat α=0.78 and control over eating α=0.82).

A researcher generated questionnaire assessing child's liking for 21 vegetables and 12 fruits commonly used in UK households was also used. The items were rated on a 5 point scale ranging from 'like a lot' to 'dislike a lot', with a never tried option available.

3.5 DATA ANALYSIS

The statistical packages SPSS 21 and 22 were used for the quantitative analysis of the data obtained. For the coding of the qualitative data and content analysis NVIVO10 was used.

Details for the specific statistical analysis followed in every study can be found in the relevant chapters.

CHAPTER 4
LABORATORY STUDY

Data from this chapter has been presented as a poster presentation at EGEA VII, Healthy Diet, Healthy environment within a fruitful economy: The role of fruits and vegetables conference, 3rd-5th June 2015, Milan, Italy.

4.1 INTRODUCTION

The public health benefits of eating a healthy diet are well established. Dietary patterns can help to reduce the risks of chronic disease and prevent obesity, thereby extending and improving quality of life. Increasing daily consumption of fresh fruit and vegetables is particularly good for improving health. Indeed, the World Health Organisation recommends eating at least five portions of fruit and vegetables daily (WHO, 2003). Dietary habits in the UK however are generally poor with intake below the recommended levels (Cooke et al., 2004, Wardle et al., 2001)

For compliance with global recommendations, interventions promoting fruit and vegetable intake are needed. As discussed within the introduction, food preferences are formed in early childhood and therefore interventions may be most effective in the formative years when eating behaviours are being established. Determining the early factors that influence children's food choice is therefore critical. Epidemiological data suggest that breastfeeding may protect against the later development of obesity in children, but the reasons for this are still unclear (Yan, Liu, Zhu, Huang, & Wang, 2016). Notably, there is evidence that flavour can be transmitted through breast milk and may influence food acceptance at weaning, an important step in the infant's development of food preferences (Hausner, Nicklaus, Issanchou, Mølgaard, & Møller, 2010; Maier, Chabanet, Schaal, Leathwood, & Issanchou, 2008; Mennella & Beauchamp, 1999). By improving maternal diet and consequently children's acceptance of healthy foods and susceptibility to obesity, the effectiveness of breast feeding to improve long-term health outcomes could be increased.

Given the importance of breastfeeding in the prevention of later disease and the specific need to change children's food preferences to combat child obesity, research in this area is surprisingly limited. The potential for breast feeding alone (without supplemental flavour exposure) to facilitate acceptance of novel dietary flavours at weaning, compared to formula feeding, remains equivocal. In a small number of studies, a general effect of early feeding (breast milk vs. formula feeding) on infants' acceptance of weaning foods have been observed (Forestell & Mennella, 2007; Hausner et al., 2010; Maier, Chabanet, Schaal, Issanchou, et al., 2007; Maier et al., 2008; Sullivan & Birch, 1994). These studies tend to show that breast fed infants appear to accept weaning foods more readily than formula fed infants. However, it is not clear whether this difference is observable on the first exposure or whether repeated exposure is required. Furthermore, there is evidence to suggest these effects may be dependent on the vegetable served, with the intake of 'well-liked' vegetables (carrots) generally reported to show little difference between breast-fed

and formula fed infants but intake of 'disliked' vegetables (artichoke, cauliflower, pumpkin, green beans, spinach) being greater amongst breast fed than formula fed infants (Maier et al., 2007).

Unlike milk feeding practices, the impact of the method of weaning chosen by parents on food liking in their infant, has not been explored in the literature. However, studies have highlighted some differences in eating behaviour, and in particular food fussiness and food and satiety responsiveness between infants who were spoon fed by an adult and those who were allowed to self-feed themselves using finger food (Brown & Lee, 2015; Cameron et al., 2013; Townsend & Pitchford, 2012). In all studies, self-feeding (commonly referred to as baby led weaning) is reported to have a beneficial effect on healthier eating behaviours during infancy. This could potentially lead to healthier eating habits, with decreased food fussiness leading to healthier food intake. This hypothesis, however, has not been explored to date.

The assessment of infants' liking for foods is a complex task reflecting the limited cognitive and communication abilities of this age range. Studies examining enjoyment and liking of food in infancy, particularly during weaning, rely on an array of indirect methods including the measurement of the amount of food consumed, the eating duration or the pace of feeding (Forestell & Mennella, 2007, 2012; Mennella, Forestell, Morgan, & Beauchamp, 2009; Mennella, Jagnow, & Beauchamp, 2001; Mennella & Beauchamp, 1997; Schwartz, Issanchou, & Nicklaus, 2009). Other indirect methods rely on parental (typically maternal) input to rate different aspects of the feeding event. Typically this takes the form of maternal perceptions of infant liking and enjoyment (Forestell & Mennella, 2012; Maier et al., 2008; Mennella et al., 2008). Whilst the more direct nature of such measures could be considered advantageous, the potential for the introduction of maternal biases should also be recognised. The feeding event and the infant itself will offer a plethora of cues which may help inform the perceptions developed. However, inputs such as previous experiences, opinions and behaviours of the mother will also help to mould outcomes.

Infants' facial expressions provide probably one of the most obvious cues to infant liking. They are readily available to both researchers and caregivers and are frequently used in feeding studies as an objective tool to indirectly assess liking during the eating event (Forestell & Mennella, 2007, 2012; Hodges, Hughes, Hopkinson, & Fisher, 2008; Mennella et al., 2001; Mennella & Beauchamp, 1997). However, the research systems available to code these expressions are rather complex. The most commonly used coding system is an adaptation of the Facial Expressions Coding System (FACS) which was

developed almost 40 years ago (Ekman, Friesen, & Hager, 2002). This method includes very detailed face muscle movement mapping and requires extensive and time consuming training to be applied accurately. The system has been adapted for infant's specific face muscle movement analysis (baby FACS) (Oster, 2006). Recently, a simplified and more user friendly coding system was developed and validated for use in feeding sessions [Feeding Infants: Behaviour and Facial Expression Coding System (FIBFECS)] (Hetherington et al., 2016). In addition to the coding of infants' facial expressions FIBFECS incorporates other aspects of feeding related infant behaviours (such as reaching for the spoon or turning the head away in refusal) to provide a more complete approach to the assessment of infant liking for food.

While infant facial expressions can provide valuable information during a feeding event, reliance on these cues can be misleading. For example, examination of the impact of repeated exposure to novel tastes (green beans) has shown that over time intake increases, yet the frequency of negative facial expressions does not decline (Forestell & Mennella, 2012). Conversely, other studies have reported fewer negative facial expressions in infants previously exposed to carrot flavour compared to those without prior exposure, but no difference in intake was recorded (Mennella et al., 2001). A further limitation introduced through a reliance on coding facial expression is the uncertainty that arises as a result of the variability infants demonstrate in terms of both the type of expressions displayed and the frequency in which they appear (Forestell & Mennella, 2007, 2012). These clear limitations support examination for an alternative means of assessing infants' liking for foods.

Previous studies have shown that mothers do focus on facial expressions in the assessment of their infant's perception of food. However, they have been shown to incorporate other feeding related cues, such as length of the feeding event, into the process (Forestell & Mennella, 2012). Yet, the full range of criteria mothers use to assess infants' food liking and preference has been largely underexplored in the literature and requires further investigation. It is likely that through their maternal interactions with the infant, in both feeding and non-feeding situations, they acquire a plethora of information that can be combined to enhance the assessment of preference.

Although experiences acquired through mother-infant interactions could be insightful, the potential for maternal biases to influence opinions remains a potential limitation. This short coming could possibly be overcome through researcher application of a tool designed to code mother-infant interactions. The Nursing Child Assessment Satellite Training (NCAST) tool contains the Nursing Child Assessment Feeding Scale (NCAFS),

which is one potential tool. The NCAFS is a validated measure of caregiver/parent-child interactions during feeding based on the Barnard model of caregiver-infant relationship. It consists of 76 items organized in 6 subscales. Each item is scored binary with a yes score if the behaviour appears during the feeding session and no if the behaviour is absent. Coding is achieved by a trained researcher examining interactions via video recordings of the infant feeding sessions. This approach allows each session to be was viewed as many times as required to provide the most accurate scoring.

Maternal eating behaviour is also likely to affect many aspects of the feeding interaction including feeding outcomes. As mentioned previously, mothers who don't rely on internal hunger cues, such as external, restrained and emotional eaters (as identified using the DEBQ), are more controlling of their child's food consumption (Brown & Lee, 2011b), introduce formula earlier (Brown, 2014) and offer more unhealthy and less healthy food choices (Shloim, 2014). There is also the strong potential that maternal neophobia (the fear of novel foods) will have an impact on feeding outcomes. For older children, maternal neophobia has been associated with maternal restrictive feeding practices and inversely marginally associated with a healthy eating environment (Cin Tan & Holub, 2012). However, none of these studies, however, were large scale and drawing conclusions from them is risky. Furthermore, the effect of maternal neophobia on infant's feeding outcomes is poorly studied. One study that looked on the impact of maternal neophobia on breastfeeding duration or age of solid introduction did not reach a clear conclusion (Vaarno et al., 2015).

Obviously, infants also contribute to the feeding interaction. Consequently, infant characteristics also have the potential to impact in feeding outcomes. Infant temperament has been identified as a potential contributory factor. Differences in temperament between formula fed and breast fed infants have been suggested in literature. More specifically, very limited literature suggests that breast fed infants may exhibit more difficult temperamental characteristics, with increased fussing and crying at 3 months of age (de Lauzon-Guillain et al., 2012). Consequently formula and solids are commonly used by caregivers as they believe that it will "settle" a baby into a better routine (Brown, Raynor, & Lee, 2011a). However, these findings are from cross sectional data and there is no indication of a causal relationship. Differences in temperament between infants who follow baby lead weaning and their spoon-fed peers hasn't been explored to date.

On the basis of the literature reviewed above, this chapter has been divided into three distinct but related parts. The first will assess for acute effects of early (milk) feeding practice and solid food introduction method at weaning, examining for differences in

terms of acceptance of vegetables with different sensory characteristics. The aim of the second section is to explore the distinct criteria used by mothers when they make a judgement of their infant's liking of the foods offered to them and to examine whether any criteria offer potential as alternative measures to be applied in the research field. The final part will explore the possibility of applying detailed behavioural observations of mother-infant interactions (NCAST) as an alternative measure of infant's acceptance of foods. Measures of flavour acceptance will include 1) infant intake of each test puree; 2) maternal assessment of infant responses to each puree and, 3) detailed behavioural observation of mother-child interactions.

4.2 PART 1: DIFFERENCES IN VEGETABLE INTAKE AT WEANING: IMPACT OF MILK FEEDING HISTORY AND SPOON FEEDING EXPERIENCE.

4.2.1 AIMS AND OBJECTIVES

The first part of this chapter relates to the first research question:

How do early life experiences (both milk feeding and the introduction of solid food) affect vegetable intake during the early weaning period?

4.2.2 METHODS

4.2.2.1 PARTICIPANTS

47 mother and infant pairs were recruited via advertisements on local Facebook groups and Twitter, in parent magazines and at mother and baby groups held at local Surestart children's centres. Exclusion criteria included maternal age less than 18 years old, maternal or infant medical problems, family allergies, complications during pregnancy or delivery (such as gestational diabetes, APGAR score <3 or delivery before the 38th week of gestation). Infants with feeding problems (tongue or lip tie, severe reflux or required tube feeding) were also excluded from the study. More information about the recruitment process is included in the chapter 3.

From the 47 participants initially recruited, 2 were excluded because they were taking medication for depression, 7 withdrew before the first testing session and 3 after the second session. Participants were not required to provide a reason for withdrawal. 35 mother and infant pairs completed all 4 visits and were included in the final analysis. 24 of the infants were exclusively breast fed [EBF] and 11 were exclusively formula fed [EFF] until the complementary feeding introduction.

4.2.2.2 DATA COLLECTION

During screening mothers completed a questionnaire assessing maternal liking for 21 vegetables and 12 fruits commonly used in UK households. Responses were provided on a 3 point likert scale. They also completed a food frequency questionnaire for the past 12 months with 9 frequency options.

Following successful recruitment to the study, mothers were asked to contact the researcher when they introduced any food in addition to milk (breast or formula) to their infant's diet. In the period between recruitment (typically during pregnancy or soon after birth) regular contact was maintained through emails and telephone calls to ensure that mothers were still happy to continue with the study. When mothers indicated that solid food had been introduced, a pack with a bowl, a spoon and 3 bibs, identical to those to be used in the laboratory testing sessions was sent to them. The pack also included instructions to use them as often as possible to help the babies familiarize themselves with the utensils.

A month after the introduction of solid food, mothers and infants attended 4 feeding sessions in the infant feeding laboratory of the University of Liverpool. Visits were scheduled at least 3 days apart. During the visits mothers were provided with 150g of vegetable puree (carrot, broccoli, spinach and cauliflower) in a randomized order and they were instructed to feed the baby as they would in their home settings. The vegetables were picked based on suitability for provision at weaning along with reference to the available literature to identify both liked and disliked vegetables as well as both frequently offered and novel vegetables. Spinach, cauliflower and broccoli were selected as disliked vegetables. Spinach and broccoli contain molecules that give them their green colour, but also give them a bitter taste. Broccoli and cauliflower, both belong to the family of cruciferous vegetables that contain molecules containing sulphur, again characterised but bitter taste. Carrot on the other side, is naturally sweet and has been used previously in research as a test vegetable. The feeding sessions were video recorded using 3 cameras, 2 focused on the infant's face, and 1 focused on the mother's face.

Before the first feeding sessions mothers were asked to complete and bring with them the Baby Eating Behaviour Questionnaire [BEBQ], Infant Characteristics Questionnaire [ICQ] for 6 months, a food frequency questionnaire about their infant's food consumption during the last week and a questionnaire reporting infant fruit and vegetable likes and dislikes, similar to the one completed to indicate their own preferences. Additionally, they were asked to complete a 3-day feeding diary prior to each visit. The information from the 3-day infant feeding diaries was used to identify whether infants

were fed using utensils and consequently to categorise the infants according to their spoon-feeding experience. Although this method was not ideal, it allowed a retrospective estimation for the use of utensils, as alternative or no utensil use was not factored in the initial design of the study. Additionally, the number of times vegetables, particularly carrot, spinach, orange, or green vegetables, appeared in the 3-day log were counted as a measure of vegetable familiarity. For each infant, the 3 day diaries from all 4 sessions (12 days in total) were used. For more information on the questionnaires used see the Methodology chapter (Chapter 3)

The infant's weight was measured at the first session. Infants were placed on the scale without any clothes or nappy. At the end of each feeding session mothers were asked to rate the enjoyment, satisfaction and fullness of their infant on Visual Analoge Scales (VAS). Their overall assessment of the food liking was also provided using a 9 point likert scale.

4.2.2.3 DATA ANALYSIS

All variables were tested for homogeneity to determine whether comparisons using parametric tests were appropriate. As the variables on this part followed a normal distribution, parametric test were used throughout. For all post hoc comparisons, Bonferroni corrections were used.

To examine the characteristics of the different participant groupings applied and to explore and identify potential explanations for the repeated measures ANOVA results, infant's body weight at the first visit, age of solid introduction, infant's temperament and maternal eating behaviour and food neophobia were compared between exclusively breast and formula fed infants as well as between babies with and without spoon experience using independent samples t-test on SPSS 22. It is possible that those factors could have a confounding effect on the study results. Adjustments for the factors that differed significantly between the groups were initially considered, however after seeking statistical advice it was advised that, due to the small sample size, this approach would be neither appropriate nor informative.

One way repeated measures ANOVA was used to identify the differences in intake of the vegetable intakes in grams, maternal ratings of infant's liking, satisfaction and fullness as well as maternal liking of the same vegetables (carrot, spinach, broccoli and cauliflower) for the overall sample.

A two ways mixed ANOVAs (2x4) with repeated measures for the type of vegetable variable were used to detect difference between and within groups for milk feeding and

spoon feeding history. For both milk and spoon-feeding history a binary variable was used (breast and formula fed/ experience with spoon yes/no).

The repeated measures design was selected to reduce the size of the variability error associated with the within groups variability. The design removes the variability that occurs due to the individual differences at each session and, ultimately, reduces the size of the error and increases the test power to detect difference between the means.

4.2.3 RESULTS

The baseline characteristics of infants and their mothers are shown in table 5, split per milk feeding practice and tables 6 and 7 split according to experience of using a spoon at weaning. Formula fed infants were found to be heavier than breast fed infants $t(33)=-2.46$, $p=.019$. When comparing data from the BEBQ, formula fed infants were also found to be less food responsive $t(33)=14.11$, $p<.001$, while the difference in satiety responsiveness approached but failed to reach significance $t(33)=3.90$, $p=.057$. However, no significant differences were found for any of the other variables examined When infants were divided per experience of using a spoon during the introduction to solids, the only difference identified was in the age of introduction to solids. Infants who did not have any prior spoon-feeding experience were introduced to solids significantly later, than their peers $t(33)=7.62$, $p=.009$ when a binary split was considered. When three distinct groupings were generated according to experience of spoon use at introduction to solids, an effect of group on age of introduction to solids was identified $F(2,32)=7.25$, $p=.003$]. Post hoc tests identified that the differences lay between no spoon feeding experience and only spoon feeding experience ($p=.002$) while difference between mixed spoon and fingerfood experience and only spoon feeding experience approached but didn't reach significance ($p=.066$)

Overall, no significant differences were identified between the four different vegetable purees in terms of intake in grams ($F(3,136)=0.842$, $p=.473$) or the various maternal ratings of their infant's liking (table 8).

Looking more specifically for differences across the four vegetables for breast fed and formula fed infants, there were no overall effect of vegetable type ($F(3,99)= 1.65$, $p=.194$). Additionally, although in all cases intake in formula fed babies was higher, there was no significant effect of milk feeding practice ($F(1,33)= 2.80$, $p=.103$). Furthermore, no significant difference was identified when comparisons were made for the interaction of vegetable type and milk feeding history (breast or formula)

(F(3,99)=0.39, p=.715). (table 9). Similar patterns of results were observed for the maternal ratings of enjoyment and overall liking (table 10).

When grouping the infants according to their spoon feeding experience, no significant effect of vegetable type was identified for intake in grams (F(3,136)=1.53, p=.221). However, there was a significant main effect of weaning method on vegetable intake (F(1.33) =4.83 p=.035). Post hoc comparisons revealed that infants with no previous spoon experience consumed significantly reduced amounts of spinach (p<.001) and broccoli (p=.032). There was no significant interaction between the weaning method and the vegetable intake (F(3,136)=0.73, p=.510 (table 11). For maternal ratings no associations were observed (table 12)

Although there was no significant difference in the intake of vegetables by the infants, mothers reported significantly different levels of liking (F(3,136)=2.73, p=.047) and consumption (F(3,136)=17.07, p<.000) overall for the four vegetables (table 8). Post hoc comparisons, using Bonferroni correction, revealed that cauliflower was liked significantly less than carrot and broccoli when rated using the maternal vegetable liking scale (cauliflower vs. carrot p=.044, cauliflower vs. broccoli p=.002). Broccoli and carrot were consumed significantly more frequently than cauliflower (Broccoli vs. Cauliflower and carrot vs. cauliflower p<.001 in both cases) by mothers during the last 12 months. No significant differences were identified for spinach liking or consumption.

Mothers whose infants had no experience with spoon feeding reported consuming broccoli significantly more frequent than mothers whose infants had experience with spoon feeding during the past 12 months (p=.035) (table 12).

Table 5: Differences in baseline characteristics between Breast and Formula fed babies

	Total sample (n=35)	Breast fed (n=24)	Formula fed (n=11)	p-value
Infant's birth weight in kg (M±S.D.)	3.56±0.62	3.570.47	3.53±0.89	.852
Infant's weight in the first session in kg (M±S.D.)	7.84±0.88	7.60±0.89	8.34±0.67	**.019**
Age of solid introduction in weeks (M±S.D.)	23.53+-2.98	23.33+-3.30	23.98+-2.17	.552
Maternal eating behaviour (DEBQ) (M±S.D)				
Restrain	23.26+-6.95	22.79+-7.61	24.27± 5.40	.566
Emotional	32.37+-10.22	31.71+-10.6	33.82+-9.64	.574
External	32.88+-5.17	33.67+-5.13	31.00+-5.01	.174
Maternal Neophobia (M±S.D)	19.63+-7.46	18.08+-5.90	23.00+-9.54	.070
Infant Characteristics Subscale Scores (M±S.D.)				
Fussy	17.69±4.79	18.29±4.01	16.36±6.18	.275
Unadaptable	8.41±2.82	8.92±2.92	7.27±2.33	.110
Dull	-0.72±2.12	-0.79±2.32	-0.55±1.69	.755
Unpredictable	9.29±2.48	9.33±2.16	9.18±3.19	.870
Baby Eating Behaviour Questionnaire Scores (M±S.D.)				
Food Responsiveness	12.12+-3.02	13.22+-2.75	9.60+-1.96	**.001**
Food Enjoyment	12.94+-1.39	13.13+-1.26	12.50+-1.65	.238
Satiety Responsiveness	6.94+-1.91	6.54+-1.74	7.90+-2.02	.057
Slowness of Eating	7.24+-0.72	7.25+-1.73	7.20+-1.81	.940

Table 6: Differences in baseline characteristics between babies with and without previous spoon experience.

	Total sample (n=35)	Spoon experience (n=25)	No spoon experience (n=10)	p-value
Infant's birth weight in kg (M±S.D.)	3.56±0.62	3.53+-0.63	3.62+-0.62	.708
Infant's weight in the first session in kg (M±S.D.)	7.84±0.88	7.70+-0.92	8.17+-0.72	.164
Age of solid introduction in weeks (M±S.D.)	23.53+-2.98	22.73+-2.87	25.54+-2.27	**.009**
Maternal eating behaviour (DEBQ) (M±S.D)				
Restrain	23.26+-6.95	24.00+-6.54	21.40+-7.92	.324
Emotional	32.37+-10.22	31.40+-10.75	34.80+-8.82	.382
External	32.88+-5.17	32.25+-5.81	34.40+-2.84	.276
Maternal Neophobia (M±S.D)	19.63+-7.46	20.20+-7.25	18.20+-8.19	.482
Infant Characteristics Subscale Scores (M±S.D.)				
Fussy	17.69±4.79	17.88+-4.70	17.20+-5.22	.710
Unadaptable	8.41±2.82	8.60+-2.77	7.90+-3.03	.515
Dull	-0.72±2.12	-0.96+-2.19	-0.10+-1.91	.285
Unpredictable	9.29±2.48	9.52+-2.47	8.70+-2.54	.385
Baby Eating Behaviour Questionnaire Scores (M±S.D.)				
Food Responsiveness	12.12+-3.02	12.24+-2.95	11.75+-3.41	.696
Food Enjoyment	12.94+-1.39	12.88+-1.27	13.11+-1.77	.676
Satiety Responsiveness	6.94+-1.91	7.08+-1.96	6.56+-1.81	.488
Slowness of Eating	7.24+-0.72	7.20+-1.83	7.33+-1.50	.846

Table 7: infant's puree intake for the whole study sample

	Carrot	Spinach	Broccoli	Cauliflower	p-value
Vegetable intake (g) (M±S.D.)	33.74±28.44	30.21±27.62	39.67±37.54	40.73±33.72	.473
Enjoyment maternal rating (VAS) (M±S.D.)	50.35±23.56	55.09±26.67	53.03±29.12	54.60±29.67	.888
Satisfaction maternal rating (VAS) (M±S.D.)	49.66±24.22	57.29±26.41	53.49±30.00	54.57±27.45	.699
Fullness maternal rating (VAS) (M±S.D.)	50.34±24.64	49.20±28.37	51.34±30.22	50.60±28.08	.991
Maternal overall liking assessment (7 point scale) (M±S.D.)	6.1±1.81	6.32±1.88	6.49±1.72	6.03±2.26	.781

Table 8: Maternal liking and frequency of vegetable consumption for the whole study sample

	Carrot	Spinach	Broccoli	Cauliflower	p-value
Reported maternal vegetable liking (5 point scale) (M±S.D.)	1.77±.84	1.71±0.71	1.66±0.87	2.20±1.08	**.047**
Reported maternal vegetable consumption that last year (9 point scale) (M±S.D.)	3.83±1.29	2.83±1.22	3.66±1.00	2.14±0.91	**<.001**

Table 9: Infant's puree intake and maternal assessment of liking examined per milk feeding history (breast or formula fed)

	Carrot	Spinach	Broccoli	Cauliflower	p-value (interaction)
Vegetable intake (g) (M±S.D.)					
Breastfed (n=24)	31.41+-22.28	25.09+-24.38	33.19+-31.86	35.63+-34.84	.715
Formula fed (n=11)	38.83+-39.59	39.61-32.94	53.8+-46.23	51.86+-29.57	
p-value between subjects			.103		
Enjoyment maternal rating (VAS) (M±S.D.)					
Breastfed (n=24)	49.17+-23.71	52.71+-26.35	48.63+-28.85	52.79+-31.20	.873
Formula fed (n=11)	53.64+-23.42	60.27+-27.90	62.64+-28.66	58.55+-27.01	
p-value between subjects			.228		
Maternal overall liking rating (7 point scale) (M±S.D.)					
Breastfed (n=24)	6.00+-1.93	6.33+-1.81	6.25+-1.75	5.92+-2.43	.297
Formula fed (n=11)	6.55+-1.51	6.27+-2.10	7.00+-1.61	6.27+-1.90	
p-value between subjects			.348		

Table 10: Maternal liking and consumption for each vegetable per milk feeding practice followed (breast or formula fed)

	Carrot	Spinach	Broccoli	Cauliflower
Reported maternal vegetable liking (5 point scale) (M±S.D.)				
Breastfed (n=24)	1.71+-0.95	1.75+-0.74	1.50+-0.88	2.13+-1.15
Formula fed (n=11)	1.91+-0.54	1.64+-0.67	2.00+-0.77	2.36+-0.92
p-value between subjects	.521	.667	.117	.552
Reported maternal vegetable consumption that last year (9 point scale) (M±S.D.)				
Breastfed (n=24)	4.00+-1.38	2.75+-1.22	3.83+-.092	2.21+-1.03
Formula fed (n=11)	3.45+-1.04	3.00+-1.26	3.27+-1.10	2.00+-0.63
p-value between subjects	.253	.583	.125	.467

***Table 11:** Infant's puree intake and maternal assessment of liking per their previous spoon feeding experience (with or without previous spoonfeeding experience)*

	Carrot	Spinach	Broccoli	Cauliflower	p-value (interaction)
Vegetable intake (g) (M±S.D.)					
Previous spoon-feeding experience (n=25)	36.68+-31.87	37.85+-29.37	46.56+-40.51	44.99+-36.00	.510
No previous spoon-feeding experience (n=10)	26.39+-16.26	11.13+-3.87	22.44+-22.06	30.07+-25.74	
p-value between subjects		**.035**			
Post hoc p values	.341	**<.001**	**.032**	.243	
Enjoyment maternal rating (VAS) (M±S.D.)					
Previous spoon-feeding experience (n=25)	50.16+-24.93	57.04+-25.27	55.88+-31.09	55.88+-29.08	.834
No previous spoon-feeding experience (n=10)	51.60+-20.11	50.20+-30.78	45.90+-23.38	51.40+-32.49	
p-value between subjects		.467			
Maternal overall liking rating (7 point scale) (M±S.D.)					
Previous spoon-feeding experience (n=25)	6.20+-1.85	6.28+-1.90	6.60+-1.89	6.12+-2.14	.943
No previous spoon-feeding experience (n=10)	6.10+-1.79	6.40+-1.90	6.20+-1.23	5.80+-2.62	
p-value between subjects		.707			

***Table 12:** Maternal liking and consumption for each vegetable per their previous spoon feeding experience (with or without previous spoon-feeding experience)*

	Carrot	Spinach	Broccoli	Cauliflower
Reported maternal vegetable liking (5 point scale) (M±S.D.)				
Previous spoon-feeding experience (n=25)	1.76+-0.93	1.72+-0.74	1.72+-0.94	2.04+-1.06
No previous spoon-feeding experience (n=10)	1.80+-0.63	1.70+-0.67	1.50+-0.71	2.60+-1.07
p-value between subjects	.901	.941	.509	.169
Reported maternal vegetable consumption that last year (9 point scale) (M±S.D.)				
Previous spoon-feeding experience (n=25)	3.76+-1.09	2.92+-1.26	3.48+-1.08	2.16+-0.90
No previous spoon-feeding experience (n=10)	4.00+-1.76	2.60+-1.17	4.10+-0.57	2.10+-0.99
p-value between subjects	.627	.493	**.035**	.871

4.2.4 DISCUSSION

The initial aim of this study was to compare the acceptance of different vegetable purees, at weaning, between exclusive breastfed (EBF) and excusive formula fed (EFF) infants. Previous published results suggest a beneficial effect of breastfeeding in vegetable flavour and novel food acceptance (Hausner et al., 2010; Maier et al., 2008). Nevertheless, as discussed in the introductory chapter, the results are inconclusive, with some studies showing that the effect of flavour exposure via breast feeding is not always sufficient in isolation but requites the synergistic effect of repeated exposure of the flavour during weaning (Forestell & Mennella, 2007; Maier et al., 2008; Sullivan & Birch, 1994). In this study, whilst intake of all four vegetables was lower in EBF infants, milk feeding practice exerted no significant effect on vegetable intake. The low numbers in each group may help to explain this result, as despite extensive recruitment efforts the study did not have the appropriate power.

The amount and the frequency of consumption of a specific flavour that mothers need to incorporate into their diet during pregnancy or the lactation period in order for flavour learning to have a long lasting effect until weaning has not been examined. In experimental protocols usually the flavour under examination is offered in doses much larger than would be consumed within a normal diet (Hausner et al., 2010; Mennella & Beauchamp, 1999). In this cohort mothers reported consuming carrot and broccoli more frequently than spinach and cauliflower (although a significant reduction was only identified for cauliflower). It is likely that this difference was not sufficient to produce any long term effects, particularly as the pattern of frequency of consumption did not match the pattern of intake between the four vegetables.

Total energy intake in breast fed babies is reported to be lower than in formula fed infants (Garza & Butte, 1990; Heinig et al., 1993). Although intake did not significantly differ for the four different vegetables provided in this study, breast fed babies consistently consumed less of all four vegetable purees. The significant differences identified in infant's satiety and food responsiveness between breast and formula fed infants may offer an explanation for this observation. Consistent with other studies in the literature, breast fed infants were found to be more satiety and food responsive. This suggests that they were more likely to stop eating when they were full, or may get fuller more quickly than formula fed infants. This reflects minimal maternal involvement in the milk feeding process such that infants feeding directly from the breast are much more in control of their intake than bottle fed infants (regardless of whether the bottle contains breast or formula milk).

Conversely, the greater maternal involvement in formula feeding has the potential to put bottle fed infants at risk of overfeeding, leading to weight gain (Brown & Lee, 2012). Consistent with this a slower weight gain has been demonstrated for breast fed infants (Dewey, Heinig, Nommsen, Peerson,

& Lönnerdal, 1993; Kramer et al., 2002). In turn this has been associated with a decreased risk of developing overweight and obesity (Ong & Loos, 2006), putting breast fed infants in an advantageous position compared to their formula fed peers. Measurements taken in this study are consistent with these phenomena. Although there were no differences in body weight between the two groups at birth, a month after the introduction to solid food, breast fed infants weighed significantly less that formula fed infants.

Although intake is a very widely used measure of food acceptance in laboratory studies, it can be biased by multiple factors, not related to flavour acceptance. The infant's experiences with utensils during the feeding event are becoming increasingly influential. The concept of baby-led weaning (BLW) was relatively new during the recruitment and testing period of this work. However, a number of mothers in the recruited sample reported that they followed the principals of BLW including the avoidance of spoon-feeding and allowing self-feeding instead. Although utensils identical to those used in the laboratory testing sessions were sent to all mothers in advance, mothers following BLW may have been reluctant to introduce these to their feeding approach. Consequently, some infants may not have been familiar with the use of spoon. Thus, these infants could exhibit rejection of the offered food as a response to spoon-feeding and not necessarily because of food dislike. For this reason, and to explore this possibility further, the infant sample was also categorised per their spoon-feeding experience prior to the feeding sessions in the laboratory and comparisons similar to the ones undertaken between breast fed and formula fed infants were made.

While there was no overall significant difference in intake of the four vegetables, when method of introduction was taken into account a difference was identified between infants experiencing BLW and those being introduced to solids through more traditional methods. Specifically, significant differences appeared for spinach and broccoli with infants with no spoon-feeding experience consuming less of the puree in both cases. Furthermore, despite not reaching significance, the same pattern emerged for the other two vegetables (carrot and cauliflower) with infants with no spoon experience having lower intake of the vegetables. While the general pattern observed for all four vegetables can be attributed to the unfamiliar feeding situation for the infants with no spoon-feeding experience, the further significance in the consumption of broccoli and spinach could also be a result of the specific sensory characteristics of these vegetables. Both spinach and broccoli have a more bitter taste than carrot and cauliflower due to the different chemical compounds contained within them. These compounds are responsible for their green colour. Additionally, looking at the 3-day infant feeding logs mothers provided before every laboratory session, spinach and in general green vegetables appeared to be offered significantly less frequently. As such, their novelty may also impact on intake. The design of the current study makes it impossible to identify the appropriate explanation. However, as vegetable novelty is a factor known to influence both maternal feeding behaviour and infants eating behaviour, as well as their interactions during feeding, potential pathways and

mechanisms for these effects are explored in the third part of the chapter. Furthermore, As BLW is gaining popularity among parents it is important not only to account for this factor during recruitment, testing and analysis but also to gain a greater understanding of the impact of this weaning method. On this basis BLW is the focus of chapters 4 and 5 of this thesis.

Looking more deeply into factors with the potential to influence the results obtained, a number of questionnaires relating to maternal and infant characteristics known to impact on feeding outcomes were analysed. To date no studies have examined the association of milk or solid feeding practices with infant's temperament in older infants. Based on the current results, there was no evidence to support temperamental differences between breast and formula fed infants or infants with and without spoon feeding experience at weaning age. Maternal eating behaviour characteristics (restrain, external, emotional and neophobia) were also similar between milk feeding history and spoon feeding experience groups in this sample.

One interesting additional observation arising from this research relates to the average intake of puree amongst the entire infant sample. At only 30-40g, this is far lower than the average portion size of commercially prepared purees in the UK. A recent study revealed that commercially available jars of puree contain at least 120g, with the majority of them targeting infants as young as 4 months of age (16 weeks). Infants in this study had an average age of approximately 27-28 weeks (4 weeks from their mean age of solid introduction) with infants with no spoon experience typically even older. As such, this introduces the potential of infants being overfed. When using commercially prepared foods it is possible that caregivers believe that the quantity in the jar or pouch is the quantity of food that they should be expecting their child to consume. A rigid expectations of their infant's food intake, could lead to pressurised feeding jeopardizing their infant's satiety responsiveness. During this study mothers were supplied with a bowl containing 150g of vegetable puree. However, they were not given any indication of the exact amount available but rather were told to "feed their child as much or as little" as she would feel it is appropriate. In very few instances infants consumed more than 100g in any one of the sessions attended (regardless of whether broccoli or cauliflower was being tested).

Although the results of this study align with published literature (Forestell & Mennella, 2007; Maier et al., 2008; Sullivan & Birch, 1994), the limitations arising from the methodology followed should be taken into consideration. The fact that laboratory based infant feeding studies are notoriously challenging in recruitment is reflected in the limited and unbalanced sample of the study. Despite the extensive recruitment strategies and recruitment period followed, the number of breast feeding mothers more than doubles that of formula feeding mothers. A number of qualitative studies indicate that formula feeding mothers experience feelings of guilt and stigmatization as a consequence of their milk feeding practices, and therefore avoid participation in infant feeding related studies. This may explain the large difference between the size of the two groups in the sample. Finally, it needs to be

noted, that the recording of utensil use in the 3-day feeding diary was not always reliably recorded as parents varied utensil use. However, the reliance on the diary data was considered justified given the exploratory nature of this analysis. Future studies should consider accurately recording utensil use during the study design, as it was shown to have a potential impact on the outcomes.

Additionally, parental weaning practices are often not black and white, therefore a binary split of the sample into experience or not with spoon feeding is unlikely to capture the whole picture. A three way split was initially considered for the analysis (no spoon-feeding experience, only spoon-feeding experience and mixed spoon-feeding experience), however due to the small sample the study was underpowered for such a comparison and the results would not have been meaningful.

Given the limitations offered by a reliance on a single measure of intake, maternal assessment of food enjoyment were included in an analysis as an alternative indicator of infants' vegetable acceptance. However, the criteria mothers used to make their assessment of enjoyment are under examined in the literature rendering it impossible to determine how reliable these ratings are. The next part of the study will focus on these maternal assessments of liking to acquire further insight into the range of criteria considered.

4.3 PART 2: ASSESSMENT CRITERIA IDENTIFICATION

4.3.1 AIMS AND OBJECTIVES

The second part of this chapter has been designed to answer the second of the research questions raised:

What criteria do mothers use to assess food liking when feeding familiar and novel vegetables to their infants during early weaning period?

4.3.2 METHODS

4.3.2.1 PARTICIPANTS

The participant pool was identical to that included in the previous section. However, due to the initial means of data entry in NVIVO10, division of the pool per milk feeding history or weaning method was not feasible. As a consequence of data for all participants being entered as a whole, NVIVO10 was unable to produce codes for each participant. A recategorization to allow the split would require recoding using participant number as a variable which, in turn, could introduce inconsistencies in coding.

4.3.2.2 DATA COLLECTION

At the end of each feeding session mothers were asked to rate the enjoyment, satisfaction and fullness of their infant on Visual Analog Scales (VAS). Their overall assessment of food liking was also provided using a 9 point likert scale. In order to obtain a richer dataset a free text box was also provided under all rating scales and mothers were prompted to identify the criteria used for the rating and explain their response.

4.3.2.3 DATA ANALYSIS

The responses from the free answer box for the overall feeding reaction and enjoyment for all 4 sessions were transferred in NVIVO 10. Following familiarisation with the responses coding was undertaken and a thematic framework that captured the data was developed, using inductive content analysis. Data coding and categorization into the main categories was conducted by the PhD student and the interpretation was verified by a second researcher more experienced with the analytical method.

4.3.3 RESULTS

Typically, mothers listed more than one reason to justify their rating of their infant's vegetable liking or overall enjoyment in the free text responses. Two main categories emerged from the review of maternal responses; explicit cues and implicit maternal perceptions. The explicit cues category included all responses that could be identified and confirmed by an external observer, not related to

the mother or the child (e.g. a researcher), within the feeding episode. The implicit cues category included all the responses which could only be identified by a caregiver and would not realistically be identified or confirmed by an external observer. An overview of those categories, along with the themes emerged, is presented below and on table 16.

Table 13: Reference frequency of emerging themes and categories					
		Carrot	Spinach	Broccoli	Cauliflower
Intake(g) (M±SD)		33.74±28.44	30.21±27.62	39.67±37.54	40.73±33.72
Mother's liking rating (M±SD)					
Feeding session rating((M±SD)	Enjoyment	50.57±23.37	55.09±26.67	53.03±29.12	54.60±29.67
	Overall reaction	6.17±1.81	6.31±1.81	6.49±1.72	6.03±2.26
Explicit cues (reference frequency)					
Keep eating without distress/ coming back to the food	Enjoyment	9	11	11	7
	Overall liking	10	8	10	9
Quantity of food or number of spoonfuls eaten	Enjoyment	8	7	5	7
	Overall liking	7	14	7	9
Facial expressions	Enjoyment	2	3	3	4
	Overall liking	15	9	11	11
Wide or open mouth	Enjoyment	3	5	5	2
	Overall liking	8	8	10	7
Body part movement	Enjoyment	2	5	3	1
	Overall liking	12	4	8	6
Concentration or interest in food	Enjoyment	6	1	2	4
	Overall liking	4	4	6	5
Food spitting	Enjoyment	1	5	2	2
	Overall liking	3	4	5	4
Mood	Enjoyment	1	4	1	0
	Overall liking	4	8	3	3
Infant's personal involvement	Enjoyment	2	9	2	1
	Overall liking	1	5	0	5
Vocalizations	Enjoyment	0	2	0	2
	Overall liking	2	0	1	2
Initial reaction	Enjoyment	3	0	0	1
	Overall liking	0	0	0	0
Total	Enjoyment	33	48	32	34
	Overall liking	67	68	63	57

Maternal Perceptions (reference frequency)					
Eagerness or Enthusiasm for the food	Enjoyment	5	1	1	3
	Overall liking	5	1	5	5
Comparison with the same food on other occasion	Enjoyment	6	1	5	2
	Overall liking	1	0	4	2
Unusual feeding situation	Enjoyment	5	1	3	1
	Overall liking	3	0	2	1
Comparison with other foods	Enjoyment	2	2	5	3
	Overall liking	2	1	1	0
First time tried	Enjoyment	0	6	0	2
	Overall liking	0	3	0	1
Factors unrelated to the feeding	Enjoyment	2	1	1	2
	Overall liking	0	1	1	1
Infant's hunger state	Enjoyment	2	1	1	1
	Overall liking	0	0	2	0
Mothers preference	Enjoyment	1	0	0	0
	Overall liking	0	0	0	0
Total	Enjoyment	24	13	17	14
	Overall liking	11	6	15	10

4.3.3.1 EXPLICIT CUES

The first main theme that emerged from examination of the maternal text responses was the explicit cues. As described before, this theme includes cues (sub-themes or categories) that were easily identified and confirmed by an external researcher who observed the feeding session from the time the first spoon was offered, until the mother signified the end of the feeding episode.

Among the most popular criteria used by mothers to assess both food enjoyment and overall assessment of food liking was whether their **infants kept eating without any distress or whether they kept coming back for more food.** This was found to be more frequently used to the assessment of enjoyment and reaction to spinach and broccoli; 11 out of 35 mothers for each vegetable than to carrot, 9 out of 35; or cauliflower, 7 out of 35. The majority of the mothers used the cue to positively evaluate the enjoyment:

"she kept coming back for more" (if-002-11, cauliflower enjoyment)
"No hesitation to each spoonful seemed to really enjoy" (if-002-17, broccoli overall reaction)
"she seemed to like it as she wanted more" (if-002-09, spinach enjoyment)

However, a small number of mothers negatively evaluated the feeding event through the absence of the cue:

"she didn't visibly go back for more" (if-002-31, carrot enjoyment)
"what he did take took a lot of effort" (if-002-42, cauliflower enjoyment)

References to the **quantity of consumed puree or number of spoonfuls (or mouthfuls) taken** were used by mother to assess both food enjoyment and overall liking. Both large (positive evaluation) amounts:

"*He ate the whole bowl" (if-002-02, broccoli enjoyment)*
"because she appeared to eat a fair amount" (if-002-29, carrot enjoyment)

and small (negative evaluation) amounts were used to make a final assessment:

"he only had a few bites" (if-002-25, spinach enjoyment)
"The amount she took was less than usual" (if-002-40, carrot overall reaction)
"he wouldn't have more than a few spoons." (if-002-19, spinach overall reaction)

Analysis of facial expressions is the primary tool researchers use to assess food liking in infancy. In the present sample, mothers also indicated a use of facial cues. In contrast to the facial coding systems employed by researchers mothers largely refer to a generic negative expression without referencing specific individual facial characteristics and movements. Typically **facial expressions** were highlighted as justification of the overall liking assessment. Facial expressions were also utilised to

assess the enjoyment of the individual vegetable purees during the feeding. Both the presence and the absence of facial expressions informed maternal perception of their infant's enjoyment. Whilst the presence of negative expressions signified distaste:

"He made a yuck face at first" (if-002-22, cauliflower enjoyment)
"pulled a face" (if-002-24, spinach enjoyment)
"The faces she pulled whilst eating it." (if-002-03, cauliflower overall reaction)
"I thought she pulled quite strange faces" (if-002-16, carrot overall reaction)

The absence of those expressions signified enjoyment in a number of cases:

"didn't pull away negative faces" (if-002-12, broccoli enjoyment)
"She didn't make a face" (if-001-04, carrot enjoyment)
"facial expression. No negative reaction" (if-002-21, broccoli overall reaction)
"no "dislike" faces" (if-002-35, cauliflower overall reaction)

An open or wide mouth signified a non-verbal request for more food from the child. The cue was used to assess mainly the overall food liking, rather than the enjoyment of the individual foods and was equally utilized in all 4 vegetables feeding sessions. Again, while the presence of wide or open mouth impacted positively on the maternal assessment:

"he continued to open mouth for more" (if-002-32, broccoli enjoyment)
"she opened her mouth towards the spoon on several occasions" (if-001-04, carrot enjoyment)
"The way he had mouth wide open" (if-002-45, broccoli overall reaction)

A pursed mouth was a sign used to negatively assess the infant's reaction:

"refuses to open his mouth for feeding" (if-002-43, carrot overall reaction)
"but didn't open mouth to ask for more" (if-002-18, cauliflower overall reaction)
"She wouldn't open her mouth" (if-001-04, spinach overall reaction)

Infants' body part movements were used to asses, mainly, the overall reaction to the vegetable purees. Torso movements were referred to in both positive:

"leaned forward at each spoonful" (if-002-32, carrot enjoyment)
"going towards the spoon" (if-001-04, carrot overall reaction)

and negative assessment contexts:
"moved away from the food" (if-002-08, carrot overall reaction)
"He did not reach by pulling away" (if-002-45, carrot overall reaction)

Head movements (head turning) were used in an exclusively negative context:

"turned his head away" (if-002-24, spinach enjoyment)
"turning of head" (if-002-15, carrot overall reaction)

Arm and leg movements were also used mainly in positive evaluations:

"kicking her legs" (if-002-28, spinach enjoyment)
"kicking in excitement" (if-002-28, broccoli overall reaction)
"held spoon and pulled towards mouth" (if-002-06, spinach enjoyment)
"even reaching out for spoon at every mouthful." (if-002-06, cauliflower overall reaction)

The absence of movement was interpreted as a negative cue;

"legs and arms didn't kick about in excitement" (if-002-24, carrot overall reaction)

The **focus, interest and concentration** the infant showed to the food was another source of information mothers used to assess enjoyment of the vegetables. A large number of mothers referred to the lack of interest in the food or distraction by the environment in their justifications, and took this to signify lower levels of enjoyment:

"more interested in looking around room/playing with spoon" (if-002-18, broccoli enjoyment)
"didn't seem all that interested" (if-002-11, carrot enjoyment)
"Because distracted easily" (if-002-15, cauliflower enjoyment)
"quickly he showed no interest" (if-002-39, broccoli overall reaction)

Food spitting was another very obvious cue that mothers reference. Both the presence

"she pushed it back out with her tongue at first (if-002-12, cauliflower enjoyment)
"pushed away with tongue" (if-002-16, spinach enjoyment)
"stick his tongue out with the food still on it, spits the food out" (if-002-43, carrot overall reaction)
"whatever she ate it or spat it out" (if-002-12, cauliflower overall reaction)

and the absence of spitting were referred in mothers' justifications

"didn't spit out puree" (if-002-22, broccoli enjoyment)
"he swallowed more than he spat out" (if-002-33, carrot enjoyment)
"And didn't spit very much out" (if-002-22, spinach enjoyment)

Mothers also referred to **vocalizations,** infant's mood and infant's personal involvement. However, the frequency of reference to these cues was much reduced. Vocalizations where often interpreted as a complaint and a means of indicating dislike:

"she squealed a protest when I tried to give her more" (if-002-21, cauliflower enjoyment)
"he groaned at every mouthful " (if-002-32, spinach enjoyment),
"making complaining noises" (if-002-22, broccoli overall reaction),

Occasionally however, there where references of vocalizations associated with positive assessment:

"was winging if not fed quick enough" (if-002-35, spinach enjoyment).

Mothers also seemed to pay attention to their infants' **general mood** which could vary from being upset, crying or fussing, interpreted as an indication of dislike,

"she wasn't so happy" (if-002-31, spinach enjoyment)
"He was very upset" (if-002-05, carrot overall reaction)

"quickly began crying" (if-00220, spinach enjoyment)
"cried a few times" (if-002-39, broccoli enjoyment)

happy, content or smiling which would indicate that they are happy to continue eating.

"*seems very happy and content after eating it*" (if-002-04, spinach overall reaction)

Infant's personal involvement, mainly self-feeding, touching and feeling the consistency of the food along with utensil grabbing, was identified as a positive cue:

"Trying to feed herself either with the spoon or with a handful shows me he is enjoying it" (if-002-17, carrot overall reaction),
"Trying to feed himself" (if-002-46, spinach overall reaction)
"enjoyed playing with it and was very keen to keep bringing the bowl to her mouth and putting her face to the bowl" (if-002-41, cauliflower overall reaction)
"she seemed to have lots of fun squishing it between her fingers " (if-002-41, cauliflower enjoyment),

"wanted to explore the puree with the hands" (if-002-40 spinach enjoyment),
"He like feeling the consistency of the puree" (if-002-02, cauliflower enjoyment)
"She grabbed the spoon to feed herself" (if-002-31, spinach overall reaction),
"He also grabbed the bowl from me and fed himself" (if-002-02, broccoli overall reaction)

4.3.3.2 IMPLICIT CUES

References to implicit cues based on maternal perceptions where made less frequently than those to explicit cues. These factors require further insight to the child's eating behaviour than can be obtained from observation of a single feeding session by an external observer who is unrelated to the mother or the child.

Comparison with other foods, as well as **comparison with the same food on a different occasion** were the most common implicit cues used by mothers to assess their infants' enjoyment and overall food liking. Such prior experiences can bias assessment of the feeding situation as responses are rarely formed based solely on the cues observed at the actual test feeding occasion but are also moulded by past events

"She has shown a preference for broccoli in the past at home" (if-002-04, broccoli enjoyment)
"I've given him broccoli in the past mushed with potato and peas and he hasn't enjoyed it so far" (if-002-43, broccoli enjoyment)
"He loves carrots at home" (if-002-17, carrot enjoyment)
"I don't believe that he didn't like it as he has eaten cauliflower previously" (if-002-17, cauliflower overall reaction)

In some instances, comparison to the same food consumed on a different occasion brings reference to a different texture or preparation of the food. This may be particularly relevant for mothers following BLW approaches where infants are not used to being spoon fed pureed vegetables. This **lack of familiarity** is used to explain differences in behaviour in the laboratory settings:

"She does like broccoli but usually eats it unmashed so may not like the texture?" (if-002-31, broccoli enjoyment
"She normally likes it mixed with some formula milk" (if-002-03, spinach enjoyment)
"He's not had carrot on its own before" (if-002-43, carrot enjoyment)

Testing under a strict protocol in a laboratory setting creates various situations different from the norm that are referred to when justifying assessment of enjoyment or the feeding occasion.

"dosen't like to be spoon fed or used to purees" (if-002-13, cauliflower enjoyment)
"Lucy often react like that when in the bumboo seat at home, she'll then eat more when on my knee" (if-002-04, carrot overall reaction)
"Bit lumpier than I normally give" (if-002-05, broccoli enjoyment)
"was distracted by new environment I think + used to carrot sticks" (if-002-31, carrot overall reaction)

Similarly, mothers compare the behaviours the infant exhibits when they are fed familiar, well liked or disliked foods as a reference point to assess the liking of the studied vegetable:

"didn't open his mouth as willingly as he would for, say, a yogurt" (if-002-24, broccoli enjoyment)
"He starts crying and making complaining noises if he doesn't like things. Then he spits them out. He doesn't do that with Broccoli" (if-002-22, broccoli overall reaction)

Additionally, mothers appear to be aware that infant's behaviours and reactions towards a novel food are not representative of their liking. This is apparent in the present sample mainly for spinach and less frequently for cauliflower.

"because it is new to her" (if-002-08, spinach enjoyment)
"This is something he has never tried before" (if-002-17, spinach overall reaction)
"never have it before so may not have liked the taste" (if-002-05, cauliflower enjoyment)

Factors not directly related to the feeding episode were also mentioned as a justification for enjoyment or overall reaction assessment. Those include factors related to the infant's general health and wellbeing, weather conditions or fatigue levels:

"as she was teething she was quite upset" (if-002-31, spinach overall reaction)
"The weather is very hot and he hasn't been eating a lot lately" (if-002-17, broccoli overall reaction)
"refused from onset-possibly tired" (if-002-14, broccoli enjoyment)
"Maybe a long journey" (if-002-39, carrot enjoyment)

Perceived infant's hunger state was also taken into account by mothers when assessing the vegetable enjoyment or the overall reaction in the feeding episode. Hunger could aid or inhibit the consumption while fullness inhibited the consumption of the vegetable puree:

"He did not want to eat but I feel it was because he is full from a meal 2hrs ago" (if-002-45, carrot enjoyment)
"I think she was too hungry to enjoy any food than breastmilk" (if-001-04, broccoli overall reaction)
"will have been ready for some food, last feeding at 6.30 am" (if-002-17, carrot enjoyment)

Finally, there was one reference **to maternal preference on the vegetable** as a justification for the enjoyment assessment.

"because I don't like carrot that much either" (if-002-08, carrot enjoyment)

4.3.4 DISCUSSION

The second part of this chapter examined the criteria mothers use to assess their infant's enjoyment of a specific food offered during weaning and the overall assessment of liking for the food. Text responses to justify the specific ratings given were qualitatively analysed and categorized into two main categories; explicit cues, when an external observer can identify or confirm the cue, and implicit cues, when it would have been impossible for an external observer with no previous interaction with the mother or the infant to confirm the cue. Overall, explicit cues were referred to more frequently than implicit cues when making any assessments around the enjoyment or the success of the feeding session.

Currently, facial expressions are typically employed as the sole tool to assess food liking. However, it is clear from the present analysis, in conjunction with existing literature, that this is an insufficient approach. It has been shown that facial expressions can vary among infants depending on their individual temperamental characteristics (Forestell and Mennella, 2012) and that infants can increase their intake of a specific novel food overtime, without a significant decline in their negative facial expressions when they are introduced to the food (Forestell and Mennella, 2007). A coding system incorporating multiple explicit cues used by mothers could potentially prove significantly more accurate for predicting food liking in infants. However, a large number of different sub-themes (sub – cues) were identified within this theme (cue category). A synthesis of all the identified categories to create a single coding system will result into a tool equally or more complicated than the existing coding systems. Some of the presented themes were used very infrequently and consequently it could be assumed that they would offer little benefit to a coding system. As such, the most commonly used explicit cues such as the willingness of the child to continue eating without distress signals, the quantity consumed, the facial expressions, the open mouth and the body part movements could potentially be combined into a more comprehensive assessment tool worthy of further examination.

The FIBFECS coding system already includes some of these identified cue, namely some body part movements (head turning, body leaning, spoon pushing and back arching), in its behaviour coding (Hetherington et al., 2016). An expansion on this already developed and validated tool could potentially be beneficial. However, some methodological challenges should be considered carefully. It is very important that the explicit cues used are very clearly defined to increase validity and ensure consistency between coders. For example, willingness to continue eating without signs of distress was the most frequently used criterion, but what consists sign of distress can often be challenging to identify.

The identification of the implicit theme highlights the contribution from preformed maternal expectations when assessing food liking and enjoyment. Mothers use their experience in feeding situations specifically by comparing the food offered with the behaviour exhibited when the same

food has been offered in a different situation (usually at home) or with other liked and disliked food in the past. Generally, mothers used their insights into usual infant behaviour more frequently in order to assess the enjoyment of carrot. It is reasonable to assume that carrot is a vegetable offered more commonly at the beginning of complementary feeding due to its sweet taste. This offers the mother the opportunity to compare the usual infant's behaviour when consuming carrot directly with the behaviour displayed in the laboratory. On the other hand, vegetables with less appealing sensory profile, such as stronger tasting and bitter spinach are not offered as frequently. When offered for the first time, which was the case for some of the participants in the laboratory sessions, mothers cannot have any more expectations than their own preference. It is possible that maternal traits, such as neophobia, can influence their final decision when they offer a novel food to the infant. Further research with a larger sample is justified to examine the magnitude of maternal neophobia on the perception of their infant's liking ratings.

Finally, it is evident that due to the nature of the implicit cues, they do not provide any direct potential in the development of a food liking assessment tool. Estimates, however of these influences could be potentially be incorporated using an objective measurement of the quality of the interactions between the mother-infant dyad. However, in each feeding a plethora of interactions occur, that can influence or be influenced by maternal and infant characteristics. Those interactions are likely to play an important role in feeding outcomes. The next part is examining those interactions and how the influence the feeding outcomes.

4.4 PART 3: THE IMPACT OF MOTHER-INFANT INTERACTIONS AND MATERNAL AND INFANT CHARACTERISTICS ON FEEDING OUTCOMES

4.4.1 AIMS AND OBJECTIVES

The final part of this chapter relates to the third research question:

How do maternal eating behaviours and neophobia impact on mother-infant interactions during feeding of familiar and novel vegetables during the early weaning period?

4.4.2 METHODS

4.4.2.1 VEGETABLE SELECTION

Feeding sessions for two of the four vegetables offered in testing sessions were selected for coding. Due the limited sample size and the very limited impact on intake of the 4 vegetable purees examined in part one, this selection was based on the extremes of liking and familiarity criteria. It was expected that selecting the extremes would aid in the identification of any effects. Carrot was selected as it was

the most frequently offered and well liked vegetable. For the disliked vegetable, spinach was selected as this disliked vegetable was least frequently consumed by infants. The frequency the vegetables were consumed was assessed by quantifying the number of references of the vegetable in the infant feeding diaries collected before each session.

4.4.2.2 PARTICIPANTS INCLUDED IN ANALYSIS

The videos of carrot and spinach feedings were scored with the NCAST mother-infant interaction during feeding scale by a trained coder (For more details on the NCAST coding system refer to chapter 3)

The NCAST scale was designed to assess interactions during caregiver led feedings. Consequently, when recordings from the 15 infants whose mothers stated that they followed baby led weaning or had very limited experience with spoon feeding were coded, the limited caregiver involvement skewed the outcomes of the coding. Very low ratings, indicative of a dysfunctional mother-infant relationship, were obtained. With the likelihood that such distinct coding outcomes would yield unmeaningful statistical outcomes, these 15 recordings were therefore excluded. A further, two videos of carrot feeding and one video of spinach feeding had to be excluded because of a recording system malfunction. After the video exclusions, scores from 18 pairs for carrot feeding and 19 pairs for spinach feeding were analysed. This included a mix of breast fed and formula fed babies as dividing the sample further would render it too small for any meaningful analysis

For analysis, independent of the NCAST subscales (intake in grams, the length of the feeding, the baby eating behaviour questionnaire (BEBQ; maternally completed), the Dutch eating behaviour questionnaire (DEBQ), maternal neophobia score and the infant characteristics questionnaire (ICQ) subscales, all 35 mother-infant pairs were included.

4.4.2.3 DATA ANALYSIS

Feeding outcomes were represented through data reflecting intake in grams, the length of the feeding, and maternal ratings of the infant's enjoyment and liking during the feeding event. The maternal characteristics examined were represented by scores on the Dutch eating behaviour questionnaire (DEBQ) and the maternal neophobia scale. Infant temperament was measured with the Infant characteristics questionnaire (ICQ).

Differences between carrot and spinach intake in the testing sessions and between previous exposures to the vegetables were examined through paired samples t test.

Due to non-normal distribution of the NCAST scores, Spearman's rho (ρ) was applied to examine for associations between feeding outcomes and i) maternal and child characteristics or ii) NCAST scores (full scale and subscales) for both carrot and spinach feedings. To ensure a complete analysis,

associated between NCAST scores and maternal and infant characteristics were also examined using the same approach.

All analysis was conducted using SPSS 22.

4.4.3 RESULTS

Although infants were more familiar with carrot than with spinach (mean times tried at home prior to testing carrot: 8.50±5.59 times; spinach: 0.86+-1.66; t (13)=4.44; p=.001), no differences in intake were observed between feeding sessions (carrot: 36.61±35.79g; spinach: 33.36±30.90g; t(13)=0.25; p=0.810).

Table 14:Spearmans rho (ρ) values and significance levels between feeding outcomes and maternal and infant characteristics scores

		DEBQ restraint subscale score	DEBQ Emotional subscale score	DEBQ External eating subscale score	Neophobia scale score	ICQ Fussy	ICQ Unadaptable	ICQ Dull	ICQ Unpredictable
Carrot feeding length (sec)	ρ	0.090	0.069	0.020	-0.188	-0.247	-0.065	0.315	-0.071
	p	0.608	0.692	0.908	0.278	0.153	0.710	0.065	0.687
Carrot intake (g)	ρ	0.284	0.046	0.092	**-0.387**	-0.021	-0.105	0.022	-0.046
	p	0.099	0.792	0.599	**0.022**	0.905	0.549	0.902	0.792
Carrot enjoyment rating	ρ	-0.138	-0.025	-0.134	-0.120	-0.109	-0.076	0.071	-0.039
	p	0.428	0.888	0.443	0.493	0.533	0.663	0.684	0.825
Carrot liking rating	ρ	-0.082	-0.089	-0.134	-0.194	-0.020	-0.126	0.202	-0.016
	p	0.638	0.611	0.443	0.265	0.910	0.471	0.244	0.926
Spinach feeding length (sec)	ρ	**0.350**	-0.010	0.259	0.183	-0.276	-0.275	0.143	-0.026
	p	**0.039**	0.953	0.133	0.292	0.108	0.110	0.412	0.881
Spinach intake (g)	ρ	0.237	-0.175	0.145	-0.003	-0.064	-0.175	0.008	-0.097
	p	0.171	0.315	0.406	0.985	0.713	0.316	0.963	0.579
Spinach enjoyment rating	ρ	-0.016	0.027	**0.378**	0.133	-0.192	**-0.354**	0.102	-0.219
	p	0.926	0.878	**0.025**	0.445	0.268	**0.037**	0.559	0.205
Spinach liking rating	ρ	-0.143	-0.012	0.273	0.075	-0.042	-0.245	0.093	-0.176
	p	0.413	0.946	0.112	0.669	0.811	0.156	0.597	0.312

DEBQ: Dutch Eating Behaviour Questionnaire, ICQ: Infant Characteristics Questionnaire

Table 15: Spearmans rho (ρ) values and significance levels between feeding outcomes and NCAST subscale scores								
		Sensitivity to cues	Response to Distress	Socia-Emotional Growth Fostering	Cognitive Growth Fostering	Clarity of the Cues	Responsiveness to the Caregiver	NCAST scale total score
Carrot feeding length (sec)	ρ	-0.294	-0.374	0.007	**0.646**	0.187	0.231	0.218
	p	0.236	0.127	0.979	**0.004**	0.459	0.356	0.384
Carrot intake (g)	ρ	-0.124	-0.352	0.160	0.089	-0.155	0.303	-0.022
	p	0.624	0.152	0.525	0.725	0.540	0.221	0.932
Carrot enjoyment rating	ρ	0.363	0.235	0.337	0.363	0.228	0.420	**0.481**
	p	0.139	0.348	0.172	0.138	0.363	0.082	**0.043**
Carrot liking rating	ρ	0.369	0.287	0.227	0.286	0.231	0.375	0.441
	p	0.132	0.249	0.365	0.249	0.357	0.125	0.067
Spinach feeding length (sec)	ρ	-0.202	-0.023	0.088	0.356	0.272	0.157	0.250
	p	0.407	0.924	0.719	0.135	0.259	0.521	0.302
Spinach intake (g)	ρ	-0.087	-0.109	-0.203	-0.078	0.132	-0.244	-0.109
	p	0.724	0.658	0.404	0.750	0.589	0.314	0.656
Spinach enjoyment rating	ρ	-0.274	-0.237	-0.139	-0.195	**0.470**	-0.149	-0.157
	p	0.257	0.329	0.571	0.424	**0.042**	0.543	0.522
Spinach liking rating	ρ	-0.017	-0.260	-0.076	-0.214	0.285	-0.270	-0.207
	p	0.946	0.282	0.756	0.379	0.237	0.263	0.395

NCAST: Nursing Child Assessment Satellite Training

Table 16: Spearmans rho (ρ) values and significance levels between mother infant interactions measured with NCAST subscales and feeding outcomes, maternal and infant characteristics scores for carrot feeding

Carrot N=18		DEBQ restraint subscale score	DEBQ Emotional subscale score	DEBQ External eating subscale score	Neophobia scale score	ICQ Fussy	ICQ Unadaptable	ICQ Dull	ICQ Unpredictable
Sensitivity to cues	ρ	-0.443	-0.229	-0.030	-0.390	0.092	-0.156	-0.075	-0.273
	p	0.065	0.361	0.907	0.109	0.716	0.537	0.766	0.272
Response to Distress	ρ	-0.361	-0.194	**-0.518**	-0.060	**0.512**	0.406	0.009	-0.142
	p	0.141	0.439	**0.028**	0.814	**0.030**	0.094	0.971	0.574
Socia- Emotional Growth Fostering	ρ	-0.284	0.196	0.293	-0.186	-0.155	0.354	-0.120	-0.214
	p	0.253	0.436	0.238	0.460	0.538	0.149	0.635	0.393
Cognitive Growth Fostering	ρ	0.051	0.099	-0.247	-0.383	-0.248	0.034	0.195	-0.064
	p	0.840	0.695	0.323	0.117	0.321	0.892	0.437	0.800
Clarity of the Cues	ρ	-0.087	0.183	-0.243	-0.284	-0.247	-0.024	0.203	-0.059
	p	0.731	0.466	0.331	0.254	0.323	0.926	0.419	0.817
Responsiveness to the Caregiver	ρ	-0.248	-0.037	0.075	-0.439	-0.320	-0.214	0.058	-0.386
	p	0.321	0.884	0.769	0.068	0.195	0.394	0.818	0.113
NCAST scale total score	ρ	-0.301	0.041	-0.122	-0.425	-0.154	0.017	0.105	-0.263
	p	0.225	0.870	0.631	0.079	0.541	0.946	0.678	0.292

DEBQ: Dutch Eating Behaviour Questionnaire, ICQ: Infant Characteristics Questionnaire, NCAST: Nursing Child Assessment Satellite Training

Table 17: Spearmans rho (ρ) values and significance levels between mother infant interactions measured with NCAST subscales and feeding outcomes, maternal and infant characteristics scores for spinach feeding

Spinach N=19		DEBQ restraint subscale score	DEBQ Emotional subscale score	DEBQ External eating subscale score	Neophobia scale score	ICQ Fussy	ICQ Unadaptable	ICQ Dull	ICQ Unpredictable
Sensitivity to cues	ρ	0.016	0.151	-0.174	-0.208	0.314	0.100	-0.120	-0.126
	p	0.947	0.537	0.476	0.393	0.191	0.684	0.626	0.607
Response to Distress	ρ	0.231	**0.493**	0.437	-0.113	-0.103	-0.005	**-.494***	0.079
	p	0.341	**0.032**	0.061	0.645	0.676	0.984	**0.032**	0.747
Social - Emotional	ρ	0.005	0.253	0.186	-0.246	-0.225	0.090	-0.090	0.229
Growth Fostering	p	0.982	0.297	0.446	0.310	0.354	0.714	0.713	0.345
Cognitive Growth	ρ	0.148	-0.035	-0.064	**-0.463**	-0.095	0.038	0.019	0.228
Fostering	p	0.546	0.888	0.795	**0.046**	0.698	0.877	0.939	0.349
Clarity of the Cues	ρ	0.108	-0.152	-0.188	0.036	-0.264	-0.325	0.366	0.255
	p	0.661	0.534	0.441	0.883	0.275	0.174	0.123	0.293
Responsiveness to the	ρ	0.194	-0.172	-0.085	-0.004	-0.023	-0.026	**.669****	0.222
Caregiver	p	0.427	0.483	0.728	0.988	0.926	0.915	**0.002**	0.360
NCAST scale total	ρ	0.313	0.099	0.070	-0.335	-0.089	-0.102	0.075	0.282
score	p	0.192	0.687	0.775	0.161	0.717	0.677	0.760	0.243

DEBQ: Dutch Eating Behaviour Questionnaire, ICQ: Infant Characteristics Questionnaire, NCAST: Nursing Child Assessment Satellite Training

4.4.3.1 FEDING OUTCOMES AND MATERNAL AND INFANT CHARACTERISTICS

Analysis on the whole sample showed that, when feeding spinach, maternal restrictive eating behaviour was positively correlated with the length of the feeding (ρ=.350 , n=35, p=.039), while maternal external eating behaviour was positively correlated with her ratings of food enjoyment (ρ=.378, n=35, p=.025). While, when feeding carrot maternal neophobia was negatively correlated with carrot intake (ρ= -.387, n=35, p=.022) (table 11).

Looking at the infant characteristics, a negative correlation was found between infant's unadaptability scores and food enjoyment rating when feeding spinach (ρ=-.354, n=35, p=.037), but no other correlations where found for any other characteristics, or for the carrot feeding. (Table 11)

4.4.3.2 FEEDING OUTCOMES AND NCAST SCORES

Moving on to the mother-infant interactions, when feeding carrot, the length of the feeding was positively associated with the cognitive growth fostering subscale score (ρ=.646, n=18, p=.004). NCAST total score was also positively associated with the enjoyment rating (ρ=.481, n=18, p=.043). While when feeding spinach, the food enjoyment rating was positively associated with the clarity of the infant's cues during the feeding (ρ=.470, n=19, p=.042). (Table 12)

4.4.3.3 MATERNAL AND INFANT CHARACTERISTICS AND NCAST SCORES

Maternal external eating score was negatively correlated (ρ=-.518, n=18, p=.028) and infants fussiness score was positively correlated (ρ=.512, n=18, p=.030) with the response to distress subscale during carrot feeding. (Table 13)

Maternal score on the emotional subscale was positively correlated with the responsiveness to distress subscale (ρ=.493, n=19, p=.032). Maternal neophobia score was negatively correlated with cognitive growth fostering subscale score (ρ= -.463, n=19, p=.046), while infant dullness score was negatively associated with maternal responsiveness to distress (ρ= -494, n=19, p=.032) and positively correlated to infant's responsiveness to the caregiver (ρ=.669, n=19, p=.0042) during spinach feeding (table 14)

4.4.4 DISCUSSION

Maternal eating behaviour appears to impact on feeding outcomes in different ways for carrot and spinach feedings. When feeding a familiar vegetable, like carrot, infants whose mothers scored lower on the neophobia scale had a greater intake, however no associations between the DEBQ sub scores and feeding outcomes were observed for carrot feedings. On the contrary, the higher mothers scored on the external eating behaviour subscale of the DEBQ, the higher they rated spinach enjoyment. Additionally, infants whose mothers scored higher on the restraint subscale of the DEBQ had a longer feeding duration when offering spinach. Similar to external eaters, mothers who score higher in restrained eating behaviour are more likely to be more controlling and more likely to follow a mother-led rather than a baby-led style during feeding. With the testing session typically offering the first opportunity for the majority of the infants to be exposed to spinach it is plausible that such mothers wanted to be more in control of the situation. This pattern did not appear during carrot feeding

These results suggest that, even though maternal eating behaviour can influence maternal perception of their infant's food enjoyment and their interactions during the feeding, the exact impact of maternal eating behaviours is largely situational and depends on the familiarity or novelty of the vegetable being offered and possibly whether it is perceived as being liked or disliked. In this study only evidence for the vegetable familiarity were available. However, conventionally, spinach is usually perceived as a difficult and disliked vegetable. This can explain the reluctance of the mothers to offer in during the first month of solid introduction. On the contrary, carrot has a generally sweet and pleasant taste and mothers might assume that those palatability characteristics can provide a positive experience with the solid food.

Infants temperamental characteristics, on the other hand, did not to have many associations with feeding outcomes regardless of the vegetable examined. In this study the only significant correlation found was between the unadaptability subscale and maternal enjoyment rating for spinach feeding. Specifically, the higher the infant scored on the unadaptability subscale, the lower their mother's rating of food enjoyment was likely to be. As both measures rely on maternal perceptions, it is possible that when mothers perceives their infant as less adaptable she might be more inclined to think that they didn't enjoy a novel food.

Sporadic correlations were also detected between feeding outcomes and NCAST sub-scale scores. A longer feeding duration was positively correlated with a higher score on the cognitive growth fostering subscale of the NCAST, suggesting that for familiar vegetables mothers engage in other, non-feeding related activities, that promote cognitive growth. As mothers rated the carrot feeding liking higher when the dyad scored higher on the NCAST as a whole this suggests they actually rely on the quality of the interactions as a whole, including socio-emotional and cognitive growth fostering to provide an assessment for food liking. When feeding spinach, however, mothers appear to be more

focused on the feeding and the baby's cues by relying more on the clarity of their baby's cues to rate the food enjoyment. This can also be supported by evidence arising in the previous part of the chapter. Although extensive statistical analysis was not performed on the table 10 data, it is apparent that explicit infant cues were used more often to assess the enjoyment of spinach than carrot (48 mentions of explicit cues for spinach and 33 for carrot) with the associations inverted for the use of implicit cues (13 mentions for spinach and 24 for carrot).

This small scale study suggests that while a strong mother-infant interaction does not influence infant food intake during consumption of a well-liked traditional weaning food such as carrot, it does provide mothers with a positive evaluation of the event reflected by a positively correlation between the total NCAST score and the maternal enjoyment rating. These results are indicative of possible relationships between the quality of mother infant interactions and the maternal evaluation of the feeding when feeding a familiar vegetable. These findings are encouraging and support a more detailed assessment of the potential of the NCAST as a tool for assessing infant preferences.

However, the same associations were not found during feeding of an unfamiliar vegetable, with no correlation identified between maternal liking and the total NCAST score. Consistent with the previous section of this chapter, there is a potential that experience of infant reactions to a new food when previously consumed at home will mould the maternal assessments of liking. Such implicit cues will not be available for coding via NCAST and will thus cloud any relationship between NCAST and maternal scores.

When it comes to the impact of their own eating behaviours on mother infant interactions during spinach feeding, when mothers are more neophobic themselves, they appear to limit any interactions not strictly relate to the feeding, such as educational interactions that promote cognitive growth. The cognitive growth fostering subscale of the NCAST includes 9 items, 7 of which score either the quantity or the quality of maternal verbalizations. The items can refer to whether the mother verbalizes in response to infant's verbalizations or movements, the timing, and the type of those verbalizations and whether she refers to the feeding episode or not. When feeding a familiar vegetable, mothers feel comfortable in the feeding situation and are more inclined to use the feeding event as a learning and developmental experience, particularly using verbalisations (cognitive fostering). In previous literature verbalizations between mothers and infants were frequently restricted during feeding to limit potential confounders. This finding highlights the importance of unrestricted interactions, and more specifically verbalizations during the feeding episode to obtain a more complete assessment of infant's food acceptance.

Additionally, mothers more likely to consume food due to their emotional state (emotional eaters) were more likely to be more responsive to their infant's distress during the feeding when feeding spinach, potentially channelling their own feelings. We can assume that a mother is negatively

affected in an emotional level by their infant's distress and mothers who associate food with their emotional state might be more sensitive and responsive in alleviating their infant's distress during feeding.

Some interesting findings were also observed in relation to infant characteristics. When feeding spinach infant's dullness was associated with mother infant interactions associated with responsiveness. Specifically, infant dullness was negatively correlated with response to distress but positively correlated with response to the caregiver. By contrast, when feeding carrot mothers were more responsive to their infant's distress the higher they scored on the fussiness subscale. These findings are particularly interesting taking into account that the infant characteristics questionnaire (and in general every questionnaire that measures infants' behaviour) reflects their mothers' (or caregivers') perception of whether or not the infant demonstrates the behaviour. Thus, when a mother feeds a familiar vegetable, from experience she can predict her child's responses and may therefore be more inclined to respond to their child's signs of distress if she perceives this child as a generally fussy one. In an unfamiliar feeding situation, however, for infants whose mothers don't perceive them to generally respond with much excitement to the cues in everyday life, the mother is less likely to respond to their distress. Potentially in compensation for this limited response, these infants become more responsive to their caregiver's attempts for feeding and attention. For examples, the responsiveness to the caregiver subscale includes items that imply some kind of verbal or nonverbal communication exchange between the dyad in response to caregivers attempt to communicate with the infant, such as gazes, smiles, touch vocalizations and even disengagement cues like fussiness, food spitting, turning away and pushing the spoon away. Therefore, an infant that is perceived as dull might perceive the lack of their mother's responsiveness and compensate by being more responsive to their mother themselves.

Considering the limitations of the study, a few points should be noted when considering the suitability of the NCAST scale as a tool for assessing infant food preferences. Mothers who mentioned that they used BLW, or when it was identified from the infant food diaries that infants had very little experience with the spoon or puree foods were excluded from the analysis as NCAST was not appropriate to code the feeding. As BLW is gaining popularity among parents as an alternative weaning system, a means of coding mother infant interactions during feeding events following the BLW philosophy is needed. Another consideration when assessing the suitability of the NCAST scale is the demographic nature of the sample. This was fairly homogenous and primarily consisted of middle class white British women. Mothers with medical problems, and postnatal depression as well as smokers and recreational drug users where screened out. However, problematic caregiver-infant interactions, for which the NCAST was originally developed, have been shown to be quite prominent in mother-infants pairs when the mother is suffering with postnatal depression (Field, 2010) or substance abuse (M. O. Johnson, 2001). Future studies should focus more on potentially dysfunctional

mother infant interactions by recruiting a sample with greater variability in order to highlight meaningful differences in the general population and assess the full potential of the NCAST tool. Finally, even though generally typical for laboratory based studies, the number of participants included in this study was limited and as such, the results should be interpreted with great caution. While several assumptions can be made based on the results, the emerging hypothesis need to be tested in a larger population before any firm conclusions are drawn.

CHAPTER 5
PARENTAL CHARACTERISTICS ASSOCIATED WITH BABY LED WEANING STYLE OF COMPLEMENTARY FEEDING.

Data from this chapter were presented as a conference paper at Nutrition and Nurture in Infancy and Childhood: Bio-Cultural Perspectives Conference, 10th, 11th & 12th June 2015, Grange-Over-Sands, Cumbria, UK

5.1 INTRODUCTION

Differences in nutritional experiences at critical early periods in infancy can programme an individual's health for the future. Currently the weaning phase of infant feeding is gaining much attention through the emergence of the baby-led weaning (BLW) approach where infants are encouraged to self-select and self–feed family food in solid form rather than traditional spoon-feeding of purees.

Although in its infancy, research into BLW is largely identifying the approach as a means of supporting healthy eating behaviours and providing protection against the development of obesity. One qualitative study reports that both mothers and health professionals believe that allowing the infant to be in control of its eating results in a less fussy child with better appetite control (Brown & Lee, 2015). Outcomes of the examination of the safety of BLW have also been largely positive, with parents typically waiting for appropriate developmental signs to indicate that the infant is ready to handle solid food (such as the ability to sit up unaided) before weaning is introduced. As such, mothers following BLW consistently breast feed for longer and are more likely to follow current Department of Health guidelines to delay the introduction of solids to 6 months of age (Brown & Lee, 2011a; Cameron, Heath, & Taylor, 2012; Townsend & Pitchford, 2012). However, it has been argued that the reliance on the method may expose infants to higher levels of fat, sugar and salt than those in typically prepared infant foods (Rowan & Harris, 2012).

Mothers following BLW have been found to be much less controlling in their feeding style (restriction, monitoring and pressure to eat) and to have lower levels of concern for their child's weight (Brown & Lee, 2011c, 2013). More recently mothers following BLW have been shown to demonstrate significantly lower anxiety and obsessive-compulsive scores as well as higher conscientiousness scores compared to those following a traditional parent lead weaning (PLW) approach (Brown, 2015). Additionally, demographic analyses suggest mothers following BLW have a higher level of education and professional status (Brown & Lee, 2011c). With BLW currently not recognised by the Department of Health as an approved weaning style, this brings a reliance on parents to independently source information on this weaning approach. Whilst demographic characteristics are consistent with this demand, surprisingly, the information sources utilised by mothers during this critical development phase have received little attention (Brown & Lee, 2011a; Cameron et al., 2012a).

Although limited, the literature focusing on parents selecting to follow PLW practices suggests potential detrimental effects of spoon feeding on children's weight status and eating habits. Two studies have highlighted that children whose parents followed the standard approach of PLW are significantly heavier than their BLW peers (Brown & Lee, 2015; Townsend & Pitchford, 2012). As

spoon feeding is associated with higher parental control over feeding, this may reflect insufficient development of children's self-regulation. Additionally, spoon-fed toddlers were found to favour sweet foods over any other food group (Townsend & Pitchford, 2012). In conjunction with the low self-regulation speculated for this group, this could result in excessive caloric consumption.

Current research has utilised a discrete definition of BLW in which puree and spoon feeding occurs 10% or less of the time. However, as a consequence, PLW ranges in definition from strict spoon feeding to a mixed complementary feeding method incorporating BLW approaches up to 89% of the time. Many families choose a combination approach to accommodate a modern lifestyle, with PLW being the preferred method when dining out, or when there is limited time at mealtimes. However, given the results of previous examinations of maternal characteristics it is logical to predict that many factors, in addition to convenience, dictate the extent of this combination of complementary feeding practices.

Given the limited scope of previous research, both in terms of the range of weaning styles examined and the feeding practices incorporated, the aim of the current study was to provide the first comprehensive examination of differences in parental characteristics among individuals across the full range of weaning styles.

5.2 METHODS AND MATERIALS

5.2.1 PARTICIPANTS AND RECRUITMENT

Eight hundred and thirty parents with toddlers between 12-36 months old, who were born at full term and had no diagnosed developmental conditions, were recruited through relevant social media groups and mailing lists or through word of mouth advertising to mothers with younger children engaged in ongoing experimental studies in the laboratory. The 36 months cut-off point was applied to facilitate recruitment whilst managing potential for inaccurate answers due to fading memories. A web link to the survey was provided in advertisements. To avoid bias the study was not advertised in specific BLW groups and BLW was not included in the advert. The study gained ethical approval from the Ethics Committee of the Department of Psychological Sciences of the University of Liverpool in March 2014. All the aspects of the study were performed in accordance with the 1964 Declaration of Helsinki. Participants were provided with the information sheet of the study and consent was established with a tick box. The online survey was accessible from 23rd of March 2014 to 7th of May 2014. Parents with more than one child within the exclusion criteria were asked to complete the survey on one occasion only for one child.

5.2.2 THE SURVEY

5.2.2.1 WEANING STYLE

To categorise weaning styles, participants were not asked directly whether they followed PLW or BLW practices, removing the potential for differences in interpretation. Rather, using a sliding scale from 0% of the time to 100% of the time, they estimated the portion of time their child fed themselves at one month subsequent to the introduction of solid foods. Participants were subsequently grouped into four categories; strict BLW (self-feeding 90% or more of the time (Brown, 2015; Brown & Lee, 2011a, 2011c, 2013, 2015)); predominant BLW (self-feeding between 50% and 90% of the time); predominant PLW (self-feeding between 50% and 10% of the time) and strict PLW (self-feeding less than 10% of the time). Additionally, parents were asked to indicate the type of the first food offered (fruit, vegetable, baby rice or other) and the form in which the food was offered (puree, finger food or other). The final question, relating to weaning, identified the main sources of information that guided their choice of complementary feeding practices.

5.2.2.2 DEMOGRAPHICS

Parents were asked demographic questions relating to their ethnicity, household composition, age, height and weight and country of residence. In order to assess social and economic status participants were asked to report maternal and paternal (if the father was living in the same household) occupation status. The simplified National Statistics Socio-economic Classification, which contains 8 occupation classifications was then applied (ONS, 2010). Limited demographic information (birth weight and order) relating to the child was also obtained.

5.2.2.3 MILK FEEDING PRACTICES

Questions relating to milk feeding method and, where relevant, breastfeeding duration, were included. Where parents reported that their child still breastfeeds, the age of the child at questionnaire completion was used as the age of the last breastfeeding event.

5.2.3 FAMILY FOOD ENVIRONMENT AND MEAL PATTERNS.

Participants responded to three questions previously employed in a survey examining the associations between complementary feeding practices and health-related behaviours in New Zealand (Cameron et al., 2012a). Specifically, the questions were: “How often do you eat with your child (either with the same food or a different meal)?” “How often do you eat the same meal as your child, even in modified form or at different time?” and “How often does your child eat commercially prepared food?”

5.2.4 PARENTAL FEEDING STYLE

The Child Feeding Questionnaire (CFQ; (Birch et al., 2001)) assesses parental beliefs, attitudes and practices towards children's diet and is routinely employed in studies examining parental feeding styles. However, the CFQ focuses largely on controlling feeding practices. Additionally, it was designed with a suggested age range beyond the typical period for complementary feeding (2-11 years). Consequently an alternative measure, the Parental Feeding Styles Questionnaire (PFSQ; (Wardle et al., 2002) was applied in this study. The PFSQ is a 27 item scale assessing four different dimensions recognised as potential contributors to the development of obesity (emotional feeding, instrumental feeding i.e. using food as a reward), prompting/encouragement to eat and control over eating).

5.2.4.1 SOURCES OF INFORMATION

Parents were asked their main source of information about complementary feeding. Options included health professionals, friends, family or the Internet with an "other" option where a free text box provided in order to specify this choice. The "other" option was maintained for any other answer that could not be recoded in one of the defined themes.

5.2.4.2 INTRODUCTION TO SOLID FOOD AND FIRST FOOD OFFERED

Parents were asked the type of the first food given to their child at the beginning of complementary feeding. Options initially available were baby rice, fruit, and vegetable with an "other" option with a free text box provided in order to specify this choice. After recoding for any emerging themes, 3 more categories were identified and recoded, meat, bread & starches, and mixed meals (where parents reported that their child was offered food from two or more of the above categories simultaneously). The "other" option was maintained for any other answer that could not be recorded in one of the defined themes.

5.2.5 STATISTICAL ANALYSIS

Analysis was conducted using IBM SPSS Statistics (version 21, IBM Inc., Somers, NY). Data conformed to the requirements for parametric analysis. Therefore, an analysis of variance (ANOVA) was performed to compare parental characteristics and feeding practices across the four defined weaning styles. Pairwise comparisons were applied for post hoc analysis.

For nominal variables, a χ^2 test analysis was performed. Where appropriate a separate test of independence was performed as an equivalent to post hoc tests where the standardized residue z-score for each case was calculated and compared with the critical value (±1.96) to assess the difference between the expected and the actual frequency in each case.

5.3 RESULTS

The aim of the present study was to identify and highlight the differences in feeding styles, practices and information sources across the full range of complementary feeding methods. Of the 830 participants recruited, 565 completed the survey and were included in the final analysis. 33.3% of these were classified as strict BLW, 17.3% as predominant BLW, 26.2% as predominant PLW and 23.2% as strict PLW.

Table 21 demonstrates key demographic characteristics of the participants. No differences were identified between the groups for any of these characteristics. Similarly, birth order and parental occupation were not found to vary between groups. The vast majority (92.9%) of the parents completing the survey came from households comprised of both mother and father living together and on most occasions mothers provided the responses (98.6%).

Table 18: Demographic and descriptive characteristics by overall sample and complementary feeding categories

Characteristic	Overall (n=565)	Complementary feeding type				p***
		Strict BLW (n=188)	Predominant BLW (n=98)	Predominant PLW (n=148)	Strict PLW (n=131)	
Mother's Age (mean years±SE)	32.37±0.192	32.56±0.313	32.61±0.430	31.49±0.415	32.89±0.395	.051
Father's Age (mean years±SE)	34.93±0.251	34.84±0.398	35.45±0.646	34.31±0.551	35.35±0.475	.391
Child's Age (mean months±SE)	22.41±0.302	22.69±0.518	20.96±0.697	22.70±0.587	22.74±0.650	.185
Birth order (N (%*))						
1st	349 (61.8)	103 (18.2)	63 (11.2)	101 (17.9)	82 (14.5)	
2nd	155 (27.4)	62 (11.0	28 (5.0)	29 (5.1)	36 (6.4)	
3rd	38 (6.7)	13 (2.3)	5 (0.9)	12 (2.1)	8 (14)	.189
4th	18 (2.8)	8 (1.4)	1(0.2)	2(0.4)	5 (0.9)	
5th	4 (0.7)	1 (0.2)	0 (0.0)	3 (0.5)	1(0.0)	
6^{th} and after	3 (0.5)	1 (0.2)	1 (0.2)	1 (0.2)	0 (0.0)	
Mother's BMI (mean kg/m^2 ±SE)	25.50±0.25	25.55±0.45	25.02±0.52	25.22±0.48	26.10±0.53	.505
Father's BMI (mean kg/m^2 ±SE)	26.21±0.23	26.21±0.23	26.49±0.56	26.55±0.46	26.07±0.37	.698
Mother's occupation (N (%*))						
Managers, Directors and Senior Officials	38 (6.7)	15 (2.7)	5 (0.9)	13 (2.3)	5 (0.9)	
Professional Occupations	220 (38.9)	56 (9.9)	49 (8.7)	62 (11.0)	53 (9.4)	
Associate Professional and Technical Occupations	15 (2.7)	4 (0.7)	3 (0.5)	4 (0.7)	4 (0.7)	
Administrative and Secretarial Occupations	40 (7.1)	8 (1.4)	8 (1.4)	12 (2.1)	12 (2.1)	
Skilled Trades Occupations	4 (0.7)	1 (0.2)	0 (0)	2 (0.4)	1 (0.2)	.061
Caring, Leisure and Other Service Occupations	43 (7.6)	17 (3.0)	4 (0.7)	16 (2.8)	6 (1.1)	
Sales and Customer Service Occupations	18 (3.2)	6 (1.1)	3 (0.5)	4 (0.7)	5 (0.9)	
Process, Plant and Machine Operatives	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Elementary Occupations	2 (0.4)	1 (0.2)	1 (0.2)	0 (0)	0 (0)	
Not on paid occupation	185 (32.7)	80 (14.2)	25 (4.4)	35 (6.2)	45 (8.0)	
Father's occupation (N (%*))						
Managers, Directors and Senior Officials	133 (24.8)	43 (8.0)	24 (4.5)	30 5.6)	36 (6.7)	
Professional Occupations	168 (31.3)	60 (11.2)	21(3.9)	47 (8.8)	40 (7.7)	
Associate Professional and Technical Occupations	50 (93)	20 (3.7)	8 (1.5)	10 (1.9)	12 (2.2)	
Administrative and Secretarial Occupations	13 (2.4)	4 (0.7)	2 (0.4)	5 (0.9)	2 (0.4)	
Skilled Trades Occupations	77 (14.4)	22 (4.1)	16 (3.0)	26 (4.9)	13 (2.4)	.722
Caring, Leisure and Other Service Occupations	30 (3.7)	8 (1.5)	3 (0.6)	5 (0.9)	4 (0.7)	
Sales and Customer Service Occupations	31 (5.8)	9 (1.7)	6 (1.1)	6 (1.1)	10 (1.9)	
Process, Plant and Machine Operatives	18 (3.4)	4 (0.7)	5 (0.9)	5 (0.9)	4 (0.7)	
Elementary Occupations	4 (0.7)	2 (0.4)	0 (0)	0 (0)	2 (0.4)	
Not on paid occupation	22 (4.1)	6 (1.1)	7 (1.3)	6 (1.1)	3 (0.6)	

Household composition (N (%*))						
Mother and father	525 (92.9)	178 (31.5)	88 (15.6)	136 (24.1)	123(21.8)	.533
Single mother	26 (4.6)	7 (1.2)	5 (0.9)	9 (1.6)	5 (0.9)	
Single father	1 (0.2)	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	
Other	13 (2.3)	3 (0.5)	4 (0.7)	3(0.5)	3 (0.5)	
Breastfeeding initiation (N (%**))	539 (95.4)	185 (34.3)	95 (17.6)	134 (24.9)	125 (23.2)	.006
Any breastfeeding duration (mean weeks±SE)	66.00±1.68	80.48±2.47	61.04±3.52	56.65±3.52	59.47±3.71	<.001

BLW: Baby led weaning, PLW: Parent led weaning * Percentages are given in reference to the whole sample ** Percentages are given in reference to the sample who initiated breastfeeding. ***Group differences ascertained by one Way ANOVA for maternal, paternal and child's age, maternal and paternal BMI and breastfeeding duration and $\chi 2$ tests for parity, maternal and paternal occupation, household composition and breastfeeding initiation

5.3.1 PARENTAL FEEDING STYLES.

Significant differences between the four defined groups were found for all four subscales of the PFSQ [Instrumental Feeding F (3,560) =7.04, p<0.001, Control over feeding F (3.560)= 16.24, p<0.001, Emotional feeding F (3,560)=2.64, p=0.049, Encouragement F(3,560)=18.26, p<0.001]. Post hoc analysis revealed that parents who were following strict and predominant BLW style were using less instrumental feeding practices than parents in the two PLW groups (Strict BLW vs. Predominant PLW p<0.001, Strict BLW vs. Strict PLW p=0.003, Predominant BLW vs. Predominant PLW p=0.036). Parents who were practicing a strict PLW style were also found to score higher in the emotional feeding subscale than Strict and Predominant BLW groups (Strict BLW vs. Strict PLW p=0.010, Predominant BLW vs. Strict PLW p=0.034). Additionally, parents following strict BLW were found to exert significantly less control over their toddler's eating and use significantly less encouragement to increase food consumption than the other three groups (Strict BLW vs. Predominant BLW p<0.001, Strict BLW vs. Predominant PLW p<0.001, Strict BLW vs. Strict PLW p<0.001). (Figure 3)

5.3.2 FAMILY FOOD ENVIRONMENT AND MEAL PATTERNS

A significant difference was observed between the groups for both shared mealtimes and common meals (F (3,561) =9.38, p <0.001 and F (3,561) =10.08, p < 0.001 retrospectively). The frequency of commercially prepared food consumption also approached significance (F (3, 561) =2.17, p=0.054)

When examining where the between groups differences lay, parents following a strict BLW style were found to significantly share their mealtimes (Strict BLW vs. Predominant BLW p=0.006, Strict BLW vs. Predominant PLW p=0.001, Strict BLW vs. Strict PLW p<0.001) and eat the same meals with their children more often than all other groups (Strict BLW vs. Predominant BLW p=0.024, Strict BLW vs. Predominant PLW p=0.003, Strict BLW vs. Strict PLW p<0.001). Moreover, parents following a strict PLW style ate the same meal as their child significantly less frequent than the rest of the categories (Strict PLW vs. Strict BLW p<0.001, Strict PLW vs. Predominant BLW p=0.012, Strict PLW vs. Predominant PLW p=0.017,). (Figure 4)

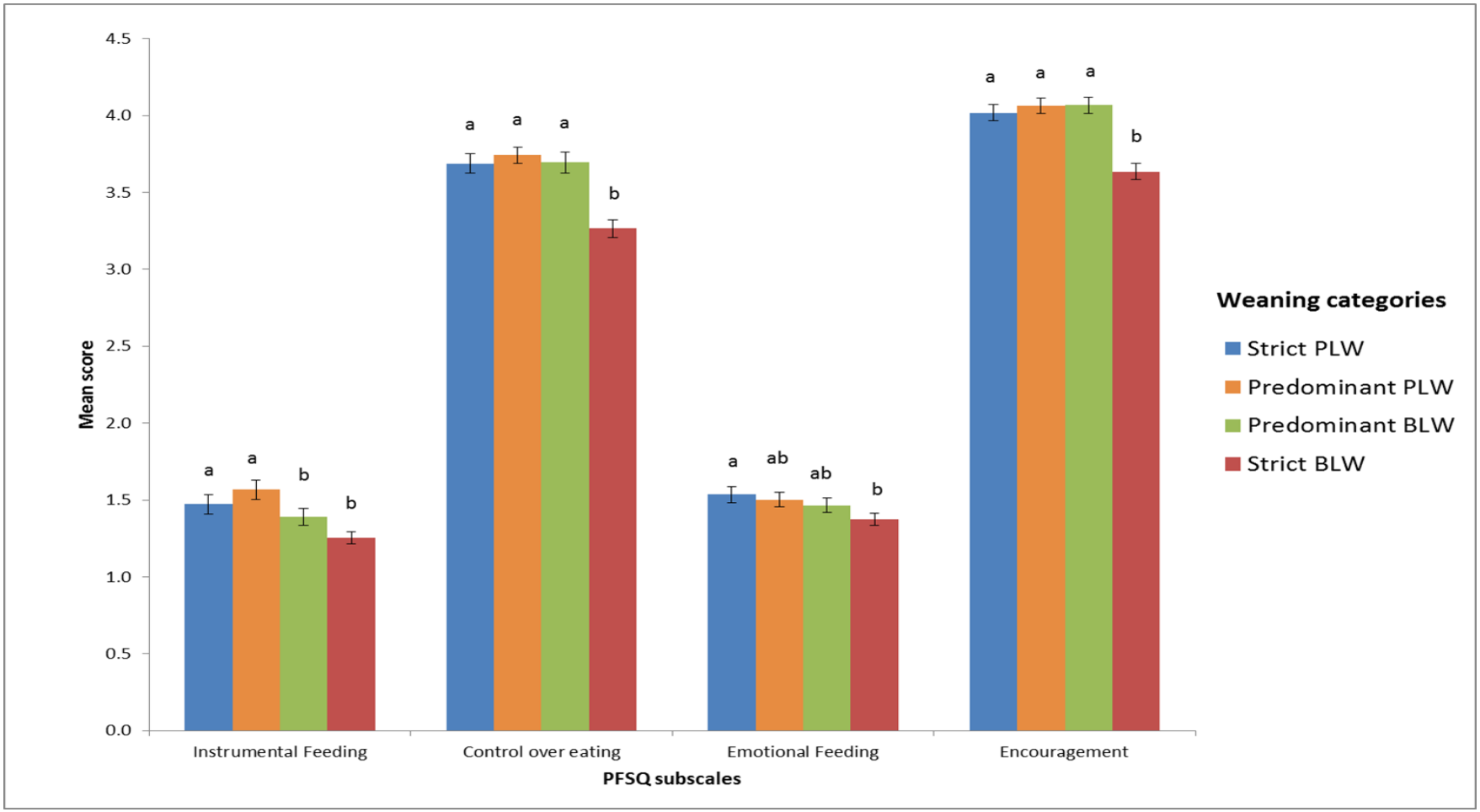

Figure 3: Mean scores in Parental Feeding Questionnaire for every group

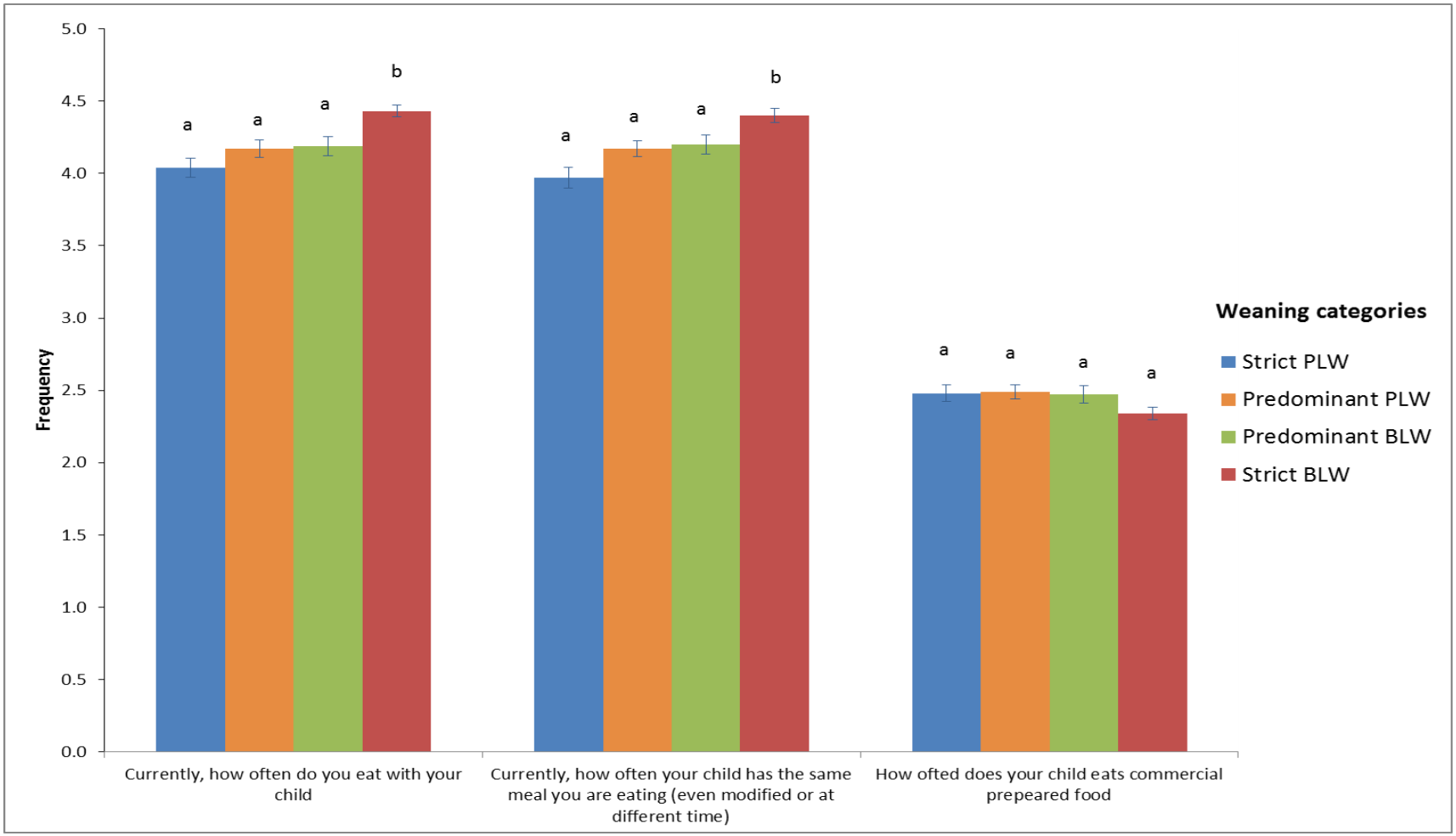

Figure 4: Mean scores in questions on family food environment for every group

5.3.3 SOURCES OF INFORMATION

Within the whole sample 39.3% of the parents identified the internet as their main source of information, 22.3% health professional advice, 14.4% books, 12.3% friends and 8% family. Differences between the main source of information used by each group ($p<0.001$) were identified.

Parents following strict or predominant PLW styles demonstrated a preference for sourcing advice on complementary feeding from health professionals significantly more than expected ($z=2.2$, $p=0.03$ and $z= 2.5$, $p=0.01$ respectively). Parents following a strict BLW style follow health professional's advice significantly less than expected ($z=-3.9$ $p<0.001$). Additionally, family advice was identified as a primary information source significantly more frequently for parents following predominant PLW style ($z=3.5$, $p<0.001$). Parents in both the predominant and strict BLW groups demonstrated a preference for independent research, with the internet found to be a significantly more popular source of advice for parents in the predominant BLW group ($z=2.0$, $p=0.05$), while parents following strict BLW style demonstrated a preference for the use of literature in books ($z=2.1$, $p=0.04$). (Table 22)

Table 19: Count and standardized residual of reported main source of information on complementary feeding in each complementary feeding category

		Strict PLW	Predominent PLW	Predominent BLW	Stict BLW	Total
Health professional	Count	38	44	19	14	115
	Std residual	**2.2**	**2.5**	-.2	**-3.9**	
Friends	Count	16	23	10	27	76
	Std residual	-.4	.7	-.9	.3	
Family	Count	11	21	1	5	38
	Std residual	0.7	**3.5**	**-2.2**	**-2.1**	
Internet	Count	42	43	53	94	232
	Std residual	-1.6	**-2.3**	2.0	1.9	
Books	Count	16	14	10	36	76
	Std residual	-.4	-1.3	-0.9	**2.1**	
Other	Count	8	3	5	12	28
	Std residual	0.6	-1.6	.1	.9	

BLW: Baby led weaning; PLW: Parent led weaning; **Bold** characters signify a z-score higher (of lower) than ±1.96.

5.3.4 MILK FEEDING PRACTICES

The vast majority of the population initiated breastfeeding (95.4%). 89.6% of the study sample was still breast feeding (either exclusively or as a part of combination feeding) at 6 weeks of age. The percentage of any breast feeding remained notably high at 6 months of age (80.4%) and 1 year of age (63%). Only one of the milk feeding practices varied between groups with babies whose parents followed a strict BLW method being breastfed for longer in comparison to the other 3 groups ($F(3,560)=13.39$, $p < 0.001$.)

5.3.5 INTRODUCTION TO SOLID FOOD AND FIRST FOOD OFFERED

There was a statistically significant difference in the age of introduction to solids ($F(3,561) =9.26$, $p<0.001$) and the age of introduction to finger foods ($F(3.561) =16.05$, $p<0.001$). Parents who were following BLW tend to introduce solid food later than the remaining 3 groups (Strict BLW vs. Predominant BLW $p=0.002$, Strict BLW vs. Predominant PLW $p<0.001$, Strict BLW vs. Strict PLW $p<0.001$). However, parents in the strict and predominant PLW groups introduced finger foods later than parents who were following strict or predominant BLW (Strict PLW vs. Predominant BLW $p<0.001$, Strict PLW vs. Predominant PLW $p<0.001$, Strict PLW vs. Strict BLW $p<0.001$, Predominant PLW vs. Predominant BLW $p=0.015$, Predominant PLW vs. Strict BLW $p=0.045$).

Within the whole sample there were also differences between the groups in the nature of the first foods offered (χ^2 $(18,565) = 106.99$, $p<.001$). Parents in the strict and predominant PLW groups offered baby cereals as an introductory food significantly more often than expected ($z=4.3$, $p<0.001$ and $z=3.0$, $p=0.001$ respectively). Parents in the strict PLW category were also significantly less likely to offer vegetables or a mixed meal ($z=-2.0$, $p= 0.023$ and $z=-2.0$, $p=0.023$ respectively). By contrast, parents followed strict BLW were significantly less likely to offer baby cereals ($z=-5.6$, $p<0.001$) and more likely to offer vegetables ($z=2.3$, $p=0.011$) or a mixed meal ($z=3.9$, $p<0.001$) as a first food. (Table 23)

Table 20: Count and standardized residual of reported type of first food given in each complementary feeding category

		Strict PLW	Predominant PLW	Predominant BLW	Strict BLW	Total
Baby rice/Baby porridge	Count	47	45	15	3	110
	Std residual	**4.3**	3	-0.9	**-5.6**	
Vegetable	Count	42	52	50	103	247
	Std residual	**-2.0**	-1.6	1.1	**2.3**	
Fruit	Count	35	47	28	55	165
	Std residual	-.5	0.6	-.1	.0	
Bread& Starches	Count	2	2	2	6	12
	Std residual	-0.5	-.6	-.1	1.0	
Meat	Count	3	2	1	6	12
	Std residual	.1	-.6	-.7	1.0	
Mixed Meal	Count	0	0	2	15	17
	Std residual	**-2.0**	**-2.1**	-.6	**3.9**	
Other	Count	2	0	0	0	2
	Std residual	**2.3**	-.7	-.6	-.8	

BLW: Baby led weaning, PLW: Parent led weaning
Bold characters signify a z-score higher (of lower) than ±1.96.

5.4 DISCUSSION

This is the first study to generate a comprehensive profile of parental characteristics, combining details on feeding styles, practices and information sources, across the full range of complementary feeding approaches. Previous studies have focused on a limited range of feeding behaviours examined in isolation and only in parents following strict BLW practices. The extended categorization obtained will allow the development of tailored advice and support through the weaning process that will complement specific parental needs and practices.

Parents following a strict BLW style were found to be a distinct grouping when considering parental feeding styles, practices and information sources. Specifically, they were less controlling over feeding issues and less likely to encourage their child to eat more than desired. Additionally, they were more likely to offer vegetables and finger foods from the beginning of complementary feeding and relied more on independent research for information relating to the introduction of solid foods. Finally, they shared mealtimes with their child and offered the same food as they ate more frequently that the other defined categories. By contrast, PLW was associated with a reliance on health professionals for advice on weaning. Consistent with this, finger foods were introduced later and initial weaning foods were more often in the form of bland baby cereal, with vegetable flavours offered less frequently. Interestingly, and in conflict with health professional's advice, strict PLW was also associated with an earlier introduction to solids.

Previous studies have demonstrated that adopting some of the characteristics of parents following a PLW approach, such as feeding children in the absence of hunger, in response to specific emotions and encouraging them to consume larger amounts of food than desired, can jeopardize appetite regulation by teaching the child to ignore internal signs of satiety in the presence of food or in response to specific emotions (Birch & Doub, 2014; Birch, McPhee, et al., 1987; Campbell et al., 2006; Johnson & Birch, 1994). Additionally, increased levels of instrumental feeding and controlling feeding practices have been identified more frequently in obese mothers (Wardle et al., 2002). By contrast, the approaches adopted by BLW appear more consistent with the development of healthy eating behaviours.

The benefits of eating a healthy diet are well established. Dietary patterns can help to reduce the risks of chronic disease and prevent obesity, thereby extending and improving quality of life. Increasing the daily consumption of fresh fruit and vegetables is particularly good for improving health and the introduction of vegetable flavours early within the solid food experience, as in BLW, has been shown to exert a positive effect in the development of associated food preferences (Forestell & Mennella, 2007; Mennella & Trabulsi, 2012). By contrast, parents who follow PLW largely introduce solid food in the form of bland-tasting baby cereal. Vegetables and mixed meals are introduced later, possibly

missing a critical flavour-learning window, however the exact timing of the introduction to vegetable tastes, after the introduction to cereal has not been examined. It could also be the case that, with parents following PLW introducing solids earlier, the actual age of vegetable introduction is similar with babies following BLW.

The importance of family mealtimes for toddlers and pre-schoolers for health has also previously been demonstrated. Frequent family mealtimes are consistently associated with better weight outcomes, lower prevalence of obesity (Anderson & Whitaker, 2010; Gable et al., 2007) and increased diet quality and fruit, vegetable and milk consumption (FitzPatrick et al., 2007; Hammons & Fiese, 2011). Additionally, eating similar meals as parents has been shown to be a strong predictor for both higher vegetable consumption and liking in pre-schoolers aged 2-5 years old (Sweetman et al., 2011). It has also been suggested that a BLW approach may further encourage parents to improve the overall quality of the family diet; however, a small scale pilot study (Rowan & Harris, 2012) failed to support this speculation.

Although there has been some previous research on the sources of information parents use when it comes to infant feeding (Pridham, 1990; Carruth & Skinner, 2000), the sources examined quickly become outdated with new and more accessible ways of obtaining information, e.g. the internet and social media becoming available. Furthermore, to date, no examination of the information sources utilised by parents following BLW has been conducted. With PLW representing the currently recommended approach to complementary feeding, support and guidance from health professionals is readily sought. However, at present, parents following BLW approaches are largely reliant on alternative information sources potentially lacking in accuracy and without a sound underlying evidence base. Given the potential for a profound impact of feeding practices and flavour preferences developed early in life on future health it is imperative that parents are supported and educated across a range of complementary feeding approaches. Encouragingly, official guidelines have begun to include content consistent with aspects of the BLW approach (e.g. the recent UK Department of Health NHS guidelines; NHS, 2011.)

The online nature of this study brings limitations in its reliance on self-reported data from a self-selected participant sample. Reported breastfeeding rates were much higher than average, suggesting a potential bias towards responses from more educated and health conscious individuals. However, a balanced distribution across the four defined complementary feeding styles was achieved. The retrospective nature of the research also renders it impossible to determine whether the identified parental feeding styles and practices provided the motivation to follow a specific complementary feeding style or developed as a consequence of the approach chosen. A longitudinal study, incorporating measures before and after the weaning period may provide information on the motives for choosing to follow a particular weaning style

To conclude, in examining parental characteristics across the full range of complementary feeding approaches, this study has identified an association between traditional PLW, consistent with the guidance offered by health care professionals, and parental characteristics that are inconsistent with the development of healthy food preferences and feeding behaviours in children. By contrast BLW appears to support positive developmental steps. Yet, this approach to complementary feeding is largely ignored by health professionals leading parents to rely on information obtained from potentially unreliable resources. It is imperative that a detailed understanding of the long term impact of each weaning approach is identified to ensure parents are educated in all approaches to complementary feeding and particularly the benefits and concerns of each and further are supported through the choices they make.

CHAPTER 6
THE IMPACT OF COMPLEMENTARY FEEDING PRACTICES ON TODDLER'S EATING BEHAVIOUR

Data from this chapter were presented as a conference paper at Nutrition and Nurture in Infancy and Childhood: Bio-Cultural Perspectives Conference, 10th, 11th & 12th June 2015, Grange-Over-Sands, Cumbria, UK

6.1 INTRODUCTION

The introduction of solid foods to the infant's diet is particularly important from both nutritional and behavioural perspectives. This period not only provides the infant with the opportunity to supplement its nutritional needs, but it also provides a unique sensory experience for both taste and texture.

The infant's taste journey begins during milk feeding, with literature widely reporting that breast milk carries volatile molecules from the mother's diet, which alters its taste (Hausner et al., 2010; Mennella & Beauchamp, 1991). Formula fed infants however have a more limited taste journey with the constant flavour of the formula milk they are given. Regardless of milk feeding status, a second programming window appears to coincide with the age at which infants are typically introduced to solid foods. Evidence shows that sweet and umami tastes are generally more easily accepted by infants 5-7 months of age. There is no clear rejection of sour and bitter taste either at this time. (Schwartz et al., 2011).

The method parents use to introduce solid food to their infant's diet determines the nature of texture exposure an infant experience. Traditional approaches involve a gradual introduction of more complex textures - first purees spoon fed by an adult, with more lumpy and solid food being offered a little later. Recently, however, an alternative approach is gaining the attention of both parents and researchers. The baby led weaning (BLW) approach negates purees and spoon feeding, by putting the infant in a central feeding role and letting them self-select and self-feed rather that being the passive receiver of the food.

There is evidence from online questionnaires in the UK and New Zealand that BLW is associated with greater satiety responsiveness and lower rates of overweight and obesity than traditionally weaned, spoon fed infants and toddlers (Brown & Lee, 2015; Cameron et al., 2013), Cameron et al). Additionally, BLW is also associated with factors that are linked to better eating habits, such as a longer duration of breastfeeding, delayed introduction of complementary feeding, less parental control over feeding, family mealtimes and less commercial/more home prepared meals. (Brown & Lee, 2015; Cameron et al., 2013; Townsend & Pitchford, 2012). However, given the contemporary nature of BLW such studies typically only report on relatively short term associations between complementary feeding method and eating behaviours or later weight status.

Although a novel concept, with no official definition, BLW is generally described in the current literature as spoon feeding less than 10% of the time (Brown & Lee, 2015). This leaves a very broad range of solid feeding methods to be categorized as parent led weaning (PLW). This range extends from exclusively spoon-feeding to self-feeding and self-selecting the majority of the time with a maximum of 11% contribution from spoon feeding. Such a combination approach is likely of benefit to parents in the busy modern day environment. However, whilst beneficial feeding outcomes have

been identified for children following a BLW approach (Brown & Lee, 2015; Cameron et al., 2013; Townsend & Pitchford, 2012), there has been no research to date looking at the effects of a combination of complementary feeding methods on children's feeding behaviours.

This survey applies a new categorisation of complementary feeding practices to examine the impact of the entire range of weaning approaches, from exclusive PLW to exclusive BLW, on children's feeding behaviours. By amalgamating the widest range of questionnaire measures presented to date in the literature, it will also generate the broadest insight to the impact of these different approaches.

6.2 METHODS AND MATERIALS

6.2.1 PARTICIPANTS AND RECRUITMENT

Study participants were the same as chapter 5. For more information refer to the relevant section.

6.2.2 THE SURVEY

The survey was largely identical in nature to that applied in the previous chapter. However, responses to questions relating to family food environment and meal patterns and sources of information were not relevant to the consideration of child feeding behaviours. By contrast, questions relating specifically to fruit and vegetable liking were incorporated.

Parents were asked the type (fruit, vegetable, baby rice or other) and the form (puree or finger food or other) of the first food given to the child as an indicator of the consequent practice. In both questions, there was space for parent to indicate what the "other" choice was.

Parents were also asked to complete the Child Eating Behaviour Questionnaire (CEBQ). The CEBQ was developed to assess the eating behaviour of young children. It includes 35 items in eight dimensions which are associated with either underweight or overweight in later life (Food responsiveness, Emotional over-eating, Enjoyment of food, Desire to drink, Satiety responsiveness, Slowness in eating, Emotional under-eating and Food fussiness).

In a previous study, an extensive food likes and dislikes questionnaire was administered (Townsend & Pitchford, 2012). However, this study only measured fruit and vegetable liking. Specifically parents were asked to indicate their child's preference from a list of 21 different vegetables using a 5 point likert scale. The option of "never tried" was available to them.

6.2.3 STATISTICAL ANALYSIS

Analysis was conducted using IBM SPSS Statistics (version 21, IBM Inc., Somers, NY). Data conformed to the requirements for parametric analysis therefore an analysis of covariance (ANCOVA) was performed to compare the effect of the different complementary feeding practices on

the different dimensions of the CEBQ. The covariates used were decided based on strong associations of the variables with the outcome found in previous literature. Analysis of variance (ANOVA) was performed to assess liking ratings of each vegetable and the total number of vegetables that haven't been tried at the time of the survey completion (from the 21 vegetables of the survey) between the feeding categories. For each vegetable, only the toddlers who were reported to have tried the vegetable were included in the analysis. An average liking score was calculated from the vegetables tried for each toddler to assess the overall effect of the complementary feeding method in the overall vegetable liking.

6.3 RESULTS

From the eight hundred and thirty parents recruited, five hundred sixty-five (68%) completed the survey and were included in the final analysis. From those 23.2% followed strict PLW, 26.2% Predominant PLW, 17.3% Predominant BLW and 33.3% Strict BLW

There was a significant difference between the four groups when considering the age of the children at the last breastfeed $F(3,560)=13.39$, $p<.001$, toddlers whose parent followed strict BLW were significantly older when they were introduced to solids $F(3,561)=9.26$, $p=0.001$. This variable, was added as covariates to comparison for CEBQ subscale scores (Table 24). Other population demographics are discussed in more detail in the previous chapter.

6.3.1 EATING BEHAVIOUR CHARACTERISTICS

A one way MANOVA revealed a significant difference of the toddlers eating behaviour between the four groups $F(24, 1665)=2.04$, $p=.002$. Further univariate tests revealed significant differences between the four defined complementary feeding method groups and food fussiness $F(3,560)=3.99$, $p=.008$) and food responsiveness $F(3,551)=4.82$, $p=.003$ from the CEBQ. When the model was corrected for confounding variables (duration of breastfeeding and age of solid introduction), however, the food responsiveness subscale was no longer significant. Adjustment for covariates strengthen the significant level for food fussiness $F(3,560)=5.30$, $p<.001$;, and, interestingly, revealed a significance difference for the mean score on the enjoyment of food subscale between the categories $F(3,560)=3.30$, $p=.020$ (Table 25).

Post hoc analysis of the significant subscales of the CEBQ revealed significantly lower level of food fussiness and higher food enjoyment for the toddlers who were allowed to self-feed most of the time in comparison to mainly spoon fed toddlers [Fussiness: (strict PLW vs. strict BLW $p=.030$); Enjoyment: (strict PLW vs. strict BLW $p=.004$), (Predominant PLW vs. strict BLW $p=.029$)].

Table 21: Demographic and descriptive characteristics by overall sample and complementary feeding categories

Characteristic	Overall (n=565)	Complementary feeding type				p*
		Strict BLW (n=188)	Predominant BLW (n=98)	Predominant PLW (n=148)	Strict PLW (n=131)	
Mother's Age (mean years±SE)	32.37±0.192	32.56±0.313	32.61±0.430	31.49±0.415	32.89±0.395	.051
Father's Age (mean years±SE)	34.93±0.251	34.84±0.398	35.45±0.646	34.31±0.551	35.35±0.475	.391
Child's Age (mean months±SE)	22.41±0.302	22.69±0.518	20.96±0.697	22.70±0.587	22.74±0.650	.185
Mother's BMI (mean kg/m^2 ±SE)	25.50±0.25	25.55±0.45	25.02±0.52	25.22±0.48	26.10±0.53	.505
Father's BMI (mean kg/m^2 ±SE)	26.21±0.23	26.21±0.23	26.49±0.56	26.55±0.46	26.07±0.37	.698
Age of introduction to solid food (mean weeks±SE)	24.66±0.19	26.01±0.26	24.35±0.34	23.99±0.40	23.71±0.47	<.001
Any breastfeeding duration (mean weeks±SE)	66.00±1.68	80.48±2.47	61.04±3.52	56.65±3.52	59.47±3.71	<.001

BLW: Baby led weaning, PLW: Parent led weaning *Group differences ascertained by one Way ANOVA

Table 22: Unadjusted and adjusted mean scores of CEBQ in each complementary feeding category

CEBC subscales score (M±S.E.)	Unadjusted model					Adjusted model*				
	Strict PLW	Predominant PLW	Predominant BLW	Strict BLW	p-value**	Strict PLW	Predominant PLW	Predominant BLW	Strict BLW	p-value***
Food Fussiness	14.31±0.39	13.13±0.36	13.21±0.45	12.57±0.32	**.008**	14.35±0.38	13.31±0.36	13.31±0.44	12.33±0.33	**.001**
Food Responsiveness	11.44±0.32	11.79±0.30	11.84±0.37	10.49±0.26	**.003**	11.27±0.31	11.61±0.29	11.74±0.36	10.80±0.27	.115
Emotional Overeating	6.39±0.19	6.45±0.17	6.06±0.21	5.90±0.16	.073	6.36±0.19	6.41±0.18	6.04±0.21	5.98±0.16	.225
Enjoyment of food	15.84±0.19	16.18±0.18	16.33±0.22	16.39±0.16	.163	15.78±0.19	10.07±0.18	16.27±0.22	16.56±0.16	**.020**
Satiety Responsiveness	15.20±0.19	14.76±0.23	14.52±0.29	15.16±0.21	.171	15.27±0.19	14.89±0.23	14.59±0.28	14.96±0.21	.326
Emotional Undereating	12.31±0.33	12.49±0.31	12.04±0.38	11.48±0.27	.073	12.19±0.33	12.45±0.31	12.02±0.39	11.56±0.28	.222

BLW: Baby led weaning, PLW: Parent led weaning, CEBQ: Child Eating Behaviour Questionnaire, *Adjusted for breastfeeding duration and age of introduction of solid food.
**Group differences ascertained by one Way ANOVA, ***Group differences ascertained by one Way ANCOVA

6.3.2 COMPLEMENTARY FEEDING METHODS AND VEGETABLE LIKING.

The liking score of 5 vegetables (tomato, beetroot, sweetcorn, courgette and cucumber) differed significantly between the groups ($F(3,551)=3.04$, $p=.029$; $F(3,555)=5.07$, $p=.002$; $F(3,535)=3.07$, $p=.027$; $F(3,470)=3.54$, $p=.015$; $F(3,549)=3.53$, $p=.015$ respectively) .The liking scores of three other vegetables (pepper, onion and squash) also approached, but did not reach significance. For all but one the significant comparisons, post-hoc test revealed higher liking scores in toddlers weaned with a strict BLW approach than their peers who were weaned with a strict PLW approach. For sweetcorn the opposite association was observed with infants who were weaned with a predominantly PLW style having the highest liking scores. There were however no significant differences between the two mixed method categories. The overall average liking score, as calculated by only the tried vegetables did not differ significant between the categories $F(3,561)=2.09$, $p=.10$. (Table 26).

When considering the number of vegetables tried, toddlers who were weaned using a strict BLW approach were found to have tried more vegetables on average than the toddlers in both PLW categories $F(3,561)=8.14$, $p<.001$;. The mean differences were not large with the strict BLW group reporting trying a median of 2 more vegetables than both PLW groups. Furthermore, toddlers in the strict BLW group were reported to have tried at least 13 of the 21 vegetables listed, whilst their peers in both PLW groups have tried a minimum of only 8 of the 21 vegetables. (Table 27)

Table 23: Univariate liking scores differences between the complementary feeding categories for each vegetable

	Strict BLW	Predominant BLW	Predominant PLW	Strict PLW	p-value*
Carrot	1.80±.064	1.92±.100	1.89±.085	1.95±.086	.534
Potato	1.71±.060	1.79±.095	1.95±.082	1.89±.091	.101
Spinach	2.51±.077	2.67±.118	2.53±.090	2.70±.097	.365
Celery	2.81±.083	2.93±.114	2.91±.103	2.97±.109	.627
Broccoli	1.96±.080	2.02±.109	2.03±.093	2.16±.111	.504
Cauliflower	2.35±.074	2.44±.110	2.34±.089	2.44±.104	.805
Tomato	2.06±.085	2.30±.120	2.10±.099	2.43±.110	**.029**
Beetroot	2.39±.083	2.50±.123	2.76±.113	2.91±.130	**.002**
Lettuce	3.19±.078	3.11±.115	3.04±.086	3.14±.091	.620
Cabbage	2.77±.072	2.85±.110	2.70±.093	2.85±.100	.622
Green Peas	1.60±.067	1.57±.088	1.78±.090	1.84±.081	.066
Sweet Corn	1.53±.060	1.65±.082	1.83±.091	1.62±.076	**.027**
Courgette/Zucchini	2.29±.070	2.29±.092	2.50±.095	2.62±.089	**.015**
Aubergine/Eggplant	2.64±.085	2.67±.109	2.82±.098	2.87±.113	.281
Sweet Potatoes	1.97±.071	1.87±.099	1.95±.090	2.18±.093	.105
Pepper	2.40±.082	2.38±.118	2.19±.088	2.56±.103	.065
Onion	2.67±.069	2.53±.101	2.41±.072	2.65±.084	.065
Squash	2.17±.072	2.04±.091	2.16±.092	2.39±.103	.079
Green Beans	2.12±.072	2.32±.105	2.19±.092	2.20±.084	.462
Cucumber	1.85±.076	2.04±.117	2.11±.105	2.29±.113	**.015**
Brussel Sprouts	2.76±.096	2.89±.136	2.86±.115	2.90±.132	.811
Overall Average	2.26±.038	2.30±.049	2.31±.047	2.41±.048	.100

BLW: Baby led weaning, PLW: Parent led weaning *Group differences ascertained by one Way ANOVA
All values are expressed as mean score±S.E., 1=Like a lot, 2=like, 3=neither like nor dislike, 4=dislike, 5=dislike a lot

Table 24: Mean, Median, minimum and maximum values of the total number of vegetable tried in each category

	Strict BLW (n=187)	Predominant BLW (n=98)	Predominant PLW (n=149)	Strict PLW (n=131)	p-value*
Mean ±SE	19.19±0.15	18.50±0.25	18.30±0.23	17.83±0.24	<.001
Median	20	19	18	18	N/A
Minimum	13	11	8	8	N/A
Maximum	21	21	21	21	N/A

BLW: Baby led weaning, PLW: Parent led weaning
*Group differences ascertained by one Way ANOVA

6.4 DISCUSSION

This is the first study to generate a more comprehensive profile of children's feeding behaviours across the full range of complementary feeding approach. Evidence was identified to support an association between a BLW approach to weaning and better eating behaviour outcomes in toddler hood. Specifically, after adjustment for breastfeeding duration and age of introduction to solid food, toddlers who were weaned following a strict BLW style, with very little or no use of spoon feeding at all, scored lower on the food fussiness subscale and scored higher on the food enjoyment subscale of the CEBQ. Additionally, although significant differences in vegetable liking were limited, toddlers who were introduced to solids using a stricter BLW approach were found to have tasted a bigger vegetable variety than their peers in the strict PLW category.

These results are partly consistent with one published study examining weaning style and eating behaviours in toddlerhood (Brown & Lee, 2015).In this published study associations were identified with all four dimensions of the CEBQ. The current study failed to identify this relationship with regard to satiety and food responsiveness subscales. In the current sample the majority of the toddlers were breastfed for an extended period of time. As there is evidence to suggest that breastfed babies are more satiety responsive (Bartok & Ventura, 2009; Brown & Lee, 2012) it is possible that the effect of breastfeeding masked any impact of the complementary feeding method. By contrast, food responsiveness is more related to the solid feeding and self-control and as such may represent a better measure of the effect of BLW on the eating behaviour of toddlers. In this study, strict BLW toddlers were found to be significantly less food responsive in the unadjusted comparison. As such, those toddlers were less likely to eat in response to the presence or the availability of food. This association is not present in the adjusted model, which indicates that either the duration of breastfeeding or the age of introduction to solids is largely responsible for this difference in the crude comparison.

Food fussiness was found to be significantly lower while food enjoyment was significantly higher in toddlers who were weaned with a strict BLW style. This finding is in accordance with previous research (Brown & Lee, 2015). Neophobia, the reluctance or avoidance to try new foods make an appearance in toddlerhood and peaks between two and six years (Addessi et al., 2005; Cooke, Carnell, & Wardle, 2006; Dovey, Staples, Gibson, & Halford, 2008),. Although once a protective mechanism against potential intoxicating food, (Pliner & Hobden, 1992) it can be the cause of limited fruit and vegetable consumption (Cooke et al., 2004, 2006) and nutritional deficiencies (Cooke et al., 2004, 2006; Falciglia, Couch, Gribble, Pabst, & Frank, 2000; Galloway et al., 2003; Russell & Worsley, 2008). Many parents can interpret this state as food fussiness, as the period when their child demonstrates very specific dietary intake patterns. Although no studies have directly examined a link between weaning style and neophobia, it might be the case that the reduced level of food fussiness

and the increased levels of food enjoyment found in BLW children in both studies is a sign of lower levels of food neophobia.

In previous work on the same sample we found that parents following a BLW style had distinctively different characteristics than parents who follow a PLW approach to weaning. Moreover, families whose toddlers have been introduced to solid feeding through a stricter BLW approach were eating together with their child, and consuming the same meal as their child more often than families with toddlers in the strict PLW category as reported in the previous chapter. Parents who follow BLW are less monitoring around food and food intake. Additionally, the mantra "food until one is just for fun" is very commonly used in the wider BLW community. This phrase is used to encourage parents to adopt a more hands off approach to complementary feeding and let their infants play and experience the food with all their senses before they decide whether they want to consume it or not. It is possible that a more laid back approach when the infants are introduced to food allows them to become more confident about the food they are consuming before they consume it. This, along with the experience of eating as a family event can help towards a more positive approach towards eating during toddlerhood, especially when food neophobia begins.

The effects of BLW on food liking is often advocated by parents following this approach, claiming that their children are much easier to feed traditionally "difficult" foods like vegetables. From a more pragmatic position, our data could be considered to support this claim. However significant differences in liking were only found for 5 vegetables from a list of 21. Additionally, the average vegetable liking was not found to differ between groups. However, our data show that parents who are following strict BLW do offer a larger variety of vegetables for their children to taste. Flavour exposure by itself is shown to have a positive effect on acceptability of individual vegetables (Ahern, Caton, Blundell, & Hetherington, 2014; Caton et al., 2014) and offering a variety of vegetables during the early stages of complementary feeding can increase infants liking an consumption of unfamiliar vegetables, at least mid-term (Fildes, Wardle, & Cooke, 2014). There is also a limited evidence base to suggest possible generalization between vegetables with similar flavour profiles. Although, it is very difficult to detect which flavour similarities can aid generalized vegetable acceptance (Ahern et al., 2014; Mennella et al., 2008).

It is possible that a combination of the characteristics of the BLW philosophy in general, as well as the individual characteristics of the parents who choose to follow it, can both contribute towards the eating behaviour outcomes observed. Some studies find direct and indirect associations between parental restriction or parental control over feeding and BMI or food intake (Carper et al., 2000; Fisher & Birch, 2000; Joyce & Zimmer-Gembeck, 2009; D. R. Musher-Eizenman, de Lauzon-Guillain, Holub, Leporc, & Charles, 2009; Powers et al., 2006). However, other studies fail to find the same associations (Al-barazanji, Arch, Buckingham, Tadayyon, & Kamal, 2000; Brann & Skinner,

2005; Faith et al., 2003; May et al., 2007). Experimental studies following an "eating in the absence of hunger" trial design, report increased consumption of prohibited food and increased disinhibition when restrictive practices were used (Fisher & Birch, 1999a, 2000; Jansen et al., 2007). Similarly, children exposed to either very little or significant levels of restriction at home demonstrated greater energy intake in the experiment, while those who experienced moderate restriction at home demonstrated a much reduced level of intake. (Jansen et al., 2007). In the case of the present findings, we are unable to categorize the level of food restriction or food monitoring at home, in order to draw more conclusive results about the effect of the parental characteristics in this sample.

This study has all the limitations that are associated with on line survey methodologies, such as reliance on a self-selected sample providing self-reported data. Although BLW was not specifically referred to during advertising and adverts were not placed on specific BLW websites, it is possible that parents who decided to take part in the study were more health conscious. As such this could artificially increase the use of BLW approaches in the study population. Another limitation of the current study is the inability to draw any conclusions about the direction of any observed interactions, especially when the confounding factors are not clearly understood. Both infant and parental characteristics can influence the complementary feeding style each family chooses to follow. Additionally, those characteristics are dynamic and may change and adapt to different situations. It is equally important to consider parent-infant and parent-child interactions in each case. Finally, as an implication of the retrospective nature of the study, it is possible that parents' responses were not completely reliable and accurate as they rely on their memory.

Future research examining the benefits of BLW as a complementary feeding practice would benefit from a longitudinal approach with the potential to reveal more about the direction of the associations identified to date in cross-sectional studies. Obtaining more objective measurements of eating and feeding behaviour rather than relying on the self-reported nature of online surveys will also help to clarify the outcomes. Ideally, future studies will take the form of randomized control trials which will minimise the impact of parental predisposition. However, it is difficult to predict the compliance of participants in such a protocol.

In summary, allowing infants to self-feed during the majority of feeding events may help to develop a less fussy toddler who enjoys food more than a toddler who, on the other side of the spectrum, was spoon-fed the majority of the time. Vegetable liking scores also appear to be higher for BLW toddlers, but only for specific vegetables within the list examined. A study recruiting a larger sample size and with consideration of a more extensive range of vegetables may be beneficial moving forward. For infants whose parents follow a mix methods approach no conclusive benefits in terms of either eating behaviours or vegetable liking were identified.

CHAPTER 7
CONCLUSIONS

The thesis set out to explore the influence of various maternal-infant feeding choices on mothers, infants and toddlers. This was achieved through the use of a variety of methodologies including observational, content and quantitative analysis of data collected both in laboratory settings and using on-line survey platforms. Initially a small-scale laboratory study was conducted to examine the effects of milk feeding practices (breast vs formula feeding) on food acceptance shortly after the introduction of complementary feeding. The data collected also allowed for a qualitative examination of the criteria used by mothers to assess food liking and enjoyment and the relationship of those ratings with the quality of the mother-infant dyad interaction. The second part of the thesis focused on complementary feeding and identified specific characteristics of parents categorised according to the weaning methods they used and the consequential eating behaviours demonstrated by their toddlers.

As discussion sections are included in all empirical chapters to compare each study findings with the rest of the literature and provide the studies strengths and limitations, this chapter will focus on summarizing the findings, answering the research questions, and provide implications for research and practice driven by the results. Additionally, an extended critique on the limitations of the laboratory feeding studies and impact of those limitations on their results is presented. A personal reflection on the impact of the studies is also included at the end of the chapter as a closing remark.

As discussed in the introduction the research enquiry is driven by five key research questions developed through a combination of scientific literature and research experiences:

Q1. How do early life experiences (both milk feeding and the introduction of solid food) affect vegetable intake during the early weaning period?

Q2. What criteria do mothers use to assess food liking when feeding familiar and novel vegetables to their infants during the early weaning period?

Q3. How do maternal eating behaviours and neophobia impact on mother-infant interactions during feeding of familiar and novel vegetables during the early weaning period?

Q4. Do parental characteristics influence the approach used to introduce solid food during the early weaning period?

Q5. Does the approach used to introduce solid food have effects on eating behaviour and the liking of vegetables beyond infancy?

The next section answers individually each research question by summarizing the findings presented in the previous chapters.

7.1 FINDINGS SUMMARY

7.1.1 Q1. HOW DO EARLY LIFE EXPERIENCES (BOTH MILK FEEDING AND THE INTRODUCTION OF SOLID FOOD) AFFECT VEGETABLE INTAKE DURING THE EARLY WEANING PERIOD?

Contrary to the literature and the resulting initial hypothesis developed, the laboratory study in chapter 3 failed to identify any evidence to support the proposal that breast fed infants where in a more advantageous position than formula fed infants to accept more readily any of the 4 different vegetables offered. However, the results could have been skewed by the uneven comparison groups and the very low number of formula fed babies in the study sample. Although the intake did not significantly differ statistically, breast fed babies consumed consistently less of all four vegetable purees. A study in a larger sample that is powered enough to provide confidence in both significant and non-significant results, therefore, is needed to reach a conclusion.

While there was some evidence of prior flavour exposure, with some of the vegetables offered found to be more frequently consumed by mothers over the previous 12 months, this did not influence an infant's own consumption. Infant temperament was also found not to differ between breast and formula fed infants, despite limited literature suggesting otherwise (Barr, Kramer, Pless, Boisjoly, & Leduc, 1989; de Lauzon-Guillain et al., 2012).

As a considerable number of mothers decided to follow a BLW approach to introduce solids, the impact of this approach, and more specifically the restricted use and the absence of spoon feeding on vegetable intake and perceived liking and enjoyment was also analysed. Although the maternal ratings of infant enjoyment and liking did not significantly differ, infants' intake of a typically more novel and disliked vegetable, such as spinach, was significantly lower when infants had no previous experience with spoon-feeding during the first month of solid introduction. In addition, a pattern of lower intake for all four vegetables for infants with no spoon-feeding experience appeared during these comparisons as well. This can be explained partly by the unfamiliar feeding situation in the lab, especially when infants were not regularly exposed to spoon and utensils. With this analysis based on an incidental finding not originally factored into the study design, there was no potential for a more sophisticated analysis of these results.

7.1.2 Q2. WHAT CRITERIA DO MOTHERS USE TO ASSESS FOOD LIKING WHEN FEEDING FAMILIAR AND NOVEL VEGETABLES TO THEIR INFANTS DURING THE EARLY WEANING PERIOD?

The thematic analysis in part 2 of chapter 4 demonstrates that mothers use a variety of cues to rate the success of the feeding event. Both explicit cues easily identified by an external observer, and implicit

cues, based on previous maternal interactions and experiences with the infant were reported. The most commonly reported cues were explicit, with facial expressions, infant's willingness to continue eating without signs of distress and the quantity eaten being the most popular. These cues are consistent with the observations most commonly used by researchers to rate food liking in laboratory-based infant feeding studies. For example, the newly developed FIBFECS coding system uses a combination of negative facial expressions and both negative (turning head away, gets fussy, push spoon away) and positive behaviours (lean forward), similar to those reported by mothers. The intake of the food is also a measurement routinely employed in infant feeding studies. This suggests that maternal perceptions of food enjoyment and feeding success are largely consistent with tools developed to measure it.

7.1.3 Q3. How do maternal eating behaviours and neophobia impact on mother-infant interactions during feeding of familiar and novel vegetables during the early weaning period?

The study results indicate that mothers use a different approach and vary their interactions with their baby when offering familiar versus novel foods. For more novel and disliked foods, like spinach, mothers seem to pay more attention to their infant's explicit cues, such as facial expression, body movements and their willingness to continue eating and the clarity of those cues is what appears to affect the maternal evaluation of the food enjoyment. For carrot, a well-liked and familiar vegetable, mothers appeared to focus on other aspects of feeding. This might be also linked with a more frequent use of implicit cues in chapter 3 when assessing enjoyment of familiar vegetables, like carrot. For such familiar vegetables, the maternal evaluation of food enjoyment is influenced by the overall quality of the mother infant interactions, which includes both the responsiveness of the caregiver and the infant, the clarity of the infant's cues but also the educational aspect of the feeding including the cognitive and the social growth fostering.

Maternal eating behaviour also appeared to affect the feeding of novel and familiar vegetables. However, it is important to remember the small size of the study and the implications for generalization. The correlations found are, indeed, sporadic, however, if further validated in larger samples could provide valuable information about the way mothers approach feeding. For instance, increased levels of maternal neophobia result in a mother who is more focused on the feeding than the educational aspect of the session, especially when the baby is presented with a novel food, like spinach. However, there is no evidence that maternal neophobia has an effect on mother infant interactions when feeding carrot. Additionally, mothers who are emotional eaters themselves appear to be more responsive and try to alleviate their infant's distress during feeding spinach, using many different strategies. Maternal restrained and external eating also positively correlated with spinach intake and maternal perception of enjoyment respectively, but no association was found for carrot, further reinforcing the argument that the impact of the maternal eating behaviour is largely situational

and potentially depends on the familiarity or the sensory characteristics of the food offered, however the exact reason and mechanism require further study.

7.1.4 Q4. Do parental characteristics influence the approach used to introduce solid food during the early weaning period?

The results from chapters 5 and 6 indicate that a strict BLW approach is associated with both parental and toddler's characteristics that are consistent with healthier eating habits when compared to a strict PLW approach to complementary feeding. More specifically, parents who follow BLW were found to exercise significantly less control and offer less encouragement over feeding, have more frequent mealtimes and share the same food with their child more often, offer vegetables from the beginning of complementary feeding and offer a greater variety of fruits and vegetables to their children to taste. They were also found to rely more on self-research than health professionals for complementary feeding related advice. Toddlers who were introduced to solid feeding with BLW approach were found to be less fussy over eating and enjoy food more, compared to their peers whose parents followed a PLW approach.

By contrast, PLW was associated with more obesogenic parental feeding practices, such as instrumental and emotional feeding. Parents following this approach introduced solid feeding earlier than parents who followed BLW and they did so by offering bland tasting baby cereals, with vegetables and other table foods following later.

The present study failed to provide conclusive results for the characteristics of parents or toddlers following a mixed (BLW and PLW) methods approach to weaning.

7.1.5 Q5. Does the approach used to introduce solid food have effects on eating behaviour and the liking of vegetables beyond infancy?

The results of chapter 6 support an association between a BLW approach and the development of healthier eating behaviour outcomes at weaning. After adjustment for breast feeding duration and age of introduction to solid food, toddlers whose parents followed a strict BLW approach, with minimal to no use of spoon feeding at all, scored lower on the food fussiness subscale and higher on the food enjoyment subscale of the CEBQ. Food responsiveness was also found to be significantly higher in toddlers who followed strict BLW, however the significance level dropped after adjustment for breast feeding duration and age of solid introduction, indicating that the co-existence of those factors along with BLW might be responsible for the initial significant difference. Additionally, although significant differences in vegetable liking were limited, toddlers who were introduced to solids using a stricter BLW approach were found to have tasted a bigger vegetable variety than their peers in the

strict PLW group. The study results were inconclusive with regard to the impact of using a mixed methods approach to weaning that combines spoon and self-feeding on different occasions.

7.2 IMPLICATIONS FOR FUTURE RESEARCH

The content analysis of maternal responses justifying the food liking ratings, offers a thorough and unique perspective on the validity of maternal perceptions as a means of assessing food liking and feeding success that could potentially contribute to the development of a comprehensive infants' food acceptance tool. However, as a direct consequence of the methodology, the results were potentially compromised by the limited number of participants in the sample. As mentioned in chapter 4, laboratory based infant feeding studies are notoriously difficult in terms of participant recruitment and retention. A more simple study design requiring fewer visits could potentially increase the participant numbers in the study. It is also important that consideration of the time required for training in observational techniques, like NCAST and FIBECS, and for scoring and analysis of video observations is built into future studies. Furthermore, on the basis that NCAST was developed to assess problematic mother-infant interactions, mothers will mental health problems could make an interesting inclusion in future studies.

The analysis of mother-infant interactions and their associations with measures of intake and maternal perception of liking was of an exploratory nature. However, the results suggest that restricting mother-infant interactions in infant feeding studies can have a profound impact on the validity of the results. Limiting the interactions, as is very often the case in studies, can confuse both the mother (or the caregiver feeding the infant), and the infant. However, when allowing for these interactions to take place, researchers should account for influences introduced by the caregiver's own liking of the food that is being offered and possibly the levels of food neophobia, especially when the food offered is novel. Another important consideration when assessing the potential to include NCAST in future infant feeding studies, is the increased prevalence of BLW practices at weaning. The NCAST was designed more than 20 years ago for feedings that were mainly parent led, therefore its validity on infant-led feedings is unclear.

In this study and in the current literature around BLW, the distinction between the groups is made by the distinction of self, versus spoon feeding. While this is true for a large amount of the cases, the philosophy behind BLW is built around responsive feeding rather than the medium the food is provided with. According to the literature, parents following BLW are likely to wait for the developmental cues that signify readiness to eat solid food and they might be more responsive to their child's cues that signify hunger or satiety. It is also likely that the baby-led approach to feeding is not isolated from the general parenting style. It is very difficult to identify whether those eating behaviours associated with BLW in the present study and in the rest of the literature can be solely

attributed to the effects of self-feeding, or to the general child upbringing and the more laid back parenting style. It is important to note that maternal anxiety impacts on early life feeding choices and feeding practices (Brown, 2015). While data on maternal anxiety were not collected for the studies of the present thesis, future studies looking into weaning styles should include those measurements of maternal anxiety in order to control for possible confounding factors.

In order to look at the effects of BLW randomised control trial protocols are needed, with infants randomly allocated to either spoon feeding or self-feeding groups when they begin the process of complementary feeding. Studies of these protocols not only introduce ethical considerations, but the parents' recruitment and compliance to the protocol would be extremely challenging. Another aspect that is worth researching is the one of maternal-infant interaction during feeding and how this might be different between BLW and PLW dyads, especially when looking specifically into caregiver responsiveness and the clarity of the infants cues. Such studies could shed some light into the mechanisms through which BLW supports the formation of healthier eating behaviours.

7.3 IMPLICATIONS FOR POLICY AND PRACTICE

Outcomes of research on BLW have policy perspectives. Currently, parents who are following BLW are more likely to rely on self-research to find information on complementary feeding rather than the reliance on health care professionals reported by parents who are following PLW. This can potentially lead them to follow incorrect and not evidence based information which can have inadvertently determinably impact on their child's health and future eating behaviours. While the NHS UK guidelines on complementary feeding introduction were fairly recently updated to include elements of BLW and responsive feeding, it seems that this transition to more contemporary approaches of infant feeding are slower to develop in the majority of health professionals. While BLW is not mentioned in the updated NHS guidelines there is an emphasis on signs of developmental readiness as a basis for assessing the timing of introducing solids. Solid introduction before 6 months is, however, discouraged. The NHS guidelines advise introducing mashed food initially, rather than starting with finger food, and introducing more complex textures once the baby is used to the mashed food. In this study BLW was associated with earlier introduction of vegetables and a greater variety of vegetables. The age at which parents introduce vegetables to traditionally weaned babies is, however, not known. Additionally, the NHS guidelines encourage responsive feeding, to help children develop autonomy and avoid jeopardizing internal hunger and satiation cues. It is important to note that, although BLW's philosophy is based on responsive feeding and infant autonomy it is possible to use similar principles while spoon-feeding by relying on infants' explicit and implicit cues for hunger and satiation. It is essential that health professionals' knowledge is updated and in line with the latest guideline updates to ensure that parents are not confused and that national policies are applied.

Following the findings in the studies presented in apprentices I and II, it is very clear that this is a very emotional time for mothers. Similar to milk feeding practices, solid food introduction methods are often discussed between mothers seeking for advice. As BLW is a relatively new method, not properly defined and explored yet, it is possible to create some confusion to mothers considering following it. Health professionals should be updated with the latest research evidence on their practice to provide guidance on alternative and novel solid introduction methods, such as BLW, in a manner that put family needs as a priority, providing they offer no harm to the baby.

7.4 LIMITATIONS

7.4.1 THESIS LIMITATIONS

Although limitations are discussed in each respective chapter, a summary is given here to provide an overview of the limitations of the thesis studies.

7.4.1.1 LABORATORY STUDY

A more extensive description of the methodological challenges and limitations presented by laboratory-based infant feeding studies in general is provided in the next section. Here, limitations specific to the present study are addressed.

Despite extensive efforts, the number of participants recruited to the study was limited and as such, the results should be interpreted with great caution. Consequently further division of the data to analyse the impact of milk feeding or weaning practices further exacerbated this issue. Additionally, the group split for breast and formula feeding infants was uneven, despite the extensive efforts to recruit similar number of pairs in both groups. However, similar studies in the field also have low participant numbers, reflecting the difficulties associated with recruiting to laboratory based infant feeding studies. During a personal communication, Julie Mennella reported that in her study, on which this PhD is based, the sample of forty-six participants was recruited by a team of researchers over a 3 year period. Studies following up this observation, (Fallon, Komninou, Bennett, Halford, & Harrold, 2016; Komninou, Fallon, Halford, & Harrold, 2016) as well as several qualitative studies (Thomson, Ebisch-Burton, & Flacking, 2015; Williams, Donaghue, & Kurz, 2012; Williams, Kurz, Summers, & Crabb, 2012) may offer an explanation for formula feeding mothers avoiding participation in infant feeding related studies as a result of feeling guilty, shamed and stigmatized for their milk feeding practices. Ultimately, while a number of assumptions can be made based on the results, the study remains underpowered to detect differences and the emerging hypothesis need to be tested in a larger population before any firm conclusions are drawn.

7.4.1.2 ON LINE SURVEY

As with all surveys collecting data on line, the results of this study rely on self-reported data from a self-selected largely of breast feeding mothers who breast feed for a longer duration than average (cite IFS), this suggests a potential bias towards responses from more educated and health conscious individuals. Additionally, although care was taken during the recruitment period so that BLW was not mentioned in the study advertisement and BLW specific groups were avoided, parents who were generally more interested in taking part in studies related to solid introduction were already familiar with BLW as a concept. Therefore, although not intended, it is possible that the survey attracted parents who followed BLW in a proportion greater that average in the population.

Additionally, when making conclusions about this study it is important to remember the bidirectional nature of the outcomes measured. Both infant and parental characteristics can influence the complementary feeding style each family chooses to follow. Additionally, these characteristics are dynamic and may change and adapt to different situations and developmental stages. It is equally important to consider parent-infant and parent-child interactions in each case. The retrospective nature of the research also renders it impossible to determine whether the identified parental feeding styles and practices provided the motivation to follow a specific complementary feeding style or developed as a consequence of the approach chosen.

7.4.2 LABORATORY BASED INFANT FEEDING STUDIES: GENERAL METHODOLOGICAL AND PRACTICAL CHALLENGES AND LIMITATIONS

Childhood is a specific period of life characterized by rapid development and very different emotional and physical needs from adulthood. As such the ethos that children should not be considered as small adults is largely well accepted (Ungar, Joffe, & Kodish, 2006). However, childhood itself represents distinct developmental phases, with the first year of life representing the most dynamic transformations. Extending the earlier philosophy to accept that infants should not be considered as small children presents multiple opportunities for study.

Studying early patterns of behaviour offers the potential to understand the complex needs of this age group and identify factors associated with optimal development. In terms of eating behaviour multiple influencing factors, including maternal diet (Hausner et al., 2010; Mennella & Beauchamp, 1999; Mennella et al., 2001), infant temperament (Haycraft, Farrow, Meyer, Powell, & Cameron, 2011; Vollrath, Tonstad, Rothbart, & Hampson, 2011) and parental feeding practices (Brown & Lee, 2015), have been found to exert an effect on later eating habits. A variety of experimental approaches have been employed in their examination. However, the benefits offered by laboratory based infant feeding studies (LBIFS) has seen a rise in publications reporting their use. This methodology offers the potential to directly observe mother-infant dyads in an environment held consistent between

participants and study visits, thus eliminating many confounding factors. However, it also presents a variety of challenges which can cloud the interpretation of the study results and limit their wider impact and application.

Despite the profound influences presented by these experimental challenges, many are largely overlooked in the published literature. This section aims to examine the issues specific to LBIFS to form a basis for discussion and reflection both within the scientific community and amongst policy makers. However, many of the limitations described will also have a broader application in different research approaches with the same population.

7.4.2.1 RECRUITMENT BIASES

7.4.2.1.1 *PARTICIPANT MOTIVATION*

Studies recruiting an infant population typically secure expressions of interest from prospective mothers during pregnancy. However, the arrival of a baby changes maternal perspectives and priorities as well as introducing time limitations that are often not considered at this time. The consequence is attrition of the potential population pool. As such it is reasonable to assume that new mothers who, despite the unexpected life changes, decide to participate in a research study are motivated individuals. In itself this situation is not unique, as most studies suffer from biases created by self-selected, highly motivated samples. However, to fully understand the level of motivation of the study participants, and design studies accordingly, other rarely reported variables can provide vital insight.

Levels of participant attrition following consent are strong indicators of study quality in addition to participant motivation. Typically, dropout rates of 20% or less are considered acceptable, with higher levels representing a threat to the validity of study outcomes. However, acceptable dropout rates can vary depending on the length of the study and the commitment that is required from the participants. Lower dropout rates are generally associated with shorter studies, whereas higher dropout rates are generally accepted for longer or more complex studies. LBIFS require high levels of commitment from their participants, with parents being required to travel with a young infant to attend multiple data collection sessions. Thus, researchers should anticipate high attrition rates. However, the ability to predict a realistic level of drop out to factor into study design is severely hampered when publications largely fail to report relevant data.

Beyond information on attrition, insight to the recruitment process, particularly with regard to timelines, the number of expressions of interest received and the number of participants initially consenting to take part, further helps to gauge motivation and inform study design. In terms of judging participant motivation, details of compensatory processes are also key. Whilst ethical

principles favour compensation for time and effort rather than payment for involvement, participants may be inclined to approach compensation as a form of incentive. As such, less internally motivated participants will complete a study only when they perceive this to be the financially viable option, whereas a smaller compensation can indicate a more internally motivated sample and again hint at the issue of population bias.

7.4.2.1.2 *FORMULA FEEDING STIGMA*

In health related research it is anecdotally accepted that the majority of volunteers expressing an interest in taking part in studies will be health conscious, well educated, middle class and white. In addition to these characteristics, contemporary infant feeding studies typically attract breastfeeding mothers (Hausner et al., 2010; Maier et al., 2008; Remy, Issanchou, Chabanet, & Nicklaus, 2013; Schwartz et al., 2011). This represents a divergence from the populations recruited to earlier studies in the field, which report a more balanced mix of breast and formula feeding mothers (Forestell & Mennella, 2007; Mennella et al., 2009; Sullivan & Birch, 1994). Moreover, this recruitment imbalance reflects a further population bias, bringing an "ideal" rather than a representative sample of the population.

Often, the ideal population reflects the intended study population. For example, the recent UK-WHO growth charts were specifically developed utilising data from infants who were exclusively breastfed (in accordance with published guidelines) and were not raised in disadvantaged conditions. However, with many health-related studies aimed at improving the experience of disadvantaged populations, recruiting an ideal population in this situation would be detrimental.

In terms of infant feeding research, formula feeding mothers typically perceive themselves to be members of a 'less than ideal' population. Evidence from both qualitative and quantitative studies clearly demonstrate that, as a result of not following published infant feeding guidelines and public health messages, they are more likely to feel guilty and stigmatised for their feeding choices (Knaak, 2006; Williams, Donaghue, et al., 2012). This introduces a reluctance to engage with studies on infant feeding, in fear that their choices will be judged and invalidated.

This reluctance creates a two-fold problem. Firstly, the vulnerable populations that heath related research is often targeted towards cannot be reached and the resulting small samples sizes render research unpublishable. As such these populations do not benefit from research outcomes and interventions and health inequalities are perpetuated. Secondly, when study populations are not representative of the general population the results cannot be extrapolated to inform policies and guidelines.

When population biases are rooted in both individuals' and society's perceptions of good practice and morality, overcoming them clearly presents a major challenge. However, the importance of recruiting

representative samples cannot be overlooked. In infant feeding research, it is crucial that these practical difficulties are acknowledged, focused recruitment strategies are developed and time and resources are allowed to facilitate the recruitment of participants whose infant feeding choices do not conform to current guidelines.

7.4.2.2 TESTING AND RESULT ANALYSIS

7.4.2.2.1 *Face-to-face interactions during feeding*.

Initial studies in the field required the mother to wear a mask whilst feeding her infant in the laboratory. The rationale being an attempt to minimize the infant's reactions to mother's facial expressions (Gerrish & Mennella, 2001; Mennella et al., 2001). Whilst mothers were provided with an identical mask to wear at home to help the child familiarize with the testing scenario, this clearly does not represent a normal feeding setting which could impact considerably on infant reactions. More contemporary studies exclude the mask, but mothers remain restricted in terms of their ability to vocalize, make facial expressions or encourage consumption in other ways (Hausner et al., 2010).

The importance of face-to-face communication between the caregiver and the infant were initially highlighted in the 1970s by Edward Tronick, who observed the structure of interactions between mothers and infants, and concluded that infants modify their behaviour if their mother modifies hers (Tronick, Als, & Brazelton, 1977). For an infant, a feeding event therefore not only satisfies their nutritional needs, but also provides an educational experience in which verbal and nonverbal communication play an important role (Tronick, 1978). Thus, when mothers cover their faces or eliminate their interactions, infants are being deprived of information to respond to and the results of studies should be interpreted with caution. As the field advances, research approaches that recognise the opportunity offered through examination of mother infant interactions require development and validation.

7.4.2.2.2 *AGE SPECIFIC HEALTH AND WELLBEING*.

In human infants the timing of introduction to solid food typically overlaps with the eruption of the first tooth (Humphrey, 2010; Mahoney, 2015). This makes sense, from the evolutionary perspective, as it demonstrates the developmental need for complementary feeding. Tooth eruption, however, is largely associated with a number of negative symptoms in the infant, including increased temperature, irritability and loss of appetite for solid food (Macknin, Piedmonte, Jacobs, & Skibinski, 2014; Ramos-Jorge, Pordeus., Ramos-Jorge., & Paiva., 2011). Bronchiolitis represent another common age specific problem with symptoms including loss of appetite for solid food.

With the demands of LBIFS, scheduling testing sessions appropriately presents a challenge in itself. Clearly the optimal approach is to assess intake when the infant is in full health. However, study visits are often scheduled in advance and typically must occur within a narrow timeframe. Consequently,

testing may take place prior to the infant's full recovery. The resulting variability can potentially skew the data or weaken the study results. As such it is essential that attempts are made to factor such confounds into analysis.

7.4.2.2.3 *MATERNAL PERCEPTIONS OF INFANT'S LIKING*

Due to the nature of development, infants' liking of specific foods can only be assessed indirectly. Typically, this is achieved by asking mothers to rate their perception of their infant's liking. However, the factors and cues that impact on maternal judgment of their infants' preferences are an area that has not been fully explored.

For toddlers and older children, parental perceptions of their offspring's food liking are broadly used to support the claim that children's food preferences resemble their parents' food preferences (Cooke et al., 2004; Falciglia et al., 2004; Howard et al., 2012; Skinner et al., 1998; Skinner, Carruth, Bounds, & Ziegler, 2002). For toddlers, one study compared maternal evaluation with paternal evaluation of the child's food liking, and it found that the two evaluations didn't differ significantly (Skinner, Carruth, Bounds, & Ziegler, 2002) This finding, however, is insufficient evidence to support the claim that maternal judgement is objective.

More recently, infants' facial expressions during LBIFS were compared with maternal evaluation of the feeding (Forestell & Mennella, 2012). The study concluded that mothers focus mainly on the infant's facial expressions to evaluate the liking, even though the researchers suggest that the main evaluation criterion should be the infant's behaviour and more specifically the infant's willingness to continue food consumption. This indicates that maternal evaluation, as a measure for infant food preference, could be flawed. Further research is justified to identify the plethora of signals available to mothers and determine which of those are routinely employed when assessing food preference.

7.4.2.3 BABY LEAD WEANING AS A NEW METHOD OF INTRODUCING SOLIDS

Typically, LBIFS protocols that involve solid feeding call for parent-led spoon feeding of age-specific foods. Recently however, a new philosophy for the introduction of solid food to an infant's diet has been gaining popularity. BLW puts the infant in the centre of feeding and allows them to choose and consume the food they prefer, in the quantity they prefer, while the caregiver has control only over the decision of what food is offered to the child.

The clash of the two philosophies introduces several challenges to LBIFS. Participant attrition is particularly relevant in longitudinal studies, where participants are recruited shortly after giving birth when complementary feeding practices are rarely a parents' priority. Only when BLW strategies are selected some months later do the incongruences between study demands and solid feeding approaches become apparent, leading to withdrawal of participants or exclusion of their data from analysis.

As preference for BLW increases amongst parents, progression in the infant feeding field depends on the development of research protocols to incorporate BLW approaches. Currently, no LBIFS testing protocols for infants who follow BLW exist in the literature, and no substantial efforts have been made towards their creation. This may reflect a reluctance by researchers to recognise BLW as a valid infant feeding method. Consequently, it is likely that a substantial period of time and numerous pilot studies will be required, before a broadly accepted methodology for the research area can be developed to enable it to adapt to changing parental choices.

The emergence of BLW approaches also highlights gaps in the current literature base. Existing LBIFS literature cannot necessarily be extrapolated to infants who follow BLW. This is a relatively new and under-researched concept, and as such the necessary evidence is not available to link the two methods of introducing solid food and identify the generalisation of the results. For example, while it is established that pre and post-natal flavour exposure increases the acceptance of the flavour the infant is exposed to (Gerrish & Mennella, 2001; Hausner et al., 2010; Mennella, Griffin, & Beauchamp, 2004; Mennella et al., 2001), BLW introduces an as yet unexamined variable – will the infant self-select the foods they have previously been exposed to? Such questions will form the basis of future research required to bridge the gap between studies accommodating different means of introducing solid foods.

7.4.2.4 CONCLUSION

The highlighted limitations of LBIFS are significant, and should be taken into consideration when reading published work in the field. Obviously, not all limitations can be avoided; often research decisions are made under strict time and resource constraints, and research methodologies take time to adapt to a changing landscape of feeding policies and guidelines. However, being aware of the challenges will facilitate improved study designs and more efficient allocation of resources. More importantly it will facilitate realistic interpretation and application of study findings by the general public and policy makers.

7.5 A FINAL PERSONAL REFLECTION

Closing this thesis, I find it suiting to write a reflection of the last 4.5 years that this journey has lasted. I started my PhD in March 2012 and I was, as most PhD students at that point are, naïve. I knew it was going to be hard, being one of the highest qualifications in higher education, but it is difficult to prepare yourself for the unknown. Reflecting, and linking it to the actual thesis topic, it was like having a small child to care for. I am not a mother myself, but through the constant contact with mothers I can now draw many parallel lines. Part of the experience is exciting, motivating and rewarding but also there are some other parts that are challenging, painful and frustrating. Easy to immerse yourself and lose yourself in, constantly thinking about it, talking about it, taking the

mishaps personally and even abandoning yourself for the sake of it - like you would do when you have a small child.

But as no one is born to know how to be a parent and care for a child, no one is born knowing how to be a researcher, a scholar or an academic. Shaping the thesis is a long process, and as frustrating as it might be it requires trial and error by design, a task that it seems has no end point. It is a learning curve and the time I spend completing the thesis has taught me a great deal about both research and myself. I received a lot of training on the methods I used. It taught me how to be flexible and adaptable, how research actually progresses and how new ideas develop overtime. Most PhD students start with a very specific plan of action and a timeline in mind and they expect their final thesis to contain pretty much those plans. However, through my experience and the experience of other PhD students I was lucky to meet during the last 4.5 years, this is rarely the case. Problems you were not aware of arise, old questions are answered in the meantime, and new questions develop. While we are striving to become independent researchers, life happens at the same time. We get ill, physically, mentally or both. We learn to balance out expectations about ourselves and our limits. I am not sure if I would choose to learn those lessons if I knew what I was signing myself for, but retrospectively I am very glad I learned them. During my studentship, my worldview and priorities changed, it taught me resilience and focus. I am definitely not the same person as I started.

The resubmission processes I underwent as an outcome of the first viva examination was a challenging one. Although a frustrating and disappointing outcome initially, after all the hard work I put in the thesis, I quickly came to terms with it and approached is as a learning opportunity. Having the time to reflect on my findings and with the comments of my examiners as a guidance I feel I have a better understanding of my field now, a more complete picture of where my results fit in the literature and what my plans for the future should be. I was given the time required to become more objective about my own work and the work of others and ultimately this further shaped me into a researcher and my thesis into a piece of work I am very proud of.

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APPENDIX I
PAPER I: DIFFERENCES IN THE EMOTIONAL AND PRACTICAL EXPERIENCES OF EXCLUSIVELY BREASTFEEDING AND COMBINATION FEEDING MOTHERS

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Komninou, S., Fallon, V., Halford, J. C. G., & Harrold, J. A. (2016). Differences in the emotional and practical experiences of exclusively breastfeeding and combination feeding mothers. *Maternal & Child Nutrition*. http://doi.org/10.1111/MCN.12364

Abstract

Background: The majority of research examining the barriers to breastfeeding focuses on the physical challenges faced by mothers rather than the risks of encountering negative emotional and practical feeding experiences.

Objective: To quantify the emotional and practical experiences of the overall sample of breastfeeding mothers and identify the differences in the emotional and practical experiences of exclusively breastfeeding mothers (EBF) and combination feeding mothers (Combi), by feeding type and intention.

Design, Setting and Participants: 845 mothers with infants up to 26 weeks of age and who had initiated breastfeeding were recruited through relevant social media via advertisements providing a link to an online survey.

Variables studied: Predictors of emotional experiences included guilt, stigma, satisfaction with feeding method, and the need to defend themselves due to infant feeding choices. Practical predictors included perceived support from health professionals, main sources of infant feeding information, and respect from their everyday environment, workplace, and when breastfeeding in public.

Outcome measures: Current feeding type and prenatal feeding intention.

Results: In the overall sample 15% of the mothers reported feeling guilty, 38% stigmatised and 55% felt the need to defend their feeding choice. Binary logit models revealed that guilt and dissatisfaction were directly associated with feeding type, being higher when supplementing with formula. No associations with feeding intention were identified.

Discussion and conclusions: This study demonstrates a link between current breastfeeding promotion strategies and the emotional state of breastfeeding mothers who supplement with formula to any extent. To minimise the negative impact on maternal wellbeing it is important that future recommendations recognise the challenges that exclusive breastfeeding brings and provide a more balanced and realistic target for mothers.

Key messages:

1. Mothers who supplement their breastfeeding with formula are almost six times more likely to feel guilty and three times more likely to feed dissatisfied with their infant feeding choice than mothers who exclusively breastfeed, with the guilt being internally sourced.

2. Mothers who exclusively breastfeed often face externally induced guilt, with family being the most frequently reported source.

3. While nursing in public may be anticipated to be the most popular source of stigmatisation experienced by breastfeeding mothers, the vast majority of participants reported that the public response was moderately to very respectful.

4. Despite current legislation and policy regarding working rights of mothers, a need to defend feeding choices in the workplace was reported by exclusively breastfeeding mothers.

Introduction

Although breastfeeding initiation rates have steadily increased in the UK over the past two decades; 62% in 1990 to 81% in 2010 (Bolling, Grant, Hamlyn, & Thornton, 2007; McAndrew et al., 2012), the number of mothers who breastfeed their infant exclusively has failed to rise. In 2010, just 1% of women were exclusively breastfeeding up until the nationally recommended six month juncture (McAndrew et al., 2012). It appears that despite virtually all mothers and healthy term babies possessing the physiological capacity to successfully breastfeed, the majority (88%) use formula in some quantity in the first six months (McAndrew et al., 2012). This indicates the presence of factors creating barriers to the most health promoting infant feeding outcomes (Neifert & Bunik, 2013).

Quantitative literature examining the barriers to breastfeeding has been orientated towards the physical challenges encountered by breastfeeding mothers. On the other hand, a large body of qualitative literature has previously highlighted the negative emotional and practical experiences of exclusively breastfeeding and combination feeding mothers (Burns, Schmied, Sheehan, & Fenwick, 2010; Hauck, Langton, & Coyle, 2002; Hegney, Fallon, & O'Brien, 2008; Hoddinott et al., 2013; Lee, 2007; Leeming, Williamson, Johnson, & Lyttle, 2013; A. M. Nelson, 2006; Thomson et al., 2015). Moreover, in a number of studies these experiences are looked at through the lens of postnatal depression and its association with breastfeeding initiation, duration, exclusivity, or related difficulties (Brown, Rance, & Bennett, 2016; C.-L.

Dennis & McQueen, 2009; C. L. Dennis & McQueen, 2007; Henderson, Evans, Straton, Priest, & Hagan, 2003; McCarter-Spaulding & Horowitz, 2007; Shakespeare, Blake, & Garcia, 2004). However, breastfeeding mothers without a postnatal mood disorder are also susceptible to negative emotional responses. Whilst many consider breastfeeding as a cornerstone of their maternal experience, a body of qualitative work highlights an array of potential negative emotions. These include shame about breastfeeding in public (J. R. Davis, 2004; Taylor & Wallace, 2012), embarrassment about breastfeeding in front of family and friends (Smyth, 2008), and stigmatisation for breastfeeding in a "bottle feeding culture" (Scott & Mostyn, 2003; Dykes & Moran, 2003).

Current breastfeeding promotion may inadvertently contribute to negative feeding experiences. Although designed to convey the health benefits of this approach to infant feeding it may instead situate breastfeeding as the "moral" and "responsible" mothering choice (Williams, Kurz, et al., 2012). As a result, failure to breastfeed becomes a major source of both internal and external guilt and stigma (Knaak, 2010; Marshall, Godfrey, & Renfrew, 2007). Breastfeeding mothers may feel direct and indirect external pressure to supplement or substitute breastfeeding with formula (Arora, McJunkin, Wehrer, & Kuhn, 2000; Baranowski et al., 1983; Tanner & Cockerill, 1996). With the decision to introduce formula considered suboptimal, qualitative studies often report that mothers also feel the need to internally justify this choice. (Stewart-Knox, Gardiner, & Wright, 2003; Tanner & Cockerill, 1996; Williams, Donaghue, et al., 2012; Williams, Kurz, et al., 2012).

Mothers who exclusively breastfeed for the first six months of their infant's life are acting in accordance with current guidelines. Yet, this moralistic approach still renders them susceptible to negative emotional responses to the feeding process. The source of these emotions can be different from those who formula feed their baby (Williams, Kurz, et al., 2012) and may reflect a perceived internal conflict between their sense of duty as a mother and a desire to attend to their own personal needs (Hauck & Irurita, 2003). Exclusively breastfeeding mothers can also find themselves facing conflicting and incompatible expectations from their close external environment, with family, work and social obligations proving unavoidable burdens to breastfeeding (Wray et al., 2013).

This large-scale internet study is the first to quantify the emotional and practical experiences of an overall sample of breastfeeding mothers and identify the differences in the emotional and practical experiences of exclusively breastfeeding mothers (EBF) and combination

feeding mothers (Combi), by feeding type and intention. It was hypothesised that mothers who chose to supplement with formula (Combi) would be more susceptible to negative experiences as opposed to those who chose to exclusively breastfeed (EBF). Furthermore, it was proposed that the source of negative feelings would differ according to feeding type with negative emotions in EBF mothers arising from external sources and in combi mothers from internal sources. Finally, with a related survey of formula feeding mothers (Fallon et al, in submission) reporting a strong association between feeding intentions in pregnancy and negative feeding experiences, a further aim was to examine whether the experiences of breastfeeding mothers would also differ according to feeding intention in pregnancy.

Method

Ethical approval

The study gained ethical approval from the University of Liverpool Institute of Psychology, Health and Society Ethics Committee in March 2015. All aspects of the study wereperformed in accordance with the 1964 Declaration of Helsinki. Participants were providedwith an information sheet and informed consent was gained with a tick box. The online survey was accessible from 30/3/2015 to 12/4/2015.

Participants and Demographics

A total of 845 mothers of infants up to 26 weeks of age, who were currently breastfeeding in any quantity, were recruited through relevant social media sites and mailing lists via advertisements providing a link to the Qualtrics survey software. The 26 weeks cut off point applied reflects the current WHO exclusive breastfeeding recommendations (WHO, 2015). The advertisements stated that participants were invited to take part in a short study which would examine the opinions and experiences of breastfeeding mothers. Women who were exclusively formula feeding, younger than 16 years of age, or non-English-speaking, were not eligible to participate. Of the 845 participants, 151 (17.9%) were excluded from final analyses as they did not complete the study. A further 7 participants, who reported the intention to exclusively formula feed, were also excluded due to statistical issues introduced by the small group size.

Maternal age, marital status, and country of residence were initially asked. To assess socio-economic status mothers were asked to report their current occupation (or if currently on maternity leave, previous occupation). The simplified National Statistics Socio-economic

Classification, which contains 8 occupation classifications was then applied (ONS, 2010). Only mothers who reported previous occupation were asked questions related to their return to their previous employment. Information relating to the infant such as birth order and age in weeks was also obtained.

Exposure Variables

The survey had a similar study design with previous work examining the emotional and practical experiences of formula feeding mothers (Fallon et al., under review). The first part of the survey assessed the practical experiences of breastfeeding mothers. Questions included the perceived level of infant feeding support that mothers received from health professionals, the perceived level of respect displayed by their everyday environment with regards to their feeding choices, and the perceived level of satisfaction experienced as a result of their feeding choices. In addition, mothers were asked whether they had breastfed in public, and if so the perceived level of respect at the time of this event. Where applicable, mothers were also asked about perceived respect for their feeding choices at the workplace (displayed or expected). All answers were provided via a 5-point likert scale (higher responses indicated higher levels of support, respect, and satisfaction). Finally, mothers were also asked about their main source of information about infant feeding. Potential responses included the media, health professionals, family members, other mothers, or previous experiences/own accord.

The second part of the survey examined the emotional experiences of breastfeeding mothers. Respondents were asked to provide a binary (yes/ no) response to indicate the presence of feelings of guilt, stigma and the need to defend as a result their infant feeding choices. Positive responses were followed up to identify the source of the feelings (see table 1). Participants were able to choose more than one source if applicable. A positive response to the presence of guilt was also followed up to ascertain whether the feelings were experienced internally, as a result of other's opinions, or both. For stigma, two additional choices were added relating to the working environment and when breastfeeding in public. The structure and content of the questionnaire is presented in table 1.

Outcome Variables

The outcome variables were current feeding type and feeding intention in pregnancy. Available answers were based on WHO-defined categories (WHO, 2002). At the time of

completion, five different categories were available to the mothers (exclusively breast feeding from birth; breastfeeding to start with but now a little formula; breastfeeding to start with but now some formula; breastfeeding to start with but now mostly formula, and combination feeding from birth).

Feeding intention was asked retrospectively, at the end of the study, to avoid response bias on answers relating to the emotional experiences

Statistical analysis

All analyses were conducted using the IBM SPSS 22 software package. Descriptive statistics were generated for demographic and exposure variables of interest (Tables 2 and 3). Independent samples t-test and χ^2 tests were used to examine bivariate associations between study variables and both feeding type, and feeding intention. Relative risk ratio's (RRRs) for the association between exposure and outcome variables were then calculated using binary logit models. Separate models were built for feeding type and feeding intention. Backward elimination was used to build the adjusted models and demographic variables were kept as confounders in the model if they changed the beta coefficients of the exposure categories by more than 10%. Feeding intention and feeding type were also included as potential confounders in the opposing models. Exposure categories were collapsed to a 3 point scale during the analysis (See tables 4 and 5) to meet the requirements of the statistical test and overcome complete separation issues within the sample. Moreover, due to unexpected singularities occurring during statistical analysis, the initial feeding type categories (N=5) were collapsed into two categories: exclusively breast feeding (EBF) from birth, and all other types of combination feeding (combi). Concurrent with feeding type, the initial feeding intention categories were collapsed into two (exclusively breastfeeding, EBF; and any type of combination feeding, combi), for the same reason (see Table 4). Those who intended to exclusively formula feed were excluded from the analysis due to statistical issues arising from the small number of cases identified (7 cases). For the respect of mothers' workplace and the respect when breastfeeding in public separate binary logit regression models were run in order to include only participants who reported paid employment and public breastfeeding respectively.

Results

Demographics

The age of the final sample of 679 (80% of the original sample) mothers ranged from 19 to 45 years (M = 31.21; SD = 4.59). Their baby's age ranged from 1 to 26 weeks (M = 16.49; SD = 7.62). The majority of the sample was married or living with their partner (95.8% cumulatively) and from the United Kingdom (88.1%). See Table 2 for full demographic details.

Overall Sample

From the total sample of 679 mothers, 14.9% experienced feelings of guilt about their choice of feeding method. The guilt was motivated from both internal and external sources in equal proportions among both feeding type groups (Table 3). Approximately one in three mothers (38%) also reported experiencing feelings of stigma about the way they chose to feed their baby while more than half of the mothers in the sample (54.5%) reported that they felt the need to defend their feeding choices. Interestingly, in all cases where these feelings were present, they arise primarily from family members (58.7%, 40.7% and 62.7% respectively), with other mothers and peers also making a notable contribution (31.7%, 38.4% and 42.7% respectively). However, regardless of the presence of negative experiences, the vast majority of the mothers in the sample were satisfied with their choice of feeding method (93.8%) and they reported high rates of respect from their everyday environment (80.6%) and when breastfeeding in public (71.9%). By contrast, when they were asked about the respect in their working environment (or the respect expected upon returning to their employment) mothers reported lower levels of respect (56.8%) and higher levels of disrespect (12.8%) than when they were asked about the respect from their everyday environment or when breastfeeding in public.

From the whole sample, only 56.6% of the mothers felt well supported by health professionals with infant feeding issues. The remainder (43.4%) of the sample reported feeling moderately to not at all supported. This finding was congruent with descriptive statistics relating to sources of infant feeding information with 42.1% of mothers using the internet as their primary resource of information around infant feeding. Here independently sourced online forums, social media and scientific evidence were ~~preferred~~ more popular to information gained from health professionals.

Differences in experience by Feeding Type

Demographic characteristics did not statistically differ between EBF and Combi feeding mothers (Table 2). The risk for Combi feeding mothers to experience guilt was almost six times higher than EBF mothers (RRR: 0.17 CI: 0.10, 0.27) and largely unaffected after adjustments for confounders (RRR: 0.16 CI: 0.09, 0.27) (Table 4). Interestingly, in the two groups, the guilt was motivated from different sources [χ^2 (2, *N*=101) = 21.30 p<.001] (Table 3). For EBF mothers feelings of guilt originated more often from the external environment (56.8%) than internal feelings (20.5%). However, for half of the Combi feeding mothers feelings of guilt could be traced from internal factors rather than external (50.9%). Key differences between feeding type were also identified when examining the nature of external sources of guilt with EBF mothers reporting they arose from family members more often than combi mothers [χ^2 (2, *N*=101) = 13.68, p<.001] (Table 2). Internet and social media sources display a trend [χ^2 (2, *N*=101) = 3.34, p=.068] for between group differences, with Combi feeding mothers reporting these sources of guilt more frequently (Table 3).

No associations between infant feeding type were observed with regard to stigma (RRR:1.36 CI:0.82, 2.24) (Table 4). However, when stigma was reported, mothers who EBF were more likely to do so as result of breastfeeding in public in comparison to combination feeding mothers [χ^2 (2, *N*=258)=5.25, p=.022] (Table 3).

Whilst no associations between infant feeding type and feeling the need to defend feeding choices were observed (Table 4, the proportion of mothers reporting defence was high, (51% for EBF mothers and 68.1% for combi feeding mothers). When the need for defence was reported, only EBF mothers identified the workplace as the source of the feelings. Additionally, combi mothers reported a need to defend their feeding choices to themselves (question 10.2 table 1) significantly more often than EBF mothers [χ2 (2, *N*=370)=32.56, p<.001] (Table 3).

With regard to the practical experiences of infant feeding, EBF mothers were more likely to turn to the internet and social media for advice on infant feeding than combi mothers (RRR: 0.52 CI:0.29, 0.95), however this association just failed to reach significance in the adjusted model (RRR: 0.54 CI:0.29, 1.01) (Table 4). There were also no differences in the perceived level of support or respect between groups. However, the sources of support were found to differ. EBF mothers reported higher rates of support from health professionals significantly more often than their combi peers [χ2 (2, *N*=679)=8.03, p=.018] (Table 3). A similar pattern

with even stronger predictive value was identified with regard to satisfaction with the milk feeding method ratings. Even though the reported level of satisfaction were ~~quite~~ high in both groups, combi mothers were more frequently dissatisfied or neutral with regard to their feeing choice, than their EBF peers (RRR: 3.18 CI:1.17, 8.68) (Table 4).

Feeding Intention

For feeding intention, although in the crude model mothers who were planning to combi feed were at higher risk of experiencing guilt (RRR: 0.49 CI: 0.26, 0.89), after adjustment for feeding type the comparison was no longer significant (RRR: 0.90 CI: 0.47, 1.74) (Table 3). Nevertheless, for those who actually reported the presence of guilt, mothers who intended to EBF more frequently reported family members as a source of the guilt [$\chi 2$ (2, N=101)=4.13, p=.048] (Table 3).

Neither of the remaining negative emotions (stigma and need to defend their feeding choices) nor any of the practical experiences (sources of information, satisfaction and perceived support and respect) examined were found to differ significantly according to feeding intention (Table 3 and 4).

Table 1: Survey question assessing feeding type, intention, emotional and practical experiences in the order they appeared in the survey.

Displayed to	Question	Response options
All	1. How are you currently feeding your baby?	Exclusively breast feeding from birth Exclusively breastfeeding to begin with, but now using a little formula (the odd feed) Exclusively breastfeeding to begin with, but now using some formula Exclusively breastfeeding to begin with, but now using mostly formula Combination of breast milk and formula milk from birth Exclusively breast feeding from birth
All	2. How satisfied you are with your choice of feeding method?	Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied
All	3. Do you find that your everyday environment is respectful of your infant feeding choices?	Very Disrespectful Disrespectful Neutral Respectful Very Respectful
Those who reported paid occupation post-partum	4. Do you (or do you expect to) find your environment in the workplace respectful of your feeding choices?	Very Disrespectful Disrespectful Neutral Respectful Very Respectful
All	5. How well supported by health care professionals do you feel when it comes to infant feeding?	Not supported at all Minimally supported Moderately supported Very supported Extremely supported
All	6. What has been your main source of information for milk feeding?	Internet online parenting forums/social media sites, health related websites, others Peers/other mothers in person

		Family members – mother, father, sister, brother, grandparents, other Health professionals – midwives, health visitors, GP, other Media - television, radio, newspaper, other Previous experiences/ own accord
All	7.1. Have you ever breast fed your baby in public?	Yes/No
If yes selected to question 7.1	7.2. If yes, how respectful are the people around you in general when you breast feed in public?	Very Disrespectful Disrespectful Neutral Respectful Very Respectful
All	8.1. Have you ever felt stigmatized for the way you choose to feed your baby?	Yes/No
If yes selected to question 8.1	8.2. If yes, where?	Internet online parenting forums/social media sites, health related websites, others Peers/other mothers in person Family members – mother, father, sister, brother, grandparents, other Health professionals – midwives, health visitors, GP, other Media - television, radio, newspaper, other My working environment When feeding in public
All	9.1. Have you ever felt guilty about the way you choose to feed your baby?	Yes/No
If yes selected to question 9.1	9.2. If yes, was this feeling the result of others opinion or your own feelings?	Other's opinions/ Own feelings/ Both
If other's opinions or Both selected to question 9.2	9.3. If so, where?	Internet online parenting forums/social media sites, health related websites, others Peers/other mothers in person Family members – mother, father, sister, brother, grandparents, other Health professionals – midwives, health visitors,

		GP, other Media - television, radio, newspaper, other
All	10.1. Have you ever felt the need to defend your choice of milk feeding method?	Yes/No
If yes selected to question 10.1	10.2. If yes, where?	Internet online parenting forums/social media sites, health related websites, others Peers/other mothers in person Family members – mother, father, sister, brother, grandparents, other Health professionals – midwives, health visitors, GP, other Media - television, radio, newspaper, other My working environment When feeding in public To myself
All	11. How were you planning to feed you baby when you were pregnant?	Exclusively formula feeding Mainly formula feeding with a little breast feeding Approximately 50% formula feeding and 50% breast feeding Mainly breast feeding with a little bit of formula feeding Exclusively breast feeding

Table 2: Maternal Characteristics by overall sample, feeding type, and feeding intention

Characteristic	Overall	Feeding Type		*P***	Feeding Intention		*P***
		EBF	*Combi*		*EBF*	*Combi*	
Maternal age (mean years ± SD)	31.21(±4.57)	31.11(±4.58)	31.57(±4.58)	.294	31.11(±4.65)	31.87(±4.08)	.143
Child's age (mean weeks ± SD)	16.49 (±7.62)	16.33 (±7.72)	17.14 (±7.23)	.262	16.44(±7.69)	16.88(±7.20)	.609
Birth order (N/%*)							
1st	311 (45.8)	239 (44.2)	72 (52.2)		274 (46.5)	37 (41.1)	
2nd	268 (39.5)	220 (40.7)	48 (34.8)		226 (38.4)	42 (46.7)	
3rd	73 (10.8)	60 (11.1)	13 (9.4)	.332	66 (11.2)	7 (7.8)	.414
4th	22 (3.2)	19 (3.5)	3 (2.2)		18 (3.1)	4 (4.4)	
5th and after	5 (0.7)	3 (0.6)	2 (1.4)		5 (0.8)	0(0.0)	
Marital status (N/%*)							
Married	422 (62.2)	346 (64.0)	76 (55.1)		363 (61.6)	59 (65.6)	
Living with a partner	228 (33.6)	177 (32.7)	51 (37.0)		201 (34.1)	27 (30.0)	
Divorced	1 (0.1)	1 (0.2)	0 (0.0)	.072	1 (0.2)	0 (0.0)	.886
Separated	2 (0.3)	1 (0.2)	1 (0.7)		2 (0.3)	0 (0.0)	
Single	26 (3.8)	16 (3.0)	10 (7.2)		22 (3.7)	4 (4.4)	
Occupation (N/%*)							
Managers, Directors and Senior Officials	46 (6.8)	37 (6.8)	9 (6.5)		38 (6.5)	8 (8.9)	
Professional Occupations	280 (41.2)	218 (40.3)	62 (44.9)		241 (40.9)	39 (43.3)	
Associate Professional and Technical Occupations	22 (3.2)	19 (3.5)	3 (2.2)		21 (3.6)	1 (1.1)	
Administrative and Secretarial Occupations	78 (11.5)	63 (11.6)	15 (10.9)		64 (10.9)	14 (15.6)	
Skilled Trades Occupations	11 (1.6)	10 (1.8)	1 (0.7)	.137	11 (1.9)	0 (0.0)	.312
Caring, Leisure and Other Service Occupations	89 (13.1)	74 (13.7)	15 (10.9)		79 (13.4)	10 (11.1)	
Sales and Customer Service Occupations	74 (10.9)	56(10.4)	18 (13.0)		61 (10.4)	13 (14.4)	
Process, Plant and Machine Operatives	2 (0.3)	1 (0.2)	1 (0.7)		2 (0.3)	0 (0.0)	
Elementary Occupations	9 (1.3)	4 (0.7)	5 (3.6)		8 (1.4)	1 (1.1)	
Not in paid occupation	68 (10.0)	59 (10.9)	9 (6.5)		64 (10.9)	4(4.4)	

EBF: Exclusive breastfeeding; Combi: Combination feeding (all types * Percentages are given within each category (EBF or Combi and feeding intentions); **Group differences ascertained by independent samples t test and x^2 tests

Table 3: Descriptive experiences of breast feeding mothers by overall sample, feeding type, and feeding intention

Breast Feeding Experience	*Overall N (%)*	*Feeding Type N (%)*		*p-value***	*Feeding Intention N (%)*		*p-value***
		EBF	*Combi*		*EBF*	*Combi*	
Guilty about choice of feeding method	679	541	138		589	90	
No	578 (85.1)	497 (91.9)	81 (58.7)	<.001	510 (86.6)	68 (75.6)	.006
Yes	101 (14.9)	44 (8.1)	57 (41.3)		79 (13.4)	22 (24.4)	
Source of guilt					79	22	
Internal	38 (37.6)	9 (20.5)	29 (50.9)		29 (36.7)	9 (40.9)	
External	33(32.7)	25 (56.8)	8 (14.0)	<.001	31 (39.2)	2 (9.1)	.120
Both	30 (26.7)	10 (22.7)	20 (35.1)		19 (24.1)	11 (50)	
Source of guilt*†							
Media	10 (15.9)	2 (5.7)	8 (28.6)	.113	8 (16.0)	2 (15.4)	.886
Health professionals	12 (19.0)	3 (8.6)	9 (32.1)	.167	9 (18.0)	3 (23.1)	.774
Family members	37 (58.7)	25 (71.4)	12 (42.9)	<.001	33 (66.0)	4 (30.7)	.042
Other mothers	20 (31.7)	11 (31.4)	9 (32.1)	.249	14 (28.0)	6 (46.2)	.320
Internet	17 (27.0)	4 (11.4)	13 (46.4)	.068	12 (24.0)	5 (38.5)	.403
Stigmatised about choice of feeding method	679	541	138		589	90	
No	421(62.0)	343 (63.4)	78 (56.5)	.137	222 (37.7)	36 (40.0)	.674
Yes	258 (38.0)	198 (36.6)	60 (43.5)		367 (62.3)	54 (60.0)	
Source of stigma*♯							
Media	76 (29.5)	60 (30.3)	16 (26.7)	.738	66 (18.0)	10 (18.5)	.383
Health professionals	41 (15.9)	28 (14.1)	13 (21.7)	.549	35 (9.5)	6 (11.1)	.661
Family members	105(40.7)	81 (40.9)	24 (40.0)	.900	92 (25.1)	13 (24.1)	.576
Other mothers	99 (38.4)	74 (37.4)	25 (41.7)	.162	84 (22.9)	15 (27.8)	.891
Internet	73 (28.3)	55 (27.8)	18 (30.0)	.588	65 (17.7)	8 (14.8)	.812
My working environment	16 (6.2)	14 (7.1)	2 (3.3)	.293	14 (3.8)	2 (3.7)	.826
When fed in public	106 (41.1)	89 (44.9)	17 (28.3)	.022	93 (25.3)	13 (24.1)	.513

Need to defend choice of feeding method	679	541	138		589	90	
No	309 (45.5)	265 (49.0)	44 (31.9)	<.001	323 (54.8)	47 (52.2)	.642
Yes	370(54.5)	276 (51.0)	94 (68.1)		266 (45.2)	43 (47.8)	
If so, where*♯							
Media	38 (10.2)	33 (12.0)	5 (5.3)	.067	34 (12.8)	4 (9.3)	.671
Health professionals	74 (20.0)	49 (17.8)	25 (26.6)	.064	67 (25.2)	7 (16.3)	.349
Family members	232 (62.7)	179 (64.9)	53 (56.4)	.142	205 (77.1)	27 (62.3)	.425
Other mothers	158 (42.7)	113 (40.9)	45 (47.9)	.241	113 (42.5)	25 (58.1)	.120
Internet	32 (8.6)	59 (21.4)	23 (24.5)	.533	74 (27.8)	8 (18.6)	.364
To my working environment	19 (5.1)	19 (6.9)	0 (0.0)	.009	17 (6.4)	2 (4.7)	.770
Internal defence	40 (10.8)	15 (5.4)	25 (26.6)	<.001	35 (13.2)	5 (11.6)	.967
Source of infant feeding information	679	541	138		589	90	
Media	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Health professionals	118 (17.4)	89 (16.5)	29 (21.0)		98 (16.6)	20 (22.2)	
Family members	55 (8.1)	45 (8.3)	10 (7.2)	.644	49 (8.3)	6 (6.7)	.679
Other mothers	91 (13.4)	71 (13.1)	20 (14.5)		79 (13.4)	12 (13.3)	
Internet	286 (42.1)	228 (42.3)	57 (41.3)		248 (42.1)	38 (42.2)	
Own accord/previous experiences	129 (19.0)	107 (19.8)	22 (15.9)		115 (19.5)	14 (15.6)	
Level of support from health professionals	679	541	138		589	90	
Not supported at all /Minimally supported	120 (17.7)	87 (16.1)	33 (23.9)		103 (17.5)	17 (18.9)	
Moderately supported	175 (25.8)	134 (24.8)	41 (29.7)	.005	151(25.6)	24 (26.7)	.660
Very supported / Extremely supported	384 (56.6)	320 (59.1)	64 (46.4)		335 (56.9)	49 (54.4)	
Satisfaction with feeding method	679	541	138		589	90	
Very dissatisfied/ Dissatisfied	24 (3.5)	11 (2.0)	13 (9.4)		20 (3.4)	4 (4.4)	
Neutral	18 (2.7)	8 (1.5)	10 (7.2)	<.001	13 (2.2)	5 (5.6)	.292
Satisfied/Very Satisfied	637 (93.8)	522 (96.5)	115 (83.3)		556 (94.4)	81 (90)	

Respect in everyday environment	679	541	138		589	90	
Very disrespectful/disrespectful	28 (4.1)	18 (3.3)	10 (7.2)		21 (3.6)	7 (7.8)	
Neutral	104 (15.3)	72 (13.3)	32 (23.2)	.002	88 (14.9)	16 (17.8)	.102
Respectful / Very respectful	547 (80.6)	451 (83.4)	96 (69.6)		480 (81.5)	67 (74.4)	
Respect in working environment α	611	482	129		525	86	
Very disrespectful/disrespectful	78 (12.8)	64 (13.3)	14 (10.9)		64 (12.2)	14 (16.3)	.260
Neutral	186 (30.4)	114 (29.9)	42 (32.6)	.758	159 (30.3)	27 (31.4)	
Respectful / Very respectful	347 (56.8)	274 (56.8)	73 (56.6)		302 (57.5)	45 (52.3)	
Respect when feed on public β	641	520	121		559	82	
Very disrespectful/disrespectful	22 (3.4)	15 (2.9)	7 (5.8)	.126	19 (3.4)	3 (3.7)	.133
Neutral	158 (24.6)	125 (24.0)	33 (27.3)		131 (23.4)	27 (32.9)	
Respectful / Very respectful	461 (71.9)	380 (73.1)	81 (66.9)		409 (73.2)	52 (63.4)	

EBF: Exclusive breastfeeding; Combi: Combination feeding (all types); * Participants could select more than one answer;

**Bivariate differences in experience ascertained by independent sample t tests and x^2 tests; †Percentages are calculated from participants who answered "External" and "Both" in the reference question; ♯ Percentages are calculated from participants who answered "yes" in the reference question; α Responses counted only for mothers who stated that they had a paid employment before pregnancy; β Responses counted only from mothers who stated that they have breastfed in public

Table 4: Crude and adjusted results for binary logit models of the association between predictor variables and feeding type/feeding intention

Predictor	Feeding Type		Feeding intentions	
	EBF/Combi		EBF/Combi	
	Crude RRR (95% CI)	*Adjusted RRR (95% CI)*	*Crude RRR (95% CI)*	*Adjusted RRR (95% CI)*
Guilty about choice of feeding method				
Yes	**0.17 (0.10, 0.27)**	**0.16 (0.09, 0.27)** ◊	**0.49 (0.26, 0.89)**	0.90 (0.47, 1.74) #
No*	1.00	1.00	1.00	1.00
Stigmatised about choice of feeding method				
Yes	1.27 (0.79, 2.05)	1.36 (0.82, 2.24) ◊	0.94 (0.55, 1.60)	0.88 (0.51, 1.52) #
No*	1.00	1.00	1.00	1.00
Need to defend choice of feeding method				
Yes	0.79 (0.49, 1.28)	0.66 (0.39, 1.09) ◊	1.45 (0.85, 2.47)	1.58 (0.91, 2.73) #
No*	1.00	1.00	1.00	1.00
Have you ever breastfeed in public				
Yes	**2.31 (1.03, 5.17)**	2.25 (0.94, 5.37) ◊	1.42 (0.60, 3.38)	1.17 (0.48, 2.87) #
No*	1.00	1.00	1.00	1.00
Source of infant feeding information**				
Internet	**0.52 (0.29, 0.95)**	0.54 (0.29, 1.01) ◊	0.70 (0.37, 1.32)	0.81 (0.42, 1.58) #
Other mothers	0.51 (0.23, 1.11)	0.64 (0.28, 1.45) ◊	0.65 (0.28, 1.49)	0.76 (0.32, 1.82) #
Family members	0.61 (0.25, 1.47)	0.65 (0.26, 1.64) ◊	0.55 (0.20, 1.51)	0.61 (0.21, 1.72) #
Own accord/previous experiences	0.59 (0.29, 1.17)	0.65 (0.32, 1.34) ◊	0.61 (0.29, 1.30)	0.68 (0.31, 1.49) #
Health Professionals	1.00	1.00	1.00	1.00
Level of support from health professionals**				
Not supported at all /Minimally supported	1.49 (0.81, 2.73)	1.39 (0.74, 2.63) ◊	1.11 (0.57, 2.18)	1.00 (0.49, 2.02) #
Moderately supported	1.67 (1.00, 2.78)	**1.74 (1.02, 2.97)** ◊	1.17 (0.67, 2.07)	1.03 (0.57, 1.86) #
Very supported / Extremely supported	1.00	1.00	1.00	1.00
Satisfaction with feeding method**				
Very dissatisfied/ Dissatisfied	**2.85 (1.08, 7.61)**	**3.18 (1.17, 8.68)** ◊	0.96 (0.29, 3.16)	0.67 (0.19, 2.32) #
Neutral	2.78 (0.91, 8.49)	2.56 (0.80, 8.25) ◊	1.66 (0.54, 5.16)	1.26 (0.39, 4.12) #
Satisfied/Very Satisfied	1.00	1.00	1.00	1.00

Respect in everyday environment**				
Very disrespectful/disrespectful	1.36 (0.53, 3.46)	1.05 (0.39, 2.85) ◊	1.97 (0.76, 5.12)	1.89 (0.69, 5.17) #
Neutral	1.52 (0.87, 2.64)	1.46 (0.82, 2.58) ◊	1.20 (0.64, 2.24)	1.05 (0.55, 2.01) #
Respectful / Very respectful	1.00	1.00	1.00	1.00
Respect/expected respect at the workplace α**				
Very disrespectful/disrespectful	0.82 (0.44, 1.55)	0.76 (0.39, 1.47)∫	1.47 (0.76, 2.83)	1.62 (0.82, 3.23) #
Neutral	1.10 (0.71, 1.70)	1.09 (0.70, 1,71)∫	1.14 (0.68, 1.90)	1.12 (0.65, 1.91) #
Respectful / Very respectful	1.00	1.00	1.00	1.00
Respect when breastfeed in public β **				
Very disrespectful/disrespectful	2.19 (0.87, 5.54)	2.18 (0.80, 5.94)⌂	1.24 (0.36, 4.34)	0.93 (0.25, 3.45) #
Neutral	1.24 (0.79, 1.95)	1.12 (6.90, 1.83)⌂	1.62 (0.98, 2.69)	1.57 (0.93, 2.66) #
Respectful / Very respectful	1.00	1.00	1.00	1.00

EBF: Exclusive breastfeeding; Combi: Combination feeding (all types); RRR: Relative risk ratio; ** Categories were collapsed to meet requirements of binary logistic regression; ◊ Adjusted for marital status and feeding intention; # Adjusted for feeding type; ∫ Adjusted for birth order; ⌂ Adjusted for mother's age, marital status and feeding intention; **Bold type** indicates significant associations; α Calculated from mothers who reported paid employment; β Calculated from mothers who reported they have breast fed in public.

Discussion

To our knowledge, this large-scale internet study is the first to examine the risk of encountering negative emotional and practical feeding experiences in different cohorts of breastfeeding mothers. Descriptive findings from the whole sample indicated that mothers reported feeling satisfied with their chosen feeding method, respected by their everyday environment including when breastfeeding in public and well supported by health professionals. Despite this, overall amongst breastfeeding mothers, 15% reported feeling guilty, 38% stigmatised and 54.5% felt the need to defend their feeding choice, with the family environment being the most frequent source of those feelings. These findings suggest that at surface level, breastfeeding mothers appear to be satisfied, respected and supported but on a deeper level, they are still susceptible to negative emotional experiences, particularly stigma and defence. Being aware that these emotions occur presents an opportunity to support breastfeeding women both emotionally and practically and limit postnatal mood issues, which bring potentially deleterious outcomes for both mother and infant.

Regression analyses identified that mothers supplementing breastfeeding with formula (combi) were far more likely to experience guilt, with these associations remaining strong after adjustment for confounders. Previous qualitative literature (Knaak, 2010; Marshall et al., 2007; Williams, Donaghue, et al., 2012) identifies the moralistic nature of the messages currently used to promote breastfeeding. The "breast is best" mantra accompanies the promotion of breastfeeding as something that should come natural, is tailored to the baby's needs and provides the best opportunity for bonding and attachment between the mother-infant dyad (Williams, Kurz, et al., 2012; Fenwick, Barclay, & Schmied, 2008; Larsen, Hall, & Aagaard, 2008; Mozingo, Davis, Droppleman, & Merideth, 2000; Murphy, 2000; Williams, Donaghue, et al., 2012). Feelings of guilt associated with formula supplementation could therefore arise from a sense of inadequacy or failing when compared to this socially constructed ideal mother.

Looking more specifically at the sources of guilt, half of the mothers who use a combination feeding method faced internally induced guilt. This is consistent with qualitative research, which reports that mothers who decide to offer formula either because their child is not thriving, or as an aid for themselves to recover from the physical and emotional challenges of breastfeeding, internalize the blame (Tanner & Cockerill, 1996; Williams, Donaghue, et al., 2012; Williams, Kurz, et al., 2012). On the other hand, with breastfeeding being demanding,

meeting maternal commitments with other children and managing domestic responsibilities in conjunction with social and public life, could produce an array of incompatible expectations from breastfeeding mothers. For working mothers, return to their workplace can also contribute to the incompatibility of their roles (Stewart-Knox, Gardiner, & Wright, 2003). Those expectations, often ~~conflicting by not nature~~ conducive to the establishment of successful breastfeeding, could potentially give rise to a source of externally derived guilt when entered into the daily life equation. (Hauck & Irurita, 2010).

Regression analysis also revealed that combi feeding mothers were at a higher risk of dissatisfaction from their infant feeding method. With breastfeeding promotion creating a perception of formula as an inferior and unsafe substitute of breastmilk that introduces a higher health risk for the babies, this is not a surprising finding. Such factors have also been linked with greater dissatisfaction with the milk feeding method in qualitative literature (Knaak, 2010; Lee, 2007; Murphy, 1999) and can lead to broader dissatisfaction with the mothers' postnatal experience (Symon, Whitford, & Dalzell, 2013). Interestingly, this finding is consistent with outcomes from a recent study looking at the emotional and practical experiences of exclusively formula feeding mothers (Fallon et al., in submission). This suggests that the effect is independent of the amount of formula supplementation and is linked directly to the act of formula provision itself.

In contrast to the initial predictions, neither of these experiences varied according to prenatal feeding intention after adjustment for confounders. It is possible that responding to a study recruiting breastfeeding mothers fostered internally positive opinions with regard to current feeding method and masked any discourse from pre-natal feeding intentions. However, breastfeeding intention is a complex concept and as the present study was not designed to assess individual components, such as the strength of feeding intention and plans for feeding duration, a complete feeding intention profile could not be generated.

Although not directly related to the main hypothesis, responses relating to managing breastfeeding in public settings and the workplace were included in this study as additional variables of importance. While nursing in public may be anticipated to be the most popular source of stigmatization in breastfeeding mothers, the vast majority reported that the public was moderately to very respectful when they nursed in public. This difference between the expected public response, which is expressed as perceived stigmatization, and the actual respect by the public has also been reported in a previous study (Sheeshka et al., 2001).

Negative media reports about public breastfeeding could be contributing to this discourse (Boyer, 2011; Taylor & Wallace, 2012). In contrast, stigmatization due to public breast-feeding was not an issue raised by only a minority of Combi feeding mothers. Mothers who are supplementing with formula milk may be less likely to breastfeed in situations where they could feel concerned about negative reactions to public breastfeeding, as they have allowed the option to offer formula. The working environment was also examined as a specific source of negative experiences. Only mothers who EBF indicated they felt the need to defend their infant feeding choices in this location. This is to be expected, as EBF mothers are more likely to require additional facilities (such as a private room and a fridge to store expressed milk) and time in the workplace than Combi feeding mothers (Brown, 2016; Wyatt, 2002). The importance of support from employers and co-workers towards the breastfeeding mothers in order to successfully continue breastfeeding is highlighted in the literature (Brown, Poag, & Kasprzycki, 2001; Johnston & Esposito, 2007; Meek, 2001). More recently the rights of breastfeeding mothers were officially established by law ("Equality Act," 2010, "Pregnancy and maternity discrimination," 2014; Murtagh & Moulton, 2011). However, there are no contemporary studies in the UK to demonstrate the efficacy of those provisions, or the change of employers' mind-set or practice towards breastfeeding mothers in the workplace. This finding could indicate a less flexible approach by employees when it comes to exclusive breastfeeding, however, direct examination of employers' attitudes towards continuation of breastfeeding, when mothers return to work, was beyond the scope of this study.

This survey is not without its limitations. It was completed by a self-selected sample of breastfeeding mothers whose willingness to participate may represent a desire to voice more extreme views than those with more neutral experiences who have no perceived benefit from taking part. Although efforts were made to advertise the study to the widest possible audience, this sample included participants from higher socio-economic status and as such cannot be generalised to women from different socio-economic backgrounds. In addition, the retrospective nature of questions relating to feeding intentions may have introduced biases. However, the high anonymity that an online study design offers is likely to balance the possible biases. Furthermore, the sample size of the study is large enough to engender confidence in the accuracy of the resulting summary of emotional and practical experience of breastfeeding mothers during the first 6 months postnatally. In addition, the design of the survey allowed differentiation of feelings from EBF and combi feeders in terms of both

feeding intention and feeding type as well as adjustment for established confounders. The differences in the proportions between the groups are, in many cases, striking.

Breastfeeding mothers who did not initially intend to breastfeed were not included in the analysis because the sample size was too small, thus creating problems in the logit regression analysis. However, looking at the decision making process of these mothers in more detail may provide useful insights to motivate mothers who were not planning to breastfeed to initiate it in the postpartum and may help to identify effective support mechanisms that can help counteract prior negative beliefs and experiences about breastfeeding.

In light of the present findings, several recommendations of future research directions can be given. While in the present study indications of the sources of guilt undoubtedly arise, future research should focus on qualitative identifying the exact reasons mothers feel guilty. This cannot only help contextualizing the present findings but can inform health professional practices that eliminate the emotional impact on mothers. Of equal importance is a qualitative examination of the decision making process and the support network of mothers who were intending to formula feed, but exclusively breastfed postnatally. Those mothers were present in the initial sample, however they had to be excluded from the analysis due to very low numbers (<1% of the sample). This examination can inform effective strategies that can aid towards breastfeeding initiation rates among mothers who have not considered breastfeeding as an option pre-natally. Additionally, replication of the present study to a targeted sample of mothers of lower socioeconomic status is critical to be able to confidently generalize the findings to the general population. Finally, as managing EBF continuation upon return to workplace was highlighted by EBF mothers as an issue, despite the protective policies in place. An evaluation of the implementation of those policies in both privet and public sector workplace settings is crucial.

Future recommendations on breastfeeding promotion policies and campaigns should take into account the diverse and multi-factorial needs of different cohorts of breastfeeding mothers in order to provide an evidence-based framework of action. Milk feeding practices should not be guided by a moral prism or viewed as a moral obligation of the mother to her child. While breastfeeding has undoubted health benefits for both mother and child (Michael S Kramer et al., 2008; Rosser, 2002), the importance of maternal mental health and wellbeing should not be overlooked in promotional efforts as this can have profound implications for maternal and infant health and wellbeing (Milgrom, Westley, & Gemmill, 2004; Murray, 1992).

To conclude, this study demonstrates that when breastfeeding mothers fail to adhere to exclusive breastfeeding guidelines, they are at risk of encountering negative emotions, particularly guilt. Such emotions are likely precursors to more serious postnatal disorders with the potential for damaging outcomes for both mother and child. Given that exclusive breastfeeding rates are very low in some countries, including the UK, this points to a large population whose emotional needs are not represented by current breast-feeding promotion practices and infant feeding policies. It is crucial that information provided to mothers is balanced and realistically reflects the challenges that exclusive breastfeeding brings. Moreover, to enhance the breast-feeding experience and empower mothers with confidence in their abilities, promotion and advice must be tailored to individual situations and respect the decisions of mothers who choose to supplement with formula.

APPENDIX II
PAPER II:
THE EMOTIONAL AND PRACTICAL EXPERIENCES OF FORMULA FEEDING MOTHERS

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Abstract

The majority of infant-feeding research is focused on identifying mother's reasons for the cessation of breastfeeding. The experience of mothers who choose to use formula is largely overlooked in quantitative designs. This study aimed to describe the emotional and practical experiences of mothers who formula feed in any quantity and examine whether these experiences would vary among different cohorts of formula feeding mothers according to prenatal feeding intention and postnatal feeding method. A total of 890 mothers of infants up to 26 weeks of age, who were currently formula feeding in any quantity, were recruited through relevant international social media sites via advertisements providing a link to an online survey. Predictors of emotional experiences included guilt, stigma, satisfaction, and defence as a result of their infant feeding choices. Practical predictor variables included support received from health professionals, respect displayed by their everyday environment, and main sources of infant feeding information. Descriptive findings from the overall sample highlighted a worryingly high percentage of mother's experienced negative emotions as a result of their decision to use formula. Multinomial logit models revealed that negative emotions such as guilt, dissatisfaction, and stigma were directly associated with feeding intention and method. The evidence suggests that the current approach to infant-feeding promotion and support may be paradoxically related to significant issues with emotional wellbeing. These findings support criticisms of how infant-feeding recommendations are framed by health care professionals and policy makers and highlight a need to address formula feeding in a more balanced, woman-centred manner.

Key Messages

A high percentage of mothers experienced negative emotions including guilt (67%), stigma (68%), and the need to defend their decision (76%) to use formula.

Mothers who had intentions to exclusively breastfeed in pregnancy (I-EBF) or those who exclusively formula fed at the time of study, yet initiated breastfeeding in accordance with current guidelines (EBF now EFF), were at a significantly higher risk of experiencing guilt and dissatisfaction as a result of their feeding method

Those that intended to exclusively formula feed in pregnancy (I-EFF) and initiated exclusive formula feeding from birth (EFF) were at a higher risk of experiencing stigma as a result of their feeding method

The study suggests that the current approach to infant feeding promotion and support in higher-income countries may be paradoxically related to significant issues with emotional wellbeing.

Introduction

Breastfeeding has unanimously positive short and long term health benefits for both mother and infant (M. Kramer & Kakuma, 2012) and these effects are enhanced with the exclusivity and duration of breastfeeding (Ip et al., 2007). The World Health Organisation [WHO] recommend exclusive breastfeeding up to six months of age, with continued breastfeeding up to two years of age or beyond (WHO, 2015). To achieve this goal, a wide variety of pro-breastfeeding initiatives and campaigns have been developed to promote the commonly affirmed "breast is best" message. The dominant infant feeding discourse emphasises not only the nutritional benefits of human milk, but also stresses the advantages of breastfeeding from environmental, economic, feminist, and attachment perspectives (Knaak, 2010; Lee, 2007). This multidisciplinary belief in the superiority of breastfeeding has been widely disseminated among the lay population and the way mothers feed their babies has become a matter of international social and public interest (Lee, 2007; Murphy, 1999) . However, despite growing evidence for the positive impact of breastfeeding promotion on breastfeeding outcomes (Semenic, Childerhose, Lauziere, & Groleau, 2012), differences in breastfeeding initiation and continuation rates persist (WHO, 2012). In many developed countries achieving the WHO recommendation remains a challenge. For example, despite UK breastfeeding initiation rates increasing by 19% since 1990 (62% in 1990 - 81% in 2010), the latest infant Feeding Survey [IFS] revealed that only 1% of UK mothers are exclusively breastfeeding their infants up to the recommended six months juncture (McAndrew et al., 2012). Sub-optimal exclusive breastfeeding statistics can also be observed in the United States (16%), Canada (25%), and Australia (15%) leaving the vast majority of babies in developed countries receiving some formula milk in the first six months of life (Australian Institute of Health and Welfare 2011; Health Canada 2011; Centers for Disease Control and Prevention 2015; Mcandrew et al. 2012). A small percentage (up to 2%) of mothers are physically unable to breastfeed due to biological problems such as hypoplasia, breast abnormalities, prior surgery or other medical contraindications (Brown et al., 2011a). However, in the majority of cases the introduction of formula is related to breastfeeding management rather than biological issues (Neifert & Bunik, 2013).

A growing body of literature highlights some of the more problematic aspects of the dominant breastfeeding discourse (Knaak, 2006, 2010; Lagan, Symon, Dalzell, & Whitford, 2014; Lee, 2007; Murphy, 1999; Williams, Donaghue, et al., 2012). While breastfeeding promotion is fundamentally a medical based discourse with the objective of conveying the health benefits of breastfeeding, it subliminally situates breastfeeding as the appropriate and "moral" choice (Knaak, 2010). Given the widespread knowledge of the many merits of breastfeeding among mothers, the moral statuses of those who decide not to breastfeed, or who are unable to, are left in jeopardy (Murphy, 1999; Spencer,

Greatrex-White, & Fraser, 2015). Assuming that every new parent desires the "best" for their infant, the "breast is best" slogan becomes a profoundly moralistic message, rather than a promotional tool to simplify the scientific evidence about the benefits of breastfeeding. This is amplified further by expert claims about the "riskiness" of choosing formula (Lee, 2007). In this manner, the pro-breastfeeding discourse has become intertwined with broader ideologies of the concept of optimal parenting (Knaak, 2010; Lee, 2007). This can lead to considerable pressure to conform to infant feeding guidelines in pregnancy and an emotional burden for those who do not manage to adhere to current recommendations in the postnatal period.

This discursive trend has also guided research protocols with a predominance of infant feeding research focused on identifying mother's reasons for the cessation of breastfeeding (Lakshman, Ogilvie, & Ong, 2009). While this is important in informing breastfeeding interventions, the lived experience of mothers who choose to use formula in a context where breastfeeding is strongly advocated has been largely overlooked (Knaak, 2006). The limited evidence which examines mothers who formula feed from this perspective does however raise important socio-cultural concerns which extend beyond those about health and nutrition (Bailey, Pain, & Aarvold, 2004; Knaak, 2010; Lee, 2007; Mozingo, Davis, Droppleman, & Meredith, 2000; Murphy, 1999). A mixed methods systematic review by Lakshman et al. in 2009 effectively synthesises the available evidence. Two key themes were identified among only 23 studies examining mother's experiences of formula feeding; maternal emotions; and perceptions of support. Negative feelings of guilt, stigma, and dissatisfaction were highlighted in all of the qualitative studies examining the emotional experiences of formula feeding women (Bailey et al., 2004; Cairney, Alder, & Barbour, 2006; Cloherty, Alexander, & Holloway, 2004; Earle, 2000; Lee, 2007; Mozingo et al., 2000; Spencer et al., 2015). In some of the studies, these feelings were internally motivated by an awareness of the superiority of breastfeeding (Bailey et al., 2004; Cloherty et al., 2004; Lee, 2007) and appeared to be more pronounced when formula feeding was not intended in pregnancy (Lakshman et al., 2009). Lee (2007) describes this intention-behaviour incongruence as one of "moral collapse" (p. 1087) which refers to women who have strong intentions to breastfeed in pregnancy and experience negative emotions as a result of being unable to in the postnatal period. However, in other studies, an allegedly unreasonable pressure to breastfeed from external sources, namely health professionals, emerged as the emotional catalyst (Earle, 2000; Lagan et al., 2014; Lee, 2007; Mozingo et al., 2000; Spencer et al., 2015). A perceived emphasis on the promotion of breastfeeding starting in pregnancy functioned as a vehicle of persuasion, rather than a vehicle of education, and alienated those who had chosen to formula feed (Lakshman et al., 2009). Mothers who initiate breastfeeding and then move to formula appear to be particularly susceptible to feelings of distress as a result of failing to conform to the "breast is best" message (Lagan et al., 2014). It has also been reported that these women experience a lack of support and information from health professionals concerning formula feeding (Lagan et al., 2014; Lakshman et al., 2009). Support

and information is instead found to be heavily slanted towards breastfeeding, which again, reinforces the supremacy of the pro-breastfeeding discourse (Cairney et al., 2006; Furber & Thomson, 2006; Lagan et al., 2014). To foster appropriate infant feeding intentions, the Baby Friendly Hospital Initiative (BFHI) code on infant feeding discourages health professionals from actively disseminating formula feeding information antenatally (UNICEF, 2010). However, this policy is often misinterpreted. Findings from two qualitative studies in the UK highlight that midwives in Baby-Friendly settings erroneously failed to provide support to formula feeding mothers in the postnatal period because they believed they were prohibited by BFHI policy (Furber & Thomson, 2006; Lagan et al., 2014). Consistent with this, mothers report a perceived reluctance by health professionals to provide advice about formula feeding postnatally (Lagan et al., 2014; Lee, 2007).

Compared with the large literature on breastfeeding and despite the high percentage of infants receiving formula (McAndrew et al., 2012) and the potentially grave consequences for maternal and infant health and wellbeing arising from negative feeding experiences, there is very limited evidence regarding the opinions and experiences of formula feeding mothers. Previous qualitative studies have only explored emotional experiences; while the quantitative studies primarily describe perceptions of information and support (see review by Lakshman et al., 2009). To our knowledge, no study has explored emotional and practical factors simultaneously nor quantified them in a large sample. Specifically, the aims of the current large scale internet study were to i) describe experiences of infant feeding support, information, respect, stigma, guilt, satisfaction, and defence in mothers who use formula in any quantity; ii) examine whether these experiences would vary among different cohorts of formula feeding mothers, and iii) examine whether these experiences would differ according to feeding intention in pregnancy. It was predicted that formula feeding mothers who planned to follow current breastfeeding guidelines in pregnancy, would perceive their infant feeding experiences more negatively than those who intended to formula feed in any quantity. Furthermore, mothers who exclusively formula feed at the time of study, yet initiated breastfeeding in accordance with current guidelines were predicted to perceive their infant feeding experiences more negatively than other cohorts of formula feeding mothers.

Method

Participants and Recruitment

A total of 890 mothers of infants up to 26 weeks of age, who were currently formula feeding in any quantity, were recruited through relevant social media sites and mailing lists via advertisements providing a link to the Qualtrics survey software. The 26 weeks cut off point applied reflects the current WHO infant feeding recommendations (WHO, 2015). The advertisements stated that participants were invited to take part in a short study which would examine the opinions and experiences of formula feeding mothers. Women who were exclusively breastfeeding, younger than

18 years of age, or non-English-speaking, were not eligible to participate. Of the 890 participants, 289 (32%) were excluded from final analyses as they did not complete the full survey. The age of the final sample of 601 mothers ranged from 18 to 46 years (M = 29.44; SD = 5.65). Their babies' ages ranged from 1 to 26 weeks (M = 17.96; SD = 7.38). The sample were predominately married (64%), primiparous (62%) women from the United Kingdom (57%). Fifty-six percent of the sample intended to exclusively breastfeed which is comparable with UK breastfeeding data (McAndrew et al., 2012). Forty six percent of the sample initiated exclusive breastfeeding but were exclusively formula feeding at the time of study. See Table 1 for full demographic details. The study gained ethical approval from the University of Liverpool Institute of Psychology, Health and Society Ethics Committee in January 2015. All aspects of the study were performed in accordance with the 1964 Declaration of Helsinki. Participants were provided with an information sheet and informed consent was gained with a tick box. The online survey was accessible from 30/1/2015 to 3/3/2015.

The Survey

Demographics

Mothers were initially asked demographic questions relating to their age, marital status, and country of residence. To assess socio-economic status participants were asked to report their current occupation (or if currently on maternity leave, previous occupation). The simplified National Statistics Socio-economic Classification, which contains 8 occupation classifications was then applied (ONS, 2010). Demographic information (birth order and age in weeks) relating to the infant was also obtained.

Exposure Variables

The exposure variables were developed from exploratory qualitative work which examined the infant feeding experiences of a sample of 19 postpartum women at two time points (4-8 weeks and 12-16 weeks). The data revealed various themes relating to emotional and practical infant feeding experiences which were consistent with the qualitative literature highlighted in the introduction and were used to generate survey items. Basic face and content validation were conducted on the items. The survey was reviewed and revised by all members of the research team with the following characteristics in mind: 1) simplicity and viability 2) reliability and precision in item wording 3) adequacy of the experience that it was intended to measure 4) reflection of the underlying concept that was measured. See Table 2 for a breakdown of items in the order that they were displayed to participants.

The first part of the survey assessed the perceived level of infant feeding support that mothers received from health professionals, the perceived level of respect displayed by their everyday

environment with regards to their feeding choices, and the perceived level of satisfaction experienced as a result of their feeding choices. All answers were provided via a 5 point Likert-scale (higher responses indicated higher levels of support, respect, and satisfaction). Mothers were also asked about their main source of information about infant feeding. Potential responses included the internet, health professionals, family members, other mothers, the media, or previous experiences/own accord.

In the second part of the survey mothers were asked to provide a binary (yes/ no) response to indicate the presence of feelings of guilt, stigma and the need to defend as a result their infant feeding choices. Display-logic was embedded in the survey software so that only participants with a positive response to these items were provided with a further item which examined the source of the feelings (potential options included the internet, health professionals, family members, other mothers, the media, or previous experiences/own accord). Participants were able to choose more than one source if applicable. A positive response to the presence of guilt was also followed up using display-logic to ascertain whether the feelings were experienced internally, as a result of other's opinions, or both. Experiencing guilt internally is not dependent on other's knowing about one's behaviour (in this case feeding intention/type) for it to arise. Conversely, experiencing guilt as a result of other's opinions is linked to public evaluation and is imposed on you by someone else.

Outcome Variables

The outcome variables, current feeding type and feeding intention in pregnancy were independently ascertained. Available answers were based on WHO-defined categories (WHO, 2002). Six different categories were available to the mothers (exclusively formula feeding from birth; breastfeeding to begin with but now a little formula; breastfeeding to begin with but now some formula; breastfeeding to begin with but now mostly formula; exclusively breastfeeding to begin with but now exclusively formula feeding; and combination feeding from birth).

Feeding intention was asked retrospectively at the end of the study to avoid response bias on answers relating to guilt, stigma or the need to defend infant feeding choices. Five choices were available to the mothers (exclusively breastfeeding, mostly breastfeeding with some formula, approximately 50% breastfeeding and 50% formula feeding, mainly formula feeding with some breastfeeding and exclusively formula feeding).

Statistical analysis

All analysis was conducted using the IBM SPSS 22 software package. Due to unexpected singularities (empty cells in the cross-tabulations) occurring during statistical analysis both outcome variables (current feeding type and feeding intention) were collapsed into three categories. Current feeding type: exclusively formula feeding from birth (EFF); exclusively breastfeeding to start with but now

exclusively formula feeding (EBF now EFF); and all other types of combination feeding (combi) and feeding intention: exclusively breastfeeding [I-EBF]; any type of combination feeding [I-combi] and exclusively formula feeding [I-EFF]. Descriptive statistics were generated for demographic and exposure variables of interest (Tables 2 and 3). One way ANOVA and χ^2 tests were used to examine bivariate associations between study variables and both feeding type, and feeding intention (Table 3). Relative risk ratio's (RRRs) for the association between exposure (emotional and practical variables) and outcome variables (feeding type and feeding intention) were then calculated using multinomial logit models. These include two sets of referent categories, one for the exposure category and one for the outcome category. Separate models were built for feeding type and feeding intention. The referent outcome category was set to reflect the hypotheses (i.e. feeding type: exclusive breastfeeding but now exclusively formula feeding; feeding intention; exclusive breastfeeding). Backward elimination was used to build the adjusted models and demographic variables were kept as confounders in the model if they changed the beta coefficients of the exposure categories by more than 10%. Feeding intention and feeding type were also included as potential confounders in the opposing models. When necessary exposure categories were collapsed (as described above) to meet the requirements of the statistical test and overcome complete separation issues within the sample (see Tables 4 and 5).

Results

Overall Sample

Of the 601 mothers, the majority experienced feelings of guilt (67%) about their choice of feeding method (Table 3). Interestingly, guilt was more likely to be internally motivated (30%) than stem from external sources (12%), although many experienced it from both channels (55%). Similar statistics were observed for other negative emotions with 68% of the sample experiencing feelings of stigma and a large majority (76%) of the sample experiencing the need to defend their choice of feeding method. External sources of guilt, stigma, and defence were primarily perceived to come from other mothers in similar quantities (68%, 62%, and 69% respectively), although this was closely followed by health professionals (64%, 59%, and 58% respectively). Despite these experiences, the majority (67%) of mothers responded that they were satisfied with their feeding method with a much lesser proportion (17%) reporting feelings of dissatisfaction. Similarly, the majority (62%) of mothers indicated that they felt respected, rather than disrespected (14%) in their everyday environment in terms of their infant feeding choices.

Thirty six percent of the sample felt well supported by health professionals about their choice of feeding method. This left the majority of mothers experiencing low to moderate levels of infant feeding support (64%) from health professionals. This was echoed in the descriptive statistics

regarding infant feeding information. The internet was favoured above health professionals as a source of infant feeding information among the sample with one in three mothers (31%) choosing this option. Remarkably, mothers were almost equally likely to gain information from health professionals (23%) as they were to use their own accord (22%).

Associations by feeding type

Descriptive statistics for all predictor variables split by feeding type can be found in Table 3. Forty six percent of the mothers who were exclusively formula feeding at the time of study initiated breastfeeding in accordance with current guidelines (EBF now EFF). EBF now EFF mothers were more likely to be married ($p<.001$) than exclusive formula feeding (EFF) mothers and mother who were combination feeding in any quantity (combi). EFF mothers were significantly younger than EBF now EFF mothers and combi mothers ($p=.001$). There were no differences in infant age, birth order, or occupational status between groups (Table 1).

Crude multinomial regression revealed that for those who experienced guilt as a result of their feeding method, the relative risk for being in the EFF group was four times lower in relation to EBF now EFF mothers and two times lower in combination feeding mothers when compared to EBF now EFF mothers (Table 4). After adjusting for maternal age, marital status, and feeding intention, the effect estimate for the EFF/EBF now EFF comparison was attenuated but the relative risk was still much lower (RRR: 0.45; 95% CI: 0.25, 0.79). Adjustment for covariates actually lowered the effect estimate further in the combi/EBF now EFF comparison (RRR: 0.38; 95% CI: 0.21, 0.64). Conversely, for those experiencing stigma as a result of their feeding method, the relative risk for being in the EFF group was much higher when compared to EBF now EFF mothers (RRR: 1.89; 95% CI: 1.04, 3.41). However, in adjusted analyses, this association was no longer significant. No associations between groups were observed with respect to defence.

In crude models, for those who experienced dissatisfaction or neutrality as a result of their feeding method, the relative risk of being in the EFF group was almost three times lower (RRR: 0.34; 95% CI: 0.15, 0.77; RRR: 0.39; 95% CI: 0.18, 0.85) when compared to EBF now EFF mothers. However, for those experiencing dissatisfaction and neutrality, a contrary association occurred when comparing combi/EBF now EFF groups (RRR: 1.78; 95% CI: 1.04, 3.06; RRR: 1.70; 95% CI: 1.01, 2.91). Neither of these associations were significant in adjusted models.

There were no differences in levels of respect or support between groups. However, one association was present when examining sources of information. Interestingly, in both crude (RRR: 2.99; 95% CI: 1.38, 6.51) and adjusted models (RRR: 2.74; 95% CI: 1.16, 6.44), for those that used family

members over health professionals as their source of infant feeding information, the relative risk for being in the EFF group was three times higher when compared to EBF now EFF mothers.

Associations by feeding intention

Descriptive statistics for all predictor variables split by feeding intention can be found in Table 3. More than half of the mothers (56% of 601) intended to exclusively breastfeed their baby in pregnancy (I-EBF). These mothers were more likely to be primiparous (p<.001) than those who planned to exclusively formula feed (I-EFF) or combination feed in any quantity (I-combi) (Table 3). Crude multinomial regression revealed that for those experiencing guilt, the relative risk for being in the I-EFF group was seven times lower when compared to I-EBF mothers (RRR: 0.14; 95% CI: 0.08, 0.26) and two times lower for I-combi mothers when compared to I-EBF mothers (RRR: 0.48; 95% CI: 0.29, 0.79). Adjustment for maternal age, birth order, and feeding type lowered the relative risk further (RRR: 0.13, 95% CI: 0.06, 0.28; RRR: 0.47, 95% CI: 0.28, 0.78 respectively). Conversely, for those experiencing stigma, the relative risk for being in the I-EFF group was 2.6 times higher than those in the I-EBF group (RRR: 2.63; 95% CI: 1.31, 5,27) and 1.7 times higher in the I-combi group (RRR: 1.75; 95% CI: 1.03, 2.96) than those in the I-EBF group. Neither association remained significant in adjusted models. Again, no associations between groups were observed with respect to defence.

Although this finding was as hypothesised, the relative risk of being in the I-EFF group rather than the I-EBF group was 14 times lower for those experiencing dissatisfaction (RRR: 0.07; 95% CI: 0.02, 0.30). The risk was also four times lower when comparing I-combi/I-EBF mothers (RRR: 0.24; 95% CI: 0.12, 0.49). In adjusted models the associations were attenuated but remained strong (Table 5). However, in adjusted models, for those experiencing disrespect from their everyday environment, the relative risk of being in the I-EFF group was three times higher (RRR: 3.25; 95% CI: 1.12; 9.38) than I-EBF mothers. No differences in levels of support were observed between groups. However, when examining sources of information, for those that used family members and their own accord over health professionals (RRR: 2.50; 95% CI: 1.04, 6.02; RRR: 3.78; 95% CI: 1.74, 8.21 respectively), the relative risk of being in the I-EFF group was higher than the risk of being in the I-EBF group. The same pattern was observed in the I-combi/I-EBF comparison (RRR: 2.51; 95% CI: 1.35, 4.68). Again, no associations for infant feeding information remained significant in adjusted models.

Table 1: Maternal Characteristics by overall sample, feeding type, and feeding intention

Characteristic	Overall	Feeding Type			*P***	Feeding Intention			*P***
		EBF now EFF	*EFF*	*Combi*		*I-EBF*	*I-EFF*	*I-Combi*	
Feeding Type/Intention (N/%*)		274 (45.6)	152 (25.3)	175 (29.1)		338 (56.2)	103 (17.1)	160 (26.6)	
Maternal age (mean years ± SD)	29.44 (±5.65)	29.23 (±5.24)	28.38 (±6.16)	30.70 (±5.62)	.001	29.05 (±5.58)	29.60 (±6.22)	29.58 (±5.52)	.592
Child's age (mean weeks ± SD)	17.96 (±7.38)	18.47 (±7.38)	17.64 (±7.70)	17.42 (±7.07)	.282	17.63 (±7.55)	16.74 (±7.60)	18.48 (±7.20)	.090
Country of Residence (N/%*)									
UK	344 (57.2)	141 (23.4)	103 (17.1)	100 (16.6)		178 (29.6)	70 (11.6)	96 (16.0)	
Ireland	7 (1.2)	2 (0.3)	4 (0.7)	1 (0.2)		3 (0.5)	3 (0.5)	1 (0.2)	
USA	122 (20.3)	67 (11.1)	21 (3.5)	34 (5.7)		74 (12.3)	17 (2.8)	31 (5.2)	
Australia	57 (9.5)	29 (4.8)	14 (2.3)	14 (2.3)	.18	34 (5.7)	8 (1.3)	15 (2.5)	.76
New Zealand	22 (3.7)	10 (1.6)	3 (0.5)	9 (1.5)		15 (2.5)	1 (0.2)	6 (1.0)	
Canada	30 (5.0)	13 (2.2)	6 (1.0)	11 (1.8)		20 (3.3)	3 (0.5)	7 (1.2)	
Other European	12 (2.0)	9 (1.5)	1 (0.2)	2 (0.3)		9 (1.5)	0 (0)	3 (0.5)	
Other World	7 (1.1)	3 (0.5)	0 (0)	4 (0.7)		5 (0.8)	1 (0.2)	1 (0.2)	
Birth order (N/%*)									
1st	370 (61.6)	168 (28)	82 (13.6)	120 (20)		238 (39.6)	39 (6.5)	93 (15.5)	
2nd	167(27.8)	80 (13.3)	51 (8.5)	36 (60		69 (11.5)	44 (7.3)	54 (9)	
3rd	38 (6.3)	18 (3)	8 (1.3)	12 (2)	.091	20 (3.3)	8 (1.3)	10 (1.7)	<.001
4th	15 (2.5)	5 (0.8)	7 (1.2)	3 (0.5)		6 (1)	8 (1.3)	1 (0.2)	
5th and after	11 (1.8)	3 (0.3)	4 (0.7)	4 (0.7)		5 (0.8)	4 (0.7)	2 (0.3)	
Marital status (N/%*)									
Married	381 (63.4)	190 (31.8)	74 (12.4)	117 (19.6)		217 (36.3)	60 (10.1)	104 (17.4)	
Living with a partner	174 (29)	70 (11.7)	55 (9.2)	49 (8.2)		91(15.2)	33 (5.5)	50 (8.4)	
Divorced	1 (0.2)	0 (0)	1 (0.2)	0 (0)	<.001	0 (0)	1 (0.2)	0 (0)	.272
Separated	4 (0.7)	1 (0.2)	2 (0.3)	1 (0.2)		2 (0.2)	1 (0.2)	1(0.3)	
Single	37 (29)	11 (1.8)	19 (3.2)	7 (1.2)		24 (0.8)	8 (1.3)	5 (4)	
Occupation (N/%*)									
Managers, Directors and Senior Officials	42 (7)	16 (2.7)	6 (1)	20 (3.3)		32 (3.8)	3 (0.5)	16 (2.7)	
Professional Occupations	216 (35.9)	99 (16.5)	46 (7.7)	71 (11.8)		132 (22)	36 (6)	48(8)	
Associate Professional and Technical Occupations	16 (2.7)	8 (1.3)	2 (0.3)	6 (1)		11 (1.8)	2 (0.3)	3 (0.5)	
Administrative and Secretarial Occupations	67 (11.1)	32 (5.3)	18 (3)	17 (2.8)		38 (6.3)	22 (12)	7 (3.7)	
Skilled Trades Occupations	18 (3.0)	11 (1.8)	3 (0.5)	4 (0.7)	.058	8 (1.3)	3 (0.5)	7 (1.2)	.112
Caring, Leisure and Other Service Occupations	64 (10.6)	30 (5)	18 (3)	16 (2.7)		36 (6)	11 (1.8)	17 (2.8)	
Sales and Customer Service Occupations	88 (14.6)	39 (6.5)	30 (5)	19 (3.2)		50 (8.3)	22 (2.7)	16 (3.7)	
Process, Plant and Machine Operatives	2 (0.3)	1 (0.2)	0 (0)	1 (0.2)		1 (0.2)	0 (0)	1 (0.2)	
Elementary Occupations	11 (1.8)	3 (0.5)	2 (0.3)	6 (1)		7 (1.2)	3 (0.2)	1 (0.5)	
Not in paid occupation	77 (12.8)	35 (5.8)	27 (4.5)	15 (2.5)		32 (5.3)	24 (4)	21	

EBF: Exclusive breastfeeding; EFF: Exclusive formula feeding; Combi: Combination feeding (all types); I-EBF: Exclusive breastfeeding intention; I-EFF: Exclusive formula feeding intentions; I-combi: Combination feeding intention (all types) * Percentages are given in reference to the whole sample; **Group differences ascertained by one Way ANOVA or x^2 tests

Table 2: Survey items examining feeding intention, type, emotional and practical experiences in order of appearance

Displayed to	Question	Response options
All	1. How are you currently feeding your baby?	Exclusively formula feeding from birth Exclusively breastfeeding to begin with, but now exclusively formula feeding Breastfeeding to begin with, but now a little formula Breastfeeding to begin with, but now some formula Breastfeeding to begin with, but now mostly formula Combination feeding from birth
All	2. How satisfied you are with your choice of feeding method?	Very Dissatisfied Dissatisfied Neutral Satisfied Very Satisfied
All	3. Do you find that your everyday environment is respectful of your infant feeding choices?	Very Disrespectful Disrespectful Neutral Respectful Very Respectful
All	4. How well supported by health care professionals do you feel when it comes to infant feeding?	Not supported at all Minimally supported Moderately supported Very supported Extremely supported
All	5. What has been your main source of information for milk feeding?	Internet online parenting forums/social media sites, health related websites, others Peers/other mothers in person Family members – mother, father, sister, brother, grandparents, other Health professionals – midwives, health visitors, GP, other Media - television, radio, newspaper, other Previous experiences/ own accord
All	6.1. Have you ever felt stigmatized for the way you choose to feed your baby?	Yes/No
If yes selected to question 6.1**	6.2. If yes, where?	Internet online parenting forums/social media sites, health related websites, others Peers/other mothers in person Family members – mother, father, sister, brother, grandparents, other Health professionals – midwives, health visitors, GP, other Media - television, radio, newspaper, other
All	7.1. Have you ever felt guilty about the way you choose to feed your baby?	Yes/No
If yes selected to question 7.1**	7.2. If yes, was this feeling the result of others opinion or your own feelings?	Other's opinions/ Own feelings/ Both

If other's opinions or Both selected to question 7.2**	7.3. If so, where?	Internet online parenting forums/social media sites, health related websites, others Peers/other mothers in person Family members – mother, father, sister, brother, grandparents, other Health professionals – midwives, health visitors, GP, other Media - television, radio, newspaper, other
All	8.1. Have you ever felt the need to defend your choice of milk feeding method?	Yes/No
If yes selected to question 8.1**	8.2. If yes, where?	Internet online parenting forums/social media sites, health related websites, others Peers/other mothers in person Family members – mother, father, sister, brother, grandparents, other Health professionals – midwives, health visitors, GP, other Media - television, radio, newspaper, other To myself
All	9. How were you planning to feed you baby when you were pregnant?	Exclusively formula feeding Mostly formula feeding with a little breast feeding Approximately 50% formula feeding and 50% breast feeding Mostly breast feeding with a little formula Exclusively breast feeding

* Forced response was activated on all items; ** Display logic was used on follow up items

Table 3: Descriptive experiences of formula feeding mothers by overall sample, feeding type, and feeding intention

Formula Feeding Experience	*Overall N (%)*	*Feeding Type N (%)*			*p-value***	*Feeding Intention N (%)*			*p-value***
		EBF now EFF	*EFF*	*Combi*		*I-EBF*	*I-EFF*	*I-Combi*	
Guilty about choice of feeding method	601	274	152	175		338	103	160	
No	197 (33)	57 (21)	83 (55)	57 (33)	<.001	71 (21)	68 (66)	58 (36)	<.001
Yes	404 (67)	217 (79)	69 (45)	118(67)		267(79)	35(34)	102(64)	
Source of guilt	404	217	69	118		267	35	102	
Internal	121 (30)	66 (30)	17 (25)	38 (32)		91 (34)	9 (26)	21 (21)	
External	50 (12)	24 (11)	14 (21)	12(10)	.264	23 (9)	10 (29)	17 (17)	.001
Both	223 (55)	127(59)	38 (55)	68 (58)		153(57)	16 (46)	64 (63)	
Source of guilt*†	273	151	52	80		176	26	81	
Media	130 (48)	74 (49)	22 (42)	34 (43)		91 (52)	12 (46)	27 (33)	
Health professionals	176 (64)	96 (64)	33 (63)	47 (59)		114(65)	16 (62)	46 (57)	
Family members	94 (34)	49 (32)	9 (17)	36 (45)		65 (40)	4 (15)	25 (31)	
Other mothers	186 (68)	106 (70)	32 (62)	48 (60)		120(68)	12 (46)	54 (67)	
Internet	177 (64)	106 (70)	35 (67)	46 (58)		113(64)	15 (58)	49 (60)	
Stigmatised about choice of feeding method	601	274	152	175		338	103	160	
No	191 (32)	81 (30)	39 (26)	71 (41)	.009	118(35)	28 (27)	45 (28)	.172
Yes	410 (68)	193 (70)	113(74)	104(59)		220(65)	75 (73)	115(72)	
Source of stigma*♯	410	193	113	104		220	75	115	
Media	180 (44)	91 (47)	42 (37)	47 (45)		105(48)	30 (40)	45 (39)	
Health professionals	244 (59)	113 (59)	74 (65)	57 (55)		125(57)	52 (69)	67 (58)	
Family members	117 (29)	56 (29)	18 (16)	43 (41)		74 (34)	11 (15)	32 (28)	
Other mothers	255 (62)	138 (72)	59 (52)	58 (56)		144(65)	33 (44)	78 (68)	
Internet	229 (56)	115 (60)	63 (56)	51 (49)		122(55)	48 (64)	59 (51)	
Need to defend choice of feeding method	601	274	152	175		338	103	160	
No	144 (24)	51 (19)	38 (25)	55 (31)	.008	82 (24)	31 (30)	31 (19)	.136
Yes	457 (76)	223 (81)	114(75)	120(69)		256(76)	72 (70)	129 (81)	
Source of defence*♯	457	223	114	120		256	72	129	
Media	62 (13)	34	15 (13)	13 (11)		37 (14)	10(14)	15 (12)	
Health professionals	265 (58)	123 (55)	76 (67)	66 (55)		140(55)	49 (68)	76 (59)	
Family members	181(40)	92 (41)	30 (26)	59 (49)		113(44)	16 (22)	52 (40)	
Other mothers	314 (69)	162 (73)	72 (63)	80 (67)		174(68)	42 (58)	98 (76)	
Internet	197 (43)	107 (48)	54 (47)	36 (30)		108(42)	39 (54)	50 (34)	
Internal defence	222 (49)	123(30)	34 (30)	65 (54)		160(63)	14 (19)	48 (37)	
Source of infant feeding information	601	274	152	175		338	103	160	

Media	3 (<1)	2 (<1)	0	1 (<1)		1 (<1)	0	2 (1)	
Health professionals	135 (23)	60 (22)	21 (14)	54 (31)		91(27)	16 (16)	28 (18)	
Family members	77 (13)	26 (10)	35 (23)	16 (9)		33 (10)	21 (20)	23 (14)	
Other mothers	66 (11)	27 (10)	17 (11)	22 (13)	<.001	36 (11)	12(12)	18(11)	<.001
Internet	187 (31)	99 (36)	36 (24)	52 (30)		123(36)	18 (18)	46 (29)	
Own accord/previous experiences	133 (22)	60 (22)	43 (28)	30 (17)		54 (16)	36 (35)	43 (27)	
Level of support from health professionals	601	274	152	175		338	103	160	
Not supported at all	44 (7)	22 (7)	14(9)	10 (6)		26 (8)	7 (7)	11 (7)	
Minimally supported	125 (21)	58 (21)	31(20)	36 (21)		78 (23)	17 (17)	30 (19)	
Moderately supported	216 (36)	91 (33)	61(40)	64 (37)	.548	113(33)	48 (47)	55 (34)	.340
Very supported	135 (23)	71 (26)	26(17)	38 (22)		79 (23)	17 (17)	39 (24)	
Extremely supported	81 (13)	34 (12)	20(13)	27 (15)		42 (12)	14 (14)	25 (16)	
Satisfaction with feeding method	601	274	152	175		338	103	160	
Very dissatisfied	37 (6)	15 (6)	3 (2)	19 (11)		33 (10)	2 (2)	2 (1)	
Dissatisfied	68 (11)	39 (14)	6 (4)	23 (13)		58 (17)	0	10 (6)	
Neutral	89 (15)	43 (16)	9 (6)	37 (21)	<.001	63 (19)	6 (6)	20 (13)	<.001
Satisfied	153 (25)	88 (32)	27 (18)	38 (22)		95 (28)	13 (13)	45 (28)	
Very Satisfied	254 (42)	89 (33)	107(70)	58 (33)		89 (26)	82 (80)	83 (52)	
Respect in everyday environment	601	274	152	175		338	103	160	
Very disrespectful	21 (3)	6 (2)	10 (7)	5 (3)		7 (2)	8 (8)	6 (4)	
Disrespectful	69 (11)	35 (13)	11 (7)	23 (13)		48 (14)	9 (9)	12 (8)	
Neutral	142 (24)	72 (26)	26 (17)	44 (25)	0.003	92 (27)	18 (18)	32 (20)	.004
Respectful	215 (36)	107(39)	51 (34)	57 (33)		115(34)	34 (33)	66 (41)	
Very Respectful	154 (26)	54 (20)	54 (36)	46 (26)		76 (23)	34 (33)	44 (28)	

EBF: Exclusive breastfeeding; EFF: Exclusive formula feeding; Combi: Combination feeding (all types); I-EBF: Exclusive breastfeeding intention; I-EFF: Exclusive formula feeding intentions; I-combi: Combination feeding intention (all types) * Participants could select more than one answer; **Bivariate differences in experience ascertained by one way ANOVA and x^2 tests; †Percentages are calculated from participants who answered "External" and "Both" in the reference question; ♯ Percentages are calculated from participants who answered "yes" in the reference question

Table 4: Crude and adjusted results for multinomial logit models* of the association between predictor variables and feeding type

Predictor	Feeding Type			
	EBF now EFF/EFF		EBF now EFF/Combi	
	Crude RRR (95% CI)	*Adjusted RRR (95% CI)*	*Crude RRR (95% CI)*	*Adjusted RRR (95% CI)*
Guilty about choice of feeding method				
Yes	**0.25 (0.15, 0.41)**	**0.45 (0.25, 0.79)**	**0.52 (0.31, 0.58)**	**0.38 (0.21, 0.64)**
No*	1.00	1.00	1.00	1.00
Stigmatised about choice of feeding method				
Yes	**1.89 (1.04, 3.41)**	1.48 (0.78, 2.83)	0.78 (0.47, 1.29)	0.85 (0.50, 1.44)
No*	1.00	1.00	1.00	1.00
Need to defend choice of feeding method				
Yes	0.75 (0.40, 1.40)	0.88 (0.44, 1.77)	0.67 (0.39, 1.16)	0.76 (0.43, 1.36)
No*	1.00	1.00	1.00	1.00
Source of infant feeding information**				
Internet and Media	1.02 (0.51, 2.04)	1.17 (0.55, 2.50)	0.69 (0.41, 1.17)	0.73 (0.42, 1.27)
Family members	**2.99 (1.38, 6.51)**	**2.74 (1.16, 6.44)**	0.74 (0.35, 1.57)	0.93 (0.43, 2.04)
Other mothers	1.66 (0.71, 3.84)	1.50 (0.60, 3.78)	1.00 (0.49, 1.99)	1.10 (0.54, 2.27)
Own accord/previous experiences	1.76 (0.88, 3.49)	1.21 (0.57, 2.60)	0.61 (0.34, 1.10)	0.66 (0.38, 1.22)
Health Professionals*	1.00	1.00	1.00	1.00
Level of support from health professionals				
Not supported at all	1.65 (0.59, 4.68)	1.57 (0.52, 4.78)	0.87 (0.32, 2.31)	0.79 (0.28, 2.21)
Minimally supported	1.70 (0.75, 3.90)	1.52 (0.62, 3.70)	1.18 (0.56, 2.47)	1.02 (0.47, 2.22)
Moderately supported	1.45 (0.71, 2.98)	1.16 (0.54, 2.51)	1.21 (0.64, 2.30)	1.13 (0.58, 2.20)
Very supported	0.62 (0.29, 1.34)	0.71 (0.31, 1.63)	0.81 (0.42, 1.59)	0.73 (0.37, 1.47)
Extremely supported*	1.00	1.00	1.00	1.00
Satisfaction with feeding method**				
Dissatisfied	**0.34 (0.15, 0.77)**	0.70 (0.30, 1.67)	**1.78 (1.04, 3.06)**	1.51 (0.87, 2.64)
Neutral	**0.39 (0.18, 0.85)**	0.48 (0.20, 1.13)	**1.70 (1.01, 2.91)**	1.42 (0.82, 2.48)
Satisfied*	1.00	1.00	1.00	1.00
Respect in everyday environment**				
Disrespectful	0.87 (0.43, 1.72)	0.89 (0.41, 1.94)	1.23 (0.67, 2.27)	1.40 (0.74, 2.67)
Neutral	0.57 (0.32, 1.02)	0.70 (0.37, 1.33)	0.93 (0.57, 1.53)	0.94 (0.56, 1.58)
Respectful*	1.00	1.00	1.00	1.00

EBF: Exclusive breastfeeding; EFF: Exclusive formula feeding; Combi: Combination feeding (all types); RRR: Relative risk ratio; * There are two referent categories in multinomial logit models, one for the exposure (indicated with *) and one for the outcome (exc BF now exc FF; to reflect the hypothesis); ** Categories were collapsed to meet requirements of multinomial logistic regression; **Bold type** indicates significant associations; Models were adjusted for maternal age, marital status, and feeding

Table 5: Crude and adjusted results for multinomial logit models* of the association between predictor variables and feeding intention

Predictor	Feeding Intention			
	I-EBF/I-EFF		I-EBF/I-Combi	
	Crude RRR (95% CI)	*Adjusted RRR (95% CI)*	*Crude RRR (95% CI)*	*Adjusted RRR (95% CI)*
Guilty about choice of feeding method				
Yes	**0.14 (0.08, 0.26)**	**0.13 (0.06, 0.28)**	**0.48 (0.29, 0.79)**	**0.47 (0.28, 0.78)**
No*	1.00	1.00	1.00	1.00
Stigmatised about choice of feeding method				
Yes	**2.63 (1.31, 5.27)**	1.81 (0.79, 4.19)	**1.75 (1.03, 2.96)**	1.65 (0.96, 2.84)
No*	1.00	1.00	1.00	1.00
Need to defend choice of feeding method				
Yes	0.95 (0.47, 1.91)	0.86 (0.36, 2.03)	1.55 (0.86, 2.79)	1.51 (0.82, 2.77)
No*	1.00	1.00	1.00	1.00
Source of infant feeding information**				
Internet and Media	0.84 (0.36, 1.92)	0.47 (0.17, 1.35)	1.21 (0.67, 2.19)	1.15 (0.63, 2.10)
Family members	**2.50 (1.04, 6.02)**	1.50 (0.50, 4.53)	0.82 (0.43, 1.57)	1.63 (0.76, 3.49)
Other mothers	1.75 (0.68, 4.53)	1.60 (0.51, 4.98)	1.50 (0.71, 3.18)	1.40 (0.66, 2.99)
Own accord/previous experiences	**3.78 (1.74, 8.21)**	1.33 (0.48, 3.66)	**2.51 (1.35, 4.68)**	2.22 (1.12, 4.38)
Health Professionals*	1.00	1.00	1.00	1.00
Level of support from health professionals				
Not supported at all	0.76 (0.21, 2.72)	0.37 (0.08, 1.74)	0.76 (0.28, 2.05)	0.74 (0.27, 2.02)
Minimally supported	1.20 (0.45, 3.25)	0.69 (0.20, 2.32)	0.79 (0.37, 1.67)	0.79 (0.37, 1.71)
Moderately supported	1.61 (0.71, 3.63)	1.80 (0.67, 4.78)	0.82 (0.43, 1.58)	0.85 (0.44, 1.65)
Very supported	0.60 (0.25, 1.46)	0.60 (0.20, 1.77)	0.72 (0.37, 1.42)	0.76 (0.38, 1.51)
Extremely supported*	1.00	1.00	1.00	1.00
Satisfaction with feeding method**				
Dissatisfied	**0.07 (0.02, 0.30)**	**0.13 (0.06, 0.28)**	**0.24 (0.12, 0.49)**	**0.26 (0.13, 0.52)**
Neutral	**0.27 (0.10, 0.68)**	0.54 (0.18, 1.60)	**0.55 (0.31, 0.98)**	0.58 (0.21, 1,04)
Satisfied*	1.00	1.00	1.00	1.00
Respect in everyday environment**				
Disrespectful	1.65 (0.74, 3.70)	**3.25 (1.12, 9.38)**	0.71 (0.37, 1.38)	0.75 (0.39, 1.47)
Neutral	0.67 (0.34, 1.32)	0.88 (0.38, 2.04)	0.67 (0.40, 1.12)	0.70 (0.41, 1.20)
Respectful*	1.00	1.00	1.00	1.00

I-EBF: Exclusive breastfeeding intention; I-EFF: Exclusive formula feeding intention; I-Combi: Combination feeding intention (all types); RRR: Relative risk ratio; * There are two referent categories in multinomial logit models, one for the exposure (indicated with *) and one for the outcome (exc BF; to reflect the hypothesis); ** Categories were collapsed to meet requirements of multinomial logistic regression; **Bold type** indicates significant associations; Models were adjusted for maternal age, birth order, and feeding type

Discussion

Given the limited evidence base in quantitative designs, the first aim of this study was to examine the emotional and practical experiences of mothers who use formula in any quantity. Descriptive findings from the overall sample indicate that despite feeling satisfied and well respected; a high percentage of mothers experienced negative emotions including guilt (67%), stigma (68%), and the need to defend their decision (76%) to use formula. This is the first study to provide numerical evidence to support qualitative research (Bailey et al., 2004; Cairney et al., 2006; Cloherty et al., 2004; Earle, 2000; Lee, 2007; Mozingo et al., 2000) and quantify the highly pervasive nature of negative emotions occurring among formula feeding women. Eighty-eight percent of women are using some quantity of formula in the first six months of life (McAndrew et al. 2012). These findings indicate a widespread public health issue that requires urgent attention from infant feeding policy makers in order to protect the emotional wellbeing of formula feeding mothers at an already precarious time. Mood disturbances are more common postpartum as compared to prepartum or the rate that characterises women in the general population (O'Hara et al., 2012; Viguera et al., 2011; Wenzel, Haugen, Jackson, & Brendle, 2005). Moreover, they are a precursor to more serious postnatal mood disorders and potentially deleterious maternal or infant health outcomes (Glasheen, Richardson, & Fabio, 2010; Grace, Evindar, & Stewart, 2003; Raes et al., 2014). Undesirable emotions relating to infant feeding may exacerbate these relationships.

Feelings of guilt were more likely to be internally motivated than stem from external sources. This is an interesting finding supporting previous literature that proposes an instinctive knowledge regarding the superiority of breastfeeding (Bailey et al., 2004; Cloherty et al., 2004; Lee, 2007) and indicates that self-reproach is the likely consequence of a discordant infant feeding outcome. With regards to external emotional catalysts, the data followed a similar pattern for guilt, stigma, and the need to defend feeding method. The primary external source of all the emotions under study was other mothers. Although this is a novel finding in the infant feeding literature, the media-fuelled "mummy-wars" between breastfeeding and formula feeding mothers may be a contributing factor (Christopher & Krell, 2014). Informal relationships between mothers both face to face, and via social media platforms are an important source of social and emotional support (Lee, 2007; Zimmerman et

al., 2008) and the socio-cultural significance of infant feeding decisions may be placing these networks in jeopardy (Christopher & Krell, 2014).

These negative emotions were secondarily driven by health professionals. These feelings may occur as a result of not conforming to health professionals' recommendations or stem from a perception that health professionals judge formula to be an inferior option (Lagan et al., 2014; Spencer et al., 2015). Such conclusions are further reinforced by data revealing that the majority of mothers in this study felt unsupported by health professionals and were more likely to rely on the internet for infant feeding information than seek advice from them. Although it is acknowledged that the vast majority of health professionals strive to promote and support the health and well-being of mothers and their infants, a perceived lack of infant feeding support and information from commissioned health services may result in errors in the preparation, handling, and storage of formula. These mistakes were noted in a number of studies reviewed by Lakshman (2009) and such consistencies in the literature raise considerable implications for infant health. Inadequate conditions when handling formula milk may lead to inadequate or excessive intake of calories and nutrients, dehydration, and diarrhoea. Moreover, there is a high risk of infection if bottles are washed or diluted with water at incorrect temperatures or stored inappropriately (Labiner-Wolfe, Fein, & Shealy, 2008; Lakshman et al., 2009).

The secondary aims of this work were to assess whether these experiences varied according to prenatal feeding intention and postnatal feeding type. Specifically, it was predicted that formula feeding mothers who had intentions to exclusively breastfeed in pregnancy (I-EBF) or those who exclusively formula fed at the time of study, yet initiated breastfeeding in accordance with current guidelines (EBF now EFF), would have more negative experiences than the other groups under study. Regression analyses revealed that both I-EBF and EBF now EFF type mothers were at a significantly higher risk of experiencing guilt about their choice of feeding method than other cohorts. These associations remained strong after adjustment for a range of confounders and could be most clearly observed when mothers expressed intentions to exclusively breastfeed in pregnancy. Guilt arises from the internal consciousness of an immoral action, this finding further exposes the moralistic nature of the pro-breastfeeding discourse (Knaak, 2010; Lee, 2007; Murphy, 1999) and highlights the emotional costs for those who try, yet are unable to achieve the current WHO guidance of exclusive breastfeeding for six months This guidance is intended to inform international government policies, but is instead widely disseminated by health professionals as an

individual feeding goal for women (Wray et al., 2013). Others have suggested that this is an unachievable "one size fits all" approach which disregards individual women's circumstances (Lagan et al., 2014; V Schmied, Sheehan, & Barclay, 2001) and sets women up for failure (Wray et al., 2013)

Similarly, the findings revealed that both I-EBF and EBF now EFF type mothers were at a significantly higher risk of experiencing dissatisfaction about their choice of feeding method than other cohorts, although this result was not significant in adjusted models for feeding type. Cultural representations of formula as nutritionally inferior, unsafe or risky have been highlighted as a contributors to feeding dissatisfaction (Knaak, 2006, 2010; Lee, 2007; Murphy, 1999); these findings lend agreement to this body of qualitative work. In addition, dissatisfaction with infant feeding has been associated with overall discontent about the initial postnatal period (Symon et al., 2013). Several other studies have noted the emotional burden for those that intend to, and initially start breastfeeding in accordance with current policies, yet change to formula feeding early (Lagan et al., 2014; Lee, 2007; V Schmied et al., 2001). These findings provide quantitative evidence to support criticisms of how infant feeding recommendations are framed by policy makers and appeals for a less prescriptive approach to the way current guidelines are presented to women (Knaak, 2006; Lagan et al., 2014; Lee, 2007). Associations for both guilt and dissatisfaction were stronger in feeding intention analyses than feeding type analyses. This suggests that the negative emotions experienced when prenatal exclusive breastfeeding expectations are unmet may be more profound than those experienced when exclusive breastfeeding is ceased in the postnatal period. Although this is a novel finding, recent work has indicated that the psychological disappointment generated by unmet expectations leads to lower wellbeing and a higher risk of depressive symptoms in the postpartum (Gregory, Butz, Ghazarian, Gross, & Johnson, 2015). Others have also noted this mismatch between idealism and realism, suggesting that policy makers are encouraging idealistic expectations in pregnancy but failing to support women to achieve these goals after birth (Hoddinott et al., 2013; Lagan et al., 2014; Lee, 2007).

Contrary to the hypothesis, I-EFF and EFF mothers were at a higher risk of experiencing stigma as a result of their feeding method than other cohorts, although these associations were attenuated in adjusted models. This suggests that mothers who intentionally use formula may be prone to a different, albeit undesirable, emotional experience. Furthermore, these mothers were also more likely to rely on family members than health professionals for infant feeding information when compared to those who attempted to follow current

breastfeeding recommendations. Stigma is defined as a negative and widely held social belief about an undesirable behaviour (Goffman, 1963), and is highly associated with perceptions of social isolation (Link & Phelan, 2006). It is argued, that the highly prevalent "breast is best" mantra serves to alienate those who intend to exclusively formula feed and creates reluctance among women to seek professional advice about their "suboptimal" feeding method. This finding resonates with other work highlighting feelings of isolation (Lee, 2007; Murphy, 1999) and information gaps in the current infant feeding message for those who decide to formula feed (Knaak, 2006, 2010; Lagan et al., 2014). The Royal College of Midwives (2004) advocates that women who choose to formula feed should have their decision respected. Similarly, the National Institute for Clinical Excellence (2008) guidelines emphasises that health professionals need to provide balanced and individualised information in discussions which encompass all infant feeding options. Counterintuitively, BFHI policy continues to prohibit health professionals from providing antenatal formula feeding advice in pregnancy, even to those who express intentions to exclusively formula feed in pregnancy (UNICEF, 2010). There may be a critical window of time for such conversations to take place to enhance perceptions of care and prevent negative maternal emotions from occurring prior to the postnatal period. Furthermore, this will enable health professionals to promote the safe and appropriate use of formula prior to commencement of use.

While the BFHI message is critically important in developing countries (Bartington, Griffiths, Tate, & Dezateux, 2006) or high-risk situations (prematurity, very low birth weight) (UNICEF, 2013) where the relevance for child survival is undisputed, it may be internalised differently among affluent or low-risk populations. The evidence presented here suggests that the current approach to infant feeding promotion and support in higher-income countries may be paradoxically related to significant issues with emotional wellbeing and may need to be situationally modified. This is not an isolated finding (Knaak, 2006; Lagan et al., 2014; Lee, 2007; Virginia Schmied, Beake, Sheehan, McCourt, & Dykes, 2011; Spencer et al., 2015; Thomson & Dykes, 2011) and points to tensions with breastfeeding initiatives such as BFHI in their current form. Exclusive breastfeeding rates are very low in some higher-income countries such as the UK and continue to stagnate (Bolling et al., 2007; McAndrew et al., 2012). At present, there is limited evidence examining the efficacy of public health interventions designed to increase rates of breastfeeding initiation and duration in higher-income settings. Only two studies in the UK have been conducted in BFHI settings and both

indicate that the benefits of the current strategy are transient and not sustained (Bartington et al., 2006; Broadfoot, Britten, Tappin, & MacKenzie, 2005). There is urgent need for further evaluation of current initiatives such as BFHI in higher-income settings to identify barriers to breastfeeding success and eliminate risks to maternal and infant wellbeing.

These conclusions are reinforced by the present study's large sample size which allowed assessment and adjustment of a range of established confounders while maintaining statistical power. The study design allowed us to distinguish between the emotional and practical experiences of different groups of formula feeders and as such provides a rationale for support to be tailored to specific cohorts of women. These experiences were however explored in a self-selected online sample of mothers. It is possible that responses were biased towards those with extreme experiences as those who are neutral about the topic may have chosen not to participate. For instance, mothers who wanted to breastfeed yet were unable to for biological reasons are likely to experience negative emotions as a result of diminished choice. Feeding intention was assessed retrospectively which may have also increased the chance of response bias. However, this is offset by the high levels of anonymity experienced when participating in online research. The study sample was predominantly first time, married mothers from the UK which limits the generalizability of findings to other settings. Data from exclusively breastfeeding women were also not obtained and so comparisons cannot be made with those who successfully adhere to current recommendations; this may be an interesting avenue for future research. The survey items used were not subject to comprehensive validity testing, again, this should be explored if the questions are to be used again with a different sample.

To conclude, descriptive findings from the overall sample indicate widespread negative emotions among those who choose to formula feed in any quantity. Although the hypotheses were only partially supported, this is the first study to identify that failure to initiate, or premature discontinuation of breastfeeding is directly associated with negative emotions, namely guilt and stigma. Women who intended to exclusively breastfeed, or initiated exclusive breastfeeding were more susceptible to guilt, whereas those that intended to or initiated exclusively formula feeding were at greater risk of experiencing stigma. As such, it exposes the specific emotional repercussions of formula feeding and provides further evidence to suggest that there is insufficient support and advice in place for those who use formula to feed their infants. The findings quantitatively summarise a rich body of qualitative work which highlights a need to address formula feeding in a more balanced,

woman-centred manner. Such consistency in the literature provides a solid basis to inform large-scale trials and evaluations examining the efficacy of current infant feeding initiatives. Ultimately, it is imperative to determine whether the benefits of the current infant feeding message outweigh the apparent risks to maternal and infant wellbeing.

APPENDIX III
INFORMATION SHEETS AND CONSENT FORMS

PARTICIPANT INFORMATION SHEET

Impact of Maternal Diet on the Development of Healthy Food Preferences in Babies

The Kissileff Ingestive Behaviour Laboratory
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Email: infant13@liv.ac.uk

You are being invited to participate in a research study. Before you decide whether to participate, it is important for you to understand why the research is being done and what it

will involve. Please take time to read the following information carefully and feel free to ask us if you would like more information or if there is anything that you do not understand. Please also feel free to discuss this with your friends, relatives and GP if you wish. We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to.

Thank you for reading this.

What is the purpose of the study?

The benefits of eating a healthy diet are well known. Despite this dietary habits in the UK are generally poor. In this study we are trying to gain a better understanding of the factors which influence food likes and dislikes in babies.

Why have I been chosen to take part?

We are looking for healthy females who are expecting or have recently given birth to a healthy full term singleton baby.

Do I have to take part?

Participation is voluntary so it is up to you whether or not you agree to take part. If you do decide to take part and then change your mind you are free to do so at any time without giving a reason and without being at a disadvantage.

What will happen to me if I take part?

Visit 1 (screening visit; arranged in a location to suit you)

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At the first visit you will be asked to provide some information about yourself (e.g. education and employment) and the health of both you and your baby. You will also be asked to complete some questionnaires about your eating habits and to provide details of your weight during pregnancy and of how you feed your baby. Your current height and weight will also be measured. If you don't complete the screening visit in the laboratory you will need to attend shortly after screening to allow these measurements to be made. Following the screening, we will telephone you to let you know whether or not you are able to continue in the study. We will also send an information pack which will confirm the details of the other study visits.

Visit 2-5 (testing visits)

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About 4 weeks after you introduce your baby to solid food and if you have been able to continue with the same feeding method as established at 1 month from you will be asked to visit the laboratory on 4 separate occasions. Height and weight measurements for yourself and your baby will be obtained prior to you being videotaped feeding your baby 4 different fruit and vegetable purees. You will also be asked to complete some questionnaires regarding your own and your baby's health and eating habits. Each visit will take about 45 mins - 1 hour to complete.

Expenses and / or payment

Reasonable travelling expenses will be paid to participants for attending the University for testing. Reasonable reimbursement will be made for participants' time. This will take the form of £40 mobile phone vouchers or vouchers for the purchase of baby care sundries e.g. Boots vouchers

Are there any risks in taking part?

There are no anticipated risks to you or your baby if you take part in the study.

Are there any benefits in taking part?

Although there are no direct benefits from taking part in the study, knowledge gained will help us to understand how healthy eating habits are formed. Healthier eating habits are associated with less risk of chronic diseases such as obesity, diabetes, high blood pressure and cancer.

What if I am unhappy or if there is a problem?

If you are unhappy, or if there is a problem, please feel free to let us know by contacting [Dr. Joanne Harrold 0151 794 1136] and we will try to help. If you remain unhappy or have a complaint which you feel you cannot come to us with then you should contact the Research Governance Officer on 0151 794 8290 (ethics@liv.ac.uk). When contacting the Research Governance Officer, please provide details of the name or description of the study (so that it can be identified), the researcher(s) involved, and the details of the complaint you wish to make.

Will my participation be kept confidential?

All information collected about you and your baby during the course of the research will be kept strictly confidential. It will be identified only by a participant number and not by name. Completed questionnaires will be stored securely for up to 15 years after which they will be destroyed. Computer data will be identified by number only and will be stored on password protected computers.

If, after screening you do not take part in the study, any personal data we hold will be destroyed unless you have offered to take part in future studies and have asked us to keep your personal details.

Can I see the information you hold?

Under the Data Protection Act 1998 you are entitled to request access to the personal data we hold. Data collected in this study may be held for up to 15 years after which it will be destroyed.

Will my taking part be covered by an insurance scheme?

Participants taking part in a University of Liverpool ethically approved study are insurance covered.

What will happen to the results of the study?

Once the study is complete we intend to publish the results in a scientific journal. The results will also be included in the student researcher's PhD thesis. We will not identify you in any way when the results are published in any form. Should you so wish, we will send you a short report of the findings of the study.

What will happen if I want to stop taking part?

You can withdraw at anytime, without explanation. Results up to the period of withdrawal may be used, if you are happy for this to be done. Otherwise you may request that they are destroyed and no further use is made of them.

Who can I contact if I have further questions?

You can contact Dr. Joanne Harrold via email on: harrold@liv.ac.uk or phone 0151 794 1136

Criminal Records Bureau check (CRB)

All the researchers who will be in contact with you and your baby have been undergone an enhanced CRB check. You may request evidence of this check from Dr Joanne Harrold

UNIVERSITY OF LIVERPOOL

Title of Research Project: Impact of maternal diet on the development of healthy food preferences in babies

Researcher(s): Dr Joanne Harrold, Sofia Komninou

	Please initial box
1. I confirm that I have read and have understood the information sheet dated 16/11/2012 for the above study and I am aware of its purpose and procedure. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my rights being affected.	☐
3. I understand that, under the Data Protection Act, I can at any time ask for access to the information I provide and I can also request the destruction of that information if I wish.	☐
4. I agree to infant weaning sessions being video recorded	☐
5. I agree to provide milk samples for chemical and sensory flavour analysis (*Study 2*)	☐
6. I agree to my GP being informed of my participation in the study if required.	☐
7. I agree to take part in the above study.	☐

Participant Name	Date	Signature
Name of Person taking consent	Date	Signature
Researcher	Date	Signature

The contact details of lead Researcher (Principal Investigator) are:

Dr Jo Harrold
Department of Experimental Psychology
Room 2.30a Eleanor Rathbone Building
Bedford Street South, Liverpool L69 7ZA
Tel: + 44 (0)151 794 1136


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LIVERPOOL

WEANING PRACTICES AND EATING BEHAVIOUR.

What is the purpose of the study?

The purpose of this study is to understand how infant feeding and weaning practices account for our taste and food preferences and acceptance in early life.

Why have I been invited to take part?

You have been invited to take part in this study because you are over 18 years old and you have a child between 12 and 36 months of age. Please if you have more than one child between 12-36 months answer this questionnaire for only one. Also, if your child has any developmental disabilities, unfortunately you are not eligible to take part in this survey.

Do I have to take part?

Taking part in this research is entirely voluntary. If you make the decision to take part in the study the confirmation question of the next page will act as a record of your awareness of the procedure and willingness to take part in the study. You can at any point choose to withdraw from the study, simply close the web page if you feel you cannot complete the questions

What will happen to me if I take part?

You will be asked to complete a series of questionnaires about the feeding practices you are following with your child, your child's eating behaviour, and your child's fruit and vegetable likes and dislikes. You will also be asked a few demographic questions.

Are there any risks in taking part?

There are no foreseeable risks associated with this study and it is hoped that you enjoy taking part. In the unlikely event that you have cause for complaint please contact the Senior Researcher: Dr. Joanne Harrold via email on: harrold@liv.ac.uk.

Are there any benefits in taking part?

You will have the option to be entered in a £…. Prize draw. We will also provide you with information at the completion of the study which you may find interesting.

What if I am unhappy or if there is a problem?

If you are unhappy, or if there is a problem, please feel free to let us know by contacting [Dr. Joanne Harrold 0151 794 1136] and we will try to help. If you remain unhappy or have a complaint which you feel you cannot come to us with then you should contact the Research Governance Officer on 0151 794 8290 (ethics@liv.ac.uk). When contacting the Research Governance Officer, please provide details of the name or description of the study (so that it can be identified), the researcher(s) involved, and the details of the complaint you wish to make.

Will my participation be kept confidential?

All data collected from the study will remain confidential at all times. The researcher is the only person that has access to data (through a secure login).

What will happen to the results of the study?

The results of the study will be used as part of my ongoing PhD research; the results gathered may be used to publish articles, in poster presentations and conference papers as well as being written in my thesis.

What will happen if I want to stop taking part?

You can withdraw at anytime, without explanation. Results up to the period of withdrawal may be used, if you are happy for this to be done. Otherwise you may request that they are destroyed and no further use is made of them.

Who can I contact if I have further questions?

You can contact Dr. Joanne Harrold via email on: harrold@liv.ac.uk or phone 0151 794 1136

☐ Tick to confirm you have read the information sheet and progress to the study