Behaviour and weight gain in early infancy

Molkenboer, Anne-Sophie E.

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By

Anne-Sophie E. Molkenboer

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Anne-Sophie E. Molkenboer

Abstract

Slow weight gain in infancy is the core sign of *failure to thrive*. However, it is far from clear what the cause of the slow weight gain in infancy is. Failure to thrive is mostly identified late in the first year at which time it becomes problematic to ascertain its causes retrospectively. The current study was designed to investigate weight gain and behaviour in the early weeks of infancy in a prospective study.

Seventy-five eight-week old infants were recruited according to their weight gain from birth to eight weeks, and classified as having slow, average or fast weight gain. Infants and their mothers were observed during two feeds. Mother-infant interaction and sucking behaviour were assessed. In addition, mothers completed questionnaires on the infant's temperament and behaviour (such as sleeping and crying), and on their own eating behaviour and adaptation to motherhood. All infants were followed up at six months and weighed again.

The follow-up weight at six months allowed the identification of infants with failure to thrive as traditionally clinically defined. Six infants were identified as failing to thrive at six months, all of which had slow weight gain from birth to eight weeks. The behaviours measured through observation and the questionnaires were investigated in relation to weight gain from birth to eight weeks and six months. No significant relationship was found between weight gain and maternal adaptation, the mother's eating behaviour or infant behaviour. One sucking behaviour parameter estimate, *pause length, end*, was found to be significantly related to weight gain to eight weeks. This result,

however, was entirely attributable to the estimates of one infant. This infant had particularly poor sucking behaviour and very slow weight gain from birth to eight weeks. Infant temperament, and in particular the infant's level of *fear* was related to weight gain from birth to eight weeks. Infants with higher levels of *fear* were more likely to have slow weight gain. The length of the feed, from which the sucking behaviour was observed, was related to weight gain, with infants with long feeds being more likely to have slow weight gain.

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Declaration

The research contained in this thesis was carried out by the author between 1996 and 2000 while a postgraduate student in the Department of Psychology at the University of Durham. None of the work contained in this thesis has been submitted in candidature for any other degree.

Statement of Copyright

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Dedicated to my mother and father, and to the memory of Oma

Chapter One

Introduction

Introduction

Poor weight gain in infancy is referred to as *failure to thrive*. Failure to thrive is often classified as either 'organic' or 'non-organic'. Organic failure to thrive originates from medical problems which result in slow weight gain. Non-organic failure to thrive, however is not associated with any known medical problems, so that it is assumed that environmental or interpersonal factors are the cause of slow weight gain. A substantial amount of research has been devoted to the investigation of failure to thrive. Infants with poor weight gain in infancy are likely to be shorter in childhood (Heptinstall et al., 1987; Corbett, 1998). In addition, poorer cognitive development has been reported for infants with poor weight gain (Singer and Fagan, 1984; Dowdney et al., 1987).

Research on failure to thrive has attempted to ascertain the causes of non-organic failure to thrive. A number of studies have focused on the relationship between the mother and her infant, investigating whether a breakdown in the relationship led to poor weight gain in the infant. Several studies have found differences between groups of infants with failure to thrive and infants with average weight gain. Relationships between the mother and her infant with failure to thrive have been described as more negative. During interaction infants have been described as expressing more anger and sadness (Polan et al., 1991), and vocalising less and crying more (Wolke et al., 1990, Mathisen et al., 1989) in comparison to average growing infants. Mothers have been observed to display more negative emotions and display less physical contact (Wolke et al., 1990) in comparison with mothers of average growing infants. In addition, the infant's feeding behaviour has also been investigated as a cause of slow weight gain. Retrospective information reported by the mothers suggests that infants with failure to thrive had feeding problems from the early months (e.g. Mitchell et al., 1980; Tolia, 1995). In research on failure to thrive infants have been described as being more fussy and demanding and less adaptable (Wolke et al., 1990), and as showing more negative affect during interaction (Polan et al., 1991).

However, these studies suffer from several methodological problems. First of all the identification of infants with failure to thrive was done on the basis of attained weight at a certain point in time, rather than on weight gain over time. Assessing the infant's growth from an attained weight at a certain point ignores the influence of birthweight on subsequent weight (Ferguson et al., 1980). In addition, it does not take into account that weights over time regress to the mean (Wright et al., 1994). Second, mother-infant interaction was assessed when infants were already identified as having failed to thrive. This complicates the issue of cause and effect, so that it is not clear whether the breakdown in the relationship between the mother and the infant leads to the infant's growth failure, or whether the infant's growth failure puts strains on the relationship leading to negative interactions. With regards to the reported feeding problems in infants with failure to thrive it should be noted that retrospective data is problematic to interpret. Current feeding difficulties may be influencing the mother's views about the infant's early feeding behaviour. In addition questionnaire data on feeding problems may be inadequate in assessing actual feeding problems; observation is more appropriate. These methodological problems are discussed in more detail in the following sections of this chapter.

An important question in research on failure to thrive is whether early feeding problems cause slow weight gain and in turn influence the mother-infant relationship, or whether the relationship between the mother and infant in some way cause slow weight gain. An investigation of the breakdown in the relationship would have to include an assessment of the infant's temperament. It is tempting to view the young infant simply as a *recipient* of nutrition and attention in the first few months, but research clearly shows the infant as an active participant from birth.

The aim of the current study was to overcome some of the methodological problems by studying weight gain in a prospective study in infants with different weight gain patterns. These infants were essentially healthy infants with differing weight gain patterns in the first eight weeks. The objective was to collect data on the infant's behaviour early in infancy, which may be predictive of weight gain. The mother's behaviour was also assessed to ascertain the relative influence of her behaviour on her infant's weight gain. Finally, the mother and the infant were observed in interaction to see whether an early breakdown in interaction was in any way predictive of poor weight gain.

An infant spends an average of four hours a day feeding in the first week; this decreases over the weeks to 2.8 hours in the eighth week (Walker and Menahem, 1994). Infants have been found to be active participants in the feeding situation, as they are able to regulate their intake of milk. The regulation of intake is defined as the ability to adjust the intake of milk or food according to the requirements of the infant (Wright, 1981). The regulation of intake in young children has been extensively investigated by Birch and colleagues, in studies on caloric compensation. There are two ways to design the experimental procedure to investigate caloric compensation. One is to have subjects consume two foods which differ in caloric density *ad libitum*, allowing them to consume as much or as little as they desire. Another way is to present subjects with a preload of two foods which are equal in amount but differ in caloric density. Subsequently they are allowed to consume other foods *ad libitum* which is then measured (Birch and Deysher, 1985). Caloric compensation enables the experimenter to assess whether there is internal regulation of food intake corresponding to the intake of the preload. Infants have also been found to be remarkably good at regulating their own intake. An important study on this topic was carried out by Fomon et al. (1975) who studied two groups of female infants who were given bottles of milk containing either 54kcal/100ml or 100kcal/100ml. Between eight and 111 days the average energy intake for infants in both groups on different formulas was very similar and the milk intake after 42 to 111 days was almost twice as much on average for the infants given the low energy milk. This indicates that the infants adjust their intake of milk according to their energy needs. The percentage of fat in weight gain in all these infants was similar over the eight to 111 days interval, suggesting that infants regulate their intake to meet their needs.

The studies on caloric compensation provide evidence for a process of regulation in infants and children. A disruption in the regulation of intake can lead to inadequate intake of milk. The process of food regulation entails two components, the regulation of food intake on one hand and the opportunity for the infant to initiate and control her actions on the other hand. The mother therefore needs to be able to accommodate the needs of the infant through sensitive behaviour towards the infant (Wright, 1988). In the current study the feeding situation was closely observed to investigate the infant's feeding behaviour and interaction between the mother and her infant.

Weight gain in infancy

Weight gain is monitored in infants as an indicator of health, especially in the first year (Wright et al., 1994; Giani et al., 1996). Postnatal growth shows a growth spurt in the first months, a form of catch-up growth (Tanner, 1989). Between 34 and 40 weeks in utero the foetus' growth slows down. After birth the infant experiences an increase in weight gain velocity until approximately twelve weeks. After twelve weeks the weight gain velocity decreases over the first year. The rate of weight gain in the first six months of life is the greatest in childhood, and thus the proportion of energy intake that is used for growth is high in the first six months (Skuse and Wolke, 1992).

In the UK baby clinics are held regularly where mothers can come and have their infants weighed. Poor weight gain, relative to the growth of a population of infants, is a cause for concern for health professionals, and can cause distress in mothers. Infant's weight gain is monitored with the use of growth charts. Growth charts show centile lines of weights in kilos, and age in weeks, as for example in the growth chart based on the UK 1990 growth data (Freeman et al., 1995). The charts may include the second, ninth, 25th, 50th 75th and 91st centile, with each line based on weight for age of infants in a normal population. The 50th centile represents the weights which 50% of infants are below, and 50% above. Nine percent of infants have a weight above the 91st centile and 91% have a weight below. So for each infant weighed on a regular basis, the points representing weights at different times can be joined to show a weight trajectory and compared with weights in the population as a whole.

Whitehead and Paul (1984) give a good overview of the different growth charts available. The National Centre for Health Statistics growth charts (NCHS; Hamill et al., 1979) is based on a sample of middle class infants recruited between 1929 and 1975. The Harvard growth standards (Stuart and Stevenson, 1959) are based on a sample of 228 infants recruited between 1929 and 1939. Both these charts, which have been widely used in research on growth faltering in the USA, are based on reference populations of over 50 years ago, and in the case of the Harvard standards based on a relatively small sample. Since the time the charts were made changes have occurred in infant feeding. First, there has been an increase in the proportion of infants that are breastfed. Secondly, the introduction of solids to an infant's diet has been delayed, and finally the composition of bottlemilk has changed to resemble breast milk more accurately (Whitehead and Paul, 1984). In Britain research on growth in infants has made use of the Tanner-Whitehouse charts (Tanner et al., 1966), on which the charts of Gairdner and Pearson (1971) are based. Since then the 'UK 1990' (Freeman et al., 1995) growth charts have become available, which have been revised ('Revised UK 1990'; Preece et al., 1996).

Guo et al. (1991) advocate the necessity of evaluating increments in length and weight rather than evaluation of growth using reference standards. Especially for infants with growth failure, a comparison with average attained weight of infants in a reference population in their opinion is inferior to the use of increments to evaluate weight gain. In research on failure to thrive (i.e. poor weight gain) the assessment of growth is crucial, and Peterson et al. (1985) indicate that a measure of gain is more sensitive than a measure of attained weight at a certain time. Velocity standards can differentiate infants who are small from infants who are failing to grow.

Another important issue in evaluating weight gain in infancy is 'regression to the mean'. Over time infants weights tend to regress to the mean, which means that weights become less extreme. The amount of regression to the mean depends on the correlations between the weights at the two timepoints (Cole, 1995). This issue is important since 'regression to the mean' means that infants who are born heavy generally move closer to the mean (50th centile) as they grow and this should not be interpreted as poor weight gain.

Slow weight gain and development

Recently, slow weight gain in infancy has been investigated in relation to a variety of long-term outcomes.

Barker et al. (1995) evaluated birthweight and recorded weight at one year in a sample of 15500 men and women born in Hertfordshire between 1911 and 1930. They found a relationship between weight gain in the first year and suicide in later life. The average weight at one year for those who had committed suicide was 395 g lower than for the rest of the sample. An increase in risk of suicide of 45% for men and 31% for women was related to each kilogram less weight gain over the first year. In an earlier study a subset of the men born in Hertfordshire were traced and men with the lowest birthweight and weight at one year had the highest death rate of ischaemic heart disease. Infants with a weight of less than 8.2 kg at one year were three times more likely to die of ischeamic heart disease than infants weighing 12.3 kg or more at one year (Barker et al., 1989). These findings are indicative of a relationship between weight gain in the first year and outcomes in later life.

Poor weight gain, in infants under the age of two years, without an apparent physical cause is referred to as non-organic failure to thrive (Wolke et al., 1990; Skuse, 1993). Infants with failure to thrive constitute 1 to 5% of hospital admissions (Powell et al., 1987; Berwick, 1982). They are typically identified as those whose weight has fallen below the fifth centile (Hutchenson et al., 1993; Black et al., 1994; Benoit et al., 1989) or third centile (McCann et al., 1994; Kotelchuck and Newberger, 1983) on a growth chart.

Failure to thrive has been widely researched and studies have found adverse outcomes in childhood. First of all, the consequences of poor weight gain in infancy and childhood can be seen in physical growth. At 15 month of age, children who had relatively slower weight gain in the first year were also shorter than comparison infants, and had a smaller head circumference (Skuse et al., 1994). At four years of age children with failure to thrive were reported to be significantly shorter then their normal growing peers (Heptinstall et al., 1987). This pattern continues into middle childhood with children who failed to thrive being significantly shorter at age six to eight than comparison children with normal weight gain over the first 18 months (Corbett, 1998).

A substantial amount of research has been devoted to the investigation of the influence of poor weight gain on cognitive development, and some studies have shown that poor growth in pre-school infants influences their performance on cognitive assessments. In a longitudinal study on failure to thrive from infancy to early childhood a continuous difference was found between infants with failure to thrive and normal growing controls (Singer and Fagan, 1984). At approximately four to seven months of age infants with failure to thrive had a lower Mental Development Index score (Bayley, 1969) when compared to matched controls. This trend continued from the first year to 20 months of age, when the same difference was found. These infants were followed up until three years of age, at which time the children with failure to thrive scored lower on the Stanford-Binet Intelligence Scale (Terman and Merrill, 1973). Their cognitive functioning at this age was described as in the borderline range (mean IQ = 78.6; Singer and Fagan, 1984). In another study (Dowdney et al., 1987) a sample of 23 infants with failure to thrive aged four years was recruited from a community population and compared with normal growing infants. The McCarthy Scales of Children's Abilities (McCarthy, 1972) were administered and infants with failure to thrive scored significantly lower on verbal, perceptual, quantitative, memory and motor subscales. Thirty-five percent of the failure to thrive infants had an overall score of below 70, indicating a need for special education (Dowdney et al., 1987). These findings were confirmed in a study by Puckering et al. (1995) in which infants with failure to thrive were found to have a cognitive deficit on all subscales of the McCarthy Scales, and the developmental quotient. Interestingly the study included an assessment of interaction in the home. The mothers of failure to thrive infants were more likely to present lower levels of positive stimulation. Positive maternal interaction was found to be a powerful predictor of the child's cognitive score, with positive interaction relating to increased scores. Positive maternal interaction influenced cognitive performance in children with failure to thrive as well as in the comparison children (Puckering et al., 1995).

Skuse et al. (1994) investigated postnatal growth and subsequent development to attempt to identify a sensitive period for early malnutrition. In this period shortly after birth, the brain is especially vulnerable to adverse influences, which affect subsequent development. Poor weight gain over the first six months was related to impaired mental abilities in the second year of life, as measured by the Bayley Scales of Infant Development (Bayley, 1969). The timing, duration and severity of growth failure predicted up to 37% of the variance in development at 15 months, which led the authors of this study to identify the first 6 months as a sensitive period for somatic growth and further mental development.

Socio-emotional problems have also been reported for children with failure to thrive. An early study by Hufton et al. (1977) reported behavioural problems such as bad temper tantrums, lying and speech problems in six year old children of this group. Almost half of the children were assessed by the child's teacher as having an abnormal personality, referring to either neurotic or antisocial characteristics. These children had been recruited after admission to a hospital, and a comparison group was not included in this study, which makes it difficult to interpret the results. Pollitt and Eichler (1976) reported more developmental disturbances in children with growth failure compared to normal growing comparison children. These were 12-60 month old children recruited from a pediatric clinic. Children attended this clinic for reasons other than growth failure (e.g. ear infection) and were selected if their weight fell below the third percentile on the growth chart. Differences in eating behaviour were the most pronounced between the two groups of children. Behavioural differences were only significant when pooled together. The combined data on sleeping, elimination, autoerotic and self-harming behaviour produced a significant difference between children with failure to thrive and normal growing children.

Barrett et al. (1982) studied the effects of chronic malnutrition on social and emotional functioning in rural Guatemalan children. Infants in rural areas of Guatemala suffer moderate malnutrition and the study investigated the influence on behaviour. Infants had received either good, average or poor energy supplementation, during the prenatal period and the first two years of life. At six to eight years of age there was a marked difference in social functioning, relating to the child's previous supplementation. Children who had received supplementation were more socially involved and interested in the environment, more active and capable of both negative and positive affective expressions, compared to the children who did not receive supplementation. This may point towards undernutrition lowering the child's capacity to develop optimal social interaction patterns in early life. The failure to develop interpersonal skills due to undernourishment has a progressive and cumulative effect, influencing the course of social and emotional development. Although the causes of growth faltering in these infants differs from infants with failure to thrive in the developed world, it is still interesting to find decreased social skills.

Despite its scarcity, research on behavioural problems in infants with failure to thrive suggests the possibility of behavioural as well as cognitive problems. Whether this is true for all infants with failure to thrive is uncertain, since the study by Hufton et al. (1977) did not compare their infants with average growing infants, and Pollit and Eichler (1976) only found a significant difference when the behavioural problems were pooled together.

Research on failure to thrive has suffered from methodological problems. The difficulties start when weight gain is evaluated; as previously mentioned weight charts used in research on failure to thrive are often inadequate in evaluating weight gain (Savage et al., 1999). In addition, criteria used to diagnose weight faltering are likely to misclassify infants. Most research uses the criterion of weight below the fifth or third centile (Benoit et al., 1989; Black et al., 1994; Hutchenson et al., 1993; Kotelchuck and Newberger, 1983; McCann et al., 1994) on a growth chart, which therefore includes infants who have low birthweights and grow normally. In addition, it ignores infants with a high birthweight with slow weight gain who fall across the centiles, but not drop below the fifth centile (Wright et al., 1994). Kristiansson et al. (1987) advocate the use of weight velocity to identify poor weight gain, and Wright et al. (1998)

propose a new chart for the evaluation of weight faltering, which assesses the change in weight gain over time.

Another difficulty is the fact that research projects on failure to thrive often investigate the development of infants who have been referred to a hospital for their weight loss (Benoit et al., 1989; McCann et al., 1994). This ignores a group of infants who are failing to thrive, but who have not been referred for their weight loss. To obtain a representative sample of infants with failure to thrive, a whole population needs to be screened, as was done in studies by Altemeier et al. (1985) and Heptinstall et al. (1987).

Fast weight gain and development

Obesity in children and adults is of growing concern as its prevalence is increasing and it has hazardous consequences for a person's health. A recent review by Dietz (1998) outlines the increased risks associated with obesity in childhood and adolescence. Obese children are the target of early and systematic discrimation. Children rank obese children lowest as those they would like to be friends with. Obesity is also linked with lower socio-economic status, and it seems to affect educational levels, family income and marriage rates, with fewer obese women marrying than non-obese women. Increased risk for diabetes has been found in adolescents and adults, as well as increased blood pressure. With these potential consequences of obesity, it seems important to attempt to identify early feeding differences which may be altered to avoid later obesity.

In infancy and childhood obesity may have a variety of causes. Children can suffer from obesity due to certain medical problems (Woolston and Forsyth, 1989). Taitz (1974) attempted to illustrate how overfeeding in infancy can lead to obesity in infants. The author hypothesised that between the 60s and 70s infants were overfed because of formulas being made up inappropriately. Infants were fed dense formulas, which resulted in decreased intake, which subsequently made infants thirsty. The infants' thirst would be interpreted as hunger so that they were fed more frequently and introduced to solids earlier, which lead to increased risk of obesity (Taitz, 1974). However, it is unclear how large the sample was from which the data was collected and most of the assertions were unproven. Changes in the infant's intake were hypothesised to result in changes in the balance between water and energy ratios. The author did not report to what extent mothers were actually making up dense formulas and how many mothers were doing this.

Fast weight gain in infancy is of importance if it predicts weight gain in adulthood. Since obesity is difficult to treat once it is established (Kramer et al., 1985), researchers have turned to infancy to investigate whether obesity in infancy predicts obesity in adulthood and what predictors are associated with obesity in infancy and childhood.

Charney et al. (1976) reviewed weight gain in adults born between 1945 and 1955. A sample of 366 adults aged 20 to 30 years were asked to report their weight and height and their charts were reviewed to establish weight gain in infancy. Weights at six weeks, three and six months were recorded which enabled each person to be classified according to their weight in infancy, as either obese (weight above the 90^{th} centile), normal (between the 25^{th} and 75^{th} centile), or underweight (below the 10^{th} centile). In adulthood a person was defined as overweight (weight more than 10% above the median weight for height and age), or obese (weight more than 20% above the median). Weight in infancy was related to weight in adulthood, and obese infants were found to be 2.6 times more likely to be overweight or obese adults. Lower socio-economic status and at least one overweight parent both increased the probability of obesity in adulthood (Charney et al., 1976). This relationship between infant weight and adult weight does not clarify any causal factors. Moreover, these results should be regarded with some caution as the adult weights were obtained from a questionnaire, which results in inaccuracies in reported weights and heights. The authors presumed an underestimation of weight and an overestimation of height, as they found 38% of mothers to be underweight but only 7% of mothers obese. The proportions for the fathers was closer to the proportion reported in the National Health Survey (National Center for Health Statistics, 1966).

Poskitt and Cole (1977) related weight in infancy to weight in childhood. Weight, height and skinfold thicknesses were collected for 203 infants, who were followed up four to five years later. In infancy 14% were obese and 26% overweight, however, in childhood this decreased to 2.5% and 11% respectively. Only one in nine obese infants were obese five years later, although one in three of the obese children had been overweight in infancy.

This finding of decrease in adiposity in childhood is important since it corresponds with findings by Rolland-Cachera et al. (1987) who proposed that adiposity increases rapidly in the first year, then decreases from one year to six years, only to start developing again at around six years of age. This second rise in adiposity is termed the ‘adiposity rebound’. A sample of 164 subjects was followed up from one month into adulthood. Early adiposity rebound was associated with higher adiposity in adulthood. Moreover, early rebound was associated with lower adiposity in infancy. The reverse was true for late rebound, which was associated with high adiposity in infancy and lower adiposity in adulthood. Body Mass Index (BMI) in infancy and in adulthood had a significant correlation of 0.25 ($p < 0.001$). Even though the correlation is low, twice as many fat as non-fat infants became fat adults (41% vs 20%). The risk ratio of fat infants becoming fat adults, compared to the whole sample was 1.6 (41% vs 26%). Garn and LaVelle (1985) reported a correlation of 0.14 for skinfold thicknesses over two decades and a risk ratio of 1.77 for obese pre-schoolers to become obese in adulthood. Gasser et al. (1995) also found a low correlation of BMI across the first year and adulthood (0.30 at $p < 0.01$). They included the age of adiposity rebound in their analysis, which displayed a low correlation of –0.30 ($p < 0.001$) with BMI in adulthood. Despite the fact that the correlations were low they give evidence that weight gain in infancy predicts obesity in adulthood to some extent.

Garn and LaVelle (1985) suggest that environmental factors need to be included in the identification of infants at risk for later obesity who might benefit from intervention. A few studies have investigated the factors associated with obesity in childhood. Takahashi et al. (1999) recruited 427 obese three-year-old children from a large sample (7962) in Japan and compared them with 854 average growing children, who were matched on sex and month of birth. Obesity in these children was defined as having a BMI of ≥ 18. Height and weight were assessed during a check up and additional information on lifestyle and environment was obtained through a questionnaire. First of all, the results show that overweight in the mother and father, defined as BMI ≥ 24kg/m^2, was associated with childhood obesity. Overweight at birth for the child, defined as ≥ 3500 g, was also related to obesity. The environmental factors such as limited play time outdoors (< 1 hour) and irregular snacking were found to be associated with obesity as well (Takahashi et al., 1999). The choice of definition of obesity for the children in the study (BMI of ≥ 18), and overweight at birth (≥ 3500 g) were not clarified by the authors. They fail to report average weights in childhood, or average birthweights, which makes the results troublesome to compare with other findings.

Mo-Suwan and Geater (1996) indicate that childhood obesity is a result of an interaction between genetic and environmental factors. To investigate this they studied 2161 primary school children. The children were classified according to their weight for height into underweight (< 90%), normal (90-110%), overweight (> 110-120%), and obese (> 120%). The following factors were found to be associated with obesity; family history of obesity, obesity of mother and father in BMI, taking less exercise than peers, high paternal income and being an only child. The authors propose that in the case of only children, overprotection and overfeeding may play a part (Mo-Suwan and Geater, 1996).

Kramer et al. (1985) conducted a study to identify determinants of adiposity in the first year. A large sample of healthy infants were followed up from birth to six and twelve months. At six months adiposity was determined by birthweight, sex, and age of introduction of solids. Together, these variables explained 22% of the variance of weight at six months. The same variables were of influence at twelve months, together with duration of breastfeeding. These variables explained 30% of the variance in weight at twelve months. For every 100 g increase in birthweight there was a 82.2 g increase in weight at twelve months. Similarly for every week delay of solids weight was 35.4 g lower, and for every week of exclusive breastfeeding weight at twelve months was 16.2 g lower. Maternal attitudes to her infant's body and her attitudes to feeding did not show any predictive value, and neither did the infant's temperament. Although the study identified certain determinants of weight gain in the first year, their predictive power remains quite weak.

These studies emphasise the importance of both genetic susceptibility and environmental factors in obesity in children. In addition, they show that although there are some correlations between infant obesity and obesity in childhood, these correlations were weak. Obesity in infancy did not necessarily result in obesity in childhood.

Mother-infant interaction and failure to thrive

Terms used in research on slow weight gain in infancy, such as non-organic failure to thrive, psychosocial dwarfism, maternal deprivation syndrome and environment failure to thrive, imply certain disturbances in interaction between the parent and the infant (Benoit et al., 1989). An early study by Spitz (1945) looked at the impact of separation from the mother. Institutionalised infants suffered from 'anaclitic depression' and 'hospitalisation' resulting in failure to grow. The author argues that even though the infants were receiving adequate calories they were emotionally deprived. However, it is not clear whether the infants were indeed receiving adequate nutrition. The only report in relation to food intake is the report on the preparation of food and the fact that some infants were breastfed and others bottlefed, which is hardly conclusive information on the infant's intake. Nonetheless, the role of the mother in relation to her infant has since received a lot of attention in research on failure to thrive (Boddy and Skuse, 1994).

Certain maternal characteristics have been assessed in relation to failure to thrive. One is the influence of maternal attachment on the course of interaction in mothers with hospitalised infants (Benoit et al., 1989). A group of 25 mothers had infants who were failing to thrive and they were compared to a matched control group of mothers with hospitalised infants without failure to thrive. The infants were on average seven to eight months of age. All mothers completed an interview on adult attachment, which was scored blind to the mother's group status. They found that mothers of infants with failure to thrive were less likely to have been securely attached as children, which is argued to adversely influence the relationship with their own infant. Mothers of the infants with failure to thrive were described as passive, confused, enmeshed, or intensely angry with respect to their attachment relationships, which in turn may continue into the current relationship with their infant. It must be taken into account in assessing these findings that the sample consisted entirely of hospitalised infants, who are by no means representative of all infants who fail to thrive in infancy.

Another characteristic is the parenting style of the mother, which was assessed in a study by Black et al. (1994). A sample of 102 infants with failure to thrive and 67 group matched control infants with average weight gain were recruited from a primary care clinic. Mothers were observed in interaction with their infant during feeding and according to their behaviour were labeled as displaying either a nurturant, authoritarian or neglecting parenting style. Infants with failure to thrive were more likely to have a neglecting mother. Moreover, within the failure to thrive group adaptive behaviour in the infant was associated with nurturant parenting, and maladaptive behaviour with authoritarian parenting (Black et al., 1994). The interaction in this study was observed in a laboratory, which is not the ideal setting to observe interaction, as it might be unnatural and uncomfortable for the parent. Nonetheless, the interesting finding in this study is the heterogeneity of the parenting styles within the failure to thrive group, which implies that there is no one style that is typical of mothers of growth faltering infants.

Polan and Ward (1994) examined the role of the mother's touch in relation to growth faltering. Mothers of 21 infants with failure to thrive and 18 average growing infants were compared on their touching behaviour during interaction. Infants were between nine and 19 months of age and recruited or referred from a pediatric primary care clinic. Mothers and infants were observed during a feeding and a play session, and these observations were scored for different forms of maternal touch. Mothers of infants with failure to thrive scored significantly lower than mothers of average growing infants on matter-of-fact touch during feeding, and unintentional touch during play. Matter-of-fact touch was defined as purposeful contact, such as wiping the infant's mouth, and unintentional touch was referred to as instances of brushing and bumping (Polan and Ward, 1994). Drotar et al. (1990) also observed mothers in interaction with their six month old infants to detect differences that might be related to failure to thrive. Infants with failure to thrive and average growing infants were observed in interaction with their mothers in a social situation and a feeding situation. During the social interaction mothers of infants with growth faltering scored lower on all dimensions: delight, emotional expression, sensitivity, accessibility, acceptance and cooperation. During the feeding interaction mothers of failure to thrive infants demonstrated significantly more arbitrary termination of feeding, but no difference was found for flexibility of timing or sensitivity (Drotar, 1990). However, once again the sample was recruited from a tertiary care setting rather than from a community sample.

Black and Krishnakumar (1999) conducted a longitudinal follow-up study of the weight trajectories of infants with poor growth. A group of 127 infants with failure to thrive were recruited from a pediatric clinic, all age < 25 months, and compared with 98 infants recruited from the community. Failure to thrive was defined as weight-for-age and weight-for-height below the fifth centile on the NCHS (National Center for Health Statistics; 1976) growth charts. At baseline the infant's health and temperament were assessed, as well as maternal depression and maternal nurturance during a feeding interaction. Infants with failure to thrive were followed up three times at six monthly intervals, and then at ages three, four, five and six years. The comparison infants were followed up at three, four, five and six years of age. Growth was monitored at all these time points. Healthy growth was found to be associated with nurturant caregiving from the mother and the mother's accurate perception of her infant's health. Mothers of infants with failure to thrive were less nurturant. Surprisingly, mothers of infants with growth deficiency perceived their infants as healthier and temperamentally less difficult than mother in the comparison group. The authors interpret this finding as a distortion in the mothers view of her infant. This distortion may be reflected in misperceptions of the infant's cues and result in a less optimal environment for the infant, which would explain the lack of nurturance during feeding observation.

These studies give an indication of the differences that are present between behaviour of the mothers with infants who are failing to thrive and mothers of average growing infants. However, such studies can not sufficiently assess the interactional relationship between the mother and her infant since the focus lies mainly with characteristics of the mother. The following studies have observed infants with failure to thrive in interaction with their mothers to detect a breakdown in the interaction, which may be responsible for subsequent failure to gain weight appropriately.

Mother-infant interaction was observed in a sample of infants, younger than a year old, who were hospitalised for failure to thrive and had a weight below the third centile (Lobo et al., 1992). Five infants had non-organic failure to thrive and five had organic failure to thrive. Infants were observed in interaction in a feeding situation and a teaching situation. Compared to a group of control infants and their mothers, the non-organic failure to thrive infants and their mothers scored lower during the feeding interaction. No other differences were found between the groups (Lobo et al., 1992). The results can not be considered to be conclusive since the sample of infants was small, and all infants had been hospitalised for at least six months at the time of observation.

Mathisen et al. (1989) observed one-year old infants with and without failure to thrive and their mothers during a feeding episode. Mothers of infants with failure to thrive reported fewer unambiguous vocal, gesture and body movement in their infants, compared with mothers of average growing infants. Their infants tended to resort to crying as a way of communication. From the observation it became clear that the mothers of the growth faltering infants tended to engage is less verbal and non-verbal communication during the feeding (Mathisen et al., 1989). A study on affect expression in feeding and non-feeding situations in infant aged six to 36 months (Polan et al., 1991) produced differences according to growth status. The results revealed less positive affect, such as happiness and interest in things, in infants with failure to thrive compared with normal growing comparisons. The failure to thrive infants also expressed more negative affect, such as sadness and anger, in the feeding situation.

Wolke et al. (1990) observed a community-based sample of one year old infants with failure to thrive and compared them with control children in a play interaction session. Rather than recruiting infants which had been referred for their growth failure, these infants were selected, out of a whole population sample, by Health Visitors in the community. Infants who have been referred for their failure to thrive do not represent the entire population of infants with growth failure. According to Dowdney et al. (1987) many infants with failure to thrive never get referred, let alone admitted to hospital for treatment. Infants were observed in interaction with their mother during play sessions featuring different toys. The play sessions were scored blind to the infant's weight status, and they found that mothers of infants with failure to thrive expressed more negative emotions and displayed less physical contact. Their infants tended to vocalise less, and cry and fuss more. With regards to the play task, they were less task-oriented and less persistent, and spent less time initiating contact with their mother, than their adequate growing counterparts. During the administration of the Bayley Scales (Bayley, 1969) the infants' behaviour was also assessed, and growth faltering infants were more fussy and unhappy, less adaptable, more demanding and difficult and less socially attractive. Their mothers were asked to describe their infant's behaviour during mealtimes and they did not describe them as being fussy and difficult. Mothers also emphasised that they enjoyed these periods of the day, although the signals used by their infants were observed to be relatively ambiguous. The authors try to clarify this discrepancy by suggesting that the most severely underweight infants might be withdrawn, while infants with milder growth faltering tend to be fussy and difficult. However, these are just suggestions. Despite the fact that infants were recruited from a community setting, the sample size was very small, i.e. nine infants with failure to thrive, and so the results should be considered with this in mind.

At four years of age mealtimes of infants with failure to thrive were marked by negative interactional behaviour (Heptinstall et al., 1987). Children of the same low socio-economic status with different weight gain patterns experience different mealtimes. Twenty-three children with failure to thrive were recruited from a whole population sample, and matched with 23 comparison children. Data from an interview with mothers of four year old children showed children with failure to thrive to be more likely to eat independently without parental supervision, and the timing of mealtimes to be more unpredictable. The growth faltering children were said to be more difficult and their mothers engaged in more angry interaction and tried to pressurise their child to eat, although these differences were not statistically significant. Mothers of children with failure to thrive were more inclined to regard the child helping themselves to food as stealing. Only five percent of mothers in the comparison group had this view, as opposed to 33% of mothers in the failure to thrive group, a statistically significant difference. During a mealtime observation fewer families of infants with failure to thrive took the opportunity to communicate and socialise with each other, and the interaction was marked with more negative affect. Retrospective information obtained from the interview indicated that the negative interactive behaviour had prevailed from early infancy.

These studies examined interactional behaviour between the mother and her infant. The infants in the studies were identified as having failure to thrive when poor growth was well established. By this time interaction with the mother may have taken on adverse patterns as a result of the infant's feeding problems and it therefore becomes increasingly difficult to unravel the direction of the causal relationship. Some studies have attempted to gather information on early interaction retrospectively, but the accuracy of this information should be questioned.

Interactional behaviour during feeding times needs to be reviewed as transactional, looking at behaviour of both the mother and the infant. In the first few days the infant is likely to be capable only of reflexive behaviour, whereas over the first few months the mother has to respond to her infant's needs and behaviours (Skuse and Wolke, 1992). Dunn and Richards (1977) evaluated interaction in mothers and infants from the first few days to ten days. This initial period is a time of adaptation, and the mother's relative failure or success in feeding may influence early interaction.

Woolston (1991) emphasised that growth failure should be evaluated in the light of the age of onset, and the degree of malnutrition. In addition, failure to thrive is not typically associated with family dysfunction (Woolston, 1991). Therefore, it seems more sensible to assess all the factors that may potentially contribute to growth failure.

Mother-infant interaction and obesity

The degree and duration of obesity are determinants of the prognosis of obesity (Woolston, 1991). In this light, it is important to assess the interactions in the family that assist in the persistance of increased weight gain. Birch et al. (1991) investigated mother-infant interaction in older children, aged between 44 and 81 months. Mother-infant interaction was observed during a task situation, which was a nonfood game situation, and during an eating situation. Verbal behaviour during the interactions revealed differences according to tricep skinfold thicknesses. First of all, mothers of thinner infants were more likely to talk during the game situation, making miscellaneous comments. The same was found during the observation of lunch, in which the amount of nonfood comments were negatively correlated with the skinfold thickness, so that thinner infants and their mothers made more nonfood comments. The eating behaviour of mother and infant were also evaluated and longer eating times of the mother showed a negative relationship with her infant's skinfold thickness. On the whole, fatter infants and their mothers consumed more food and spent less time eating. Fatter infants also received less feedback and guidance in the interactions (Birch et al., 1991). Although the authors found good indications of relationships relating to the infant's weight status, not all the relationships found reached statistical significance.

DeWitt et al. (1997) studied maternal behaviours in relation to weight gain in preterm and fullterm infants. The preterm infants were classified as either Low Risk (LR) or High Risk (HR) according to their medical status. The group of fullterm infants was studied as the comparison group. Maternal sensitivity, defined as positive behaviour, and maternal punitiveness, defined as negative behaviour, were assessed during a 70-minute observation of interaction. The observation of mother-infant interaction was made in the home. Weight in infants was monitored at birth, 38 weeks corrected gestational age, six months and twelve months corrected for gestational age. Weight gain was found to be related to maternal behaviours during interaction. Maternal sensitivity did not display a significant relationship with weight in HR and LR infants. Interestingly enough, there did seem to be a relationship in the fullterm group. Increased weight gain in fullterm infants was associated with decreased maternal sensitivity. It is inferred that mothers with higher sensitivity may be more attuned to the infant's cues during the feeding. A sensitive mother may recognise refusal cues faster and stop feeding rather than encouraging the infant to increase her intake (DeWitt et al., 1997).

Woolston (1991) suggested that obesity in children is linked to disruption and disorganisation in the family setting. Parents have a problem with limit setting, and often there is a denial of the severity of the situation. Distress in the infant is responded to by additional feeding (Woolston, 1991). The same suggestion was made by Carey (1985) to explain his finding of increased likelihood of difficult temperament in infants with fast weight gain. However, Woolston (1991) did not provide any clear evidence for his assertions.

Early feeding behaviour

Synchrony of the mother-infant relationship involves the infant's capabilities to indicate her needs, and the mother's ability to perceive her infant's cues and respond appropriately to these cues. In turn it involves the infant's ability to respond to the mother's interventions (Thoman, 1975). A few studies have related weight gain to mother-infant interaction in the first weeks of the infant's life. Pollitt et al. (1978a) for example observed 40 mother-infant pairs in a feeding situation, when the infant was between 20 and 36 hours old. The number of times the mother replaced the nipple cover on the bottle was positively correlated with weight gain, whereas frequency and duration of cleaning activities was negatively correlated with weight gain. With regards to the behaviour of the infant, they found a positive correlation between the number of times the infant opened her eyes and weight gain, and a negative correlation between the number of times the infant refused the nipple and weight gain. This reflects the infant as an active participant in interaction with the mother. Alert and active behaviour which creates more interactive opportunities is positively related to weight gain, from the first week. The aggregate score of these four mother and infant behaviours accounted for 32% of the variance in weight gain. These findings point to interactional behaviours that have an influence on weight gain over the first month. A subset of these mothers and infants were observed again at one month. Nutritional behaviours in the mother, such as placing the nipple in the infant's mouth, and communication behaviours in the infant, such as vocalising cries, were found to covary with weight gain over the first month (Pollitt and Wirtz, 1981). From the first day the infant is an active participant in interaction with her mother. Behaviours of mother and infant show a relationship with weight gain, but do not clarify the causal relationship in any way. On the one hand, it is possible that the infant's poor feeding behaviour and weight gain influence the mother's behaviour towards the infant during interaction. On the other hand, it can be suggested that the mother's poor interactional behaviour, such as decreased sensitivity to the infant, may result in the infant's poor feeding behaviour and weight gain.

Vietze et al. (1980) investigated early interaction in order to detect certain precursors to failure to thrive. Infants and mothers were observed at home during a feeding interaction, as part of a larger study on child maltreatment. A subgroup of 498 infants were observed during a feeding period, shortly after birth. These observations enabled Vietze at al. to assess mother-infant interaction. After the infants' first two weeks their weight gain was assessed and failure to thrive was defined as weight gain less than two-thirds of the 50th centile on the Harvard growth chart, over a period of at least ten days. Thirtyfive infants were identified as failing to thrive and were compared with a randomly selected comparison group. Mothers of infants who were later diagnosed as failing to thrive were found to have spent less time visually attending to their infants compared to mothers of infants in the comparison group. This finding is important since it is one of the few studies which investigates failure to thrive prospectively, in a large number of infants.

Examining early feeding behaviour in infants with failure to thrive shows certain difficulties from birth. A comparison between a group of failure to thrive infants and control infants showed more neonatal problems, such as jaundice, and more feeding problems in the failure to thrive infants (Mitchell et al., 1980). Another study showed similar findings with failure to thrive infants having poorer health and more feeding problems (Kotelchuck and Newberger, 1983). Tolia (1995) described early feeding problems in a sample of seven infants with failure to thrive, aged between 13 and 30 months. An interview with the mother revealed that feeding problems were often present from birth and were described as 'never sucking vigorously on both breasts', 'turning away while nursing' and 'never finishing bottle'. The infants were described as having decreased appetite from birth, which became worse from three to nine months (Tolia, 1995). However, these findings are based on a small sample of infants who had been referred to a pediatric gastroenterology clinic, and are therefore not representative of all infants with failure to thrive. In addition, the early feeding problems were reported retrospectively and should be cautiously interpreted.

Altemeier et al. (1985) conducted a prospective study on failure to thrive in order to identify antecedents of growth failure. Out of a large group of pregnant women 20% were randomly selected to make up a group of 274 families. An interview to assess increased risk for child maltreatment, and a life stress inventory was administered during the initial prenatal visit, and the 20% lowest scores were deemed at risk for child maltreatment. After birth the infants' weights were regularly assessed and infants with failure to thrive were identified. The average age of the sample of 259 infants was 12.8 months. Twenty-one of these infants had failure to thrive, although six were judged to have organic problems. The 15 other failure to thrive infants were compared with 101 infants randomly selected from the sample. Infants with failure to thrive tended to have shorter gestational periods, even though none of the infants were born before 36 weeks gestation. The same difference was reported by Vietze et al. (1980), who had also selected infants from the same initial sample. The infants had a shorter gestational age, together with a lower average birthweight than the control infants. The infants with failure to thrive in Altemeier et al.'s study were also more likely to need a return visit after discharge because of unresolved health issues. Most importantly, they found that during the nursery hospitalisation period mothers of growth faltering infants presented more problems feeding their infant. Half of these mothers did not wish to feed their infant, or presented sufficient problems for the nurses to decide to do most of the feeding (Altemeier et al., 1985).

Benoit et al. (1989) suggests that disturbed mother-infant interaction leads to growth failure through severe feeding disturbances, rather then 'non-specific emotional deprivation'. Furthermore, psychological and organic contributors to failure to thrive may coexist and even interact, rather than exist alone. There is a need for a transactional approach in which failure to thrive is seen as the central cause for the break-down of parent-infant interaction, so that the parent does not respond appropriately to the infant, and the infant does not elicit appropriate care from the parent, which will then result in nutritional and nurturing deficiencies (Bradley and Casey, 1985). The occurrence of adverse feeding behaviour early in life might result in adverse interactional behaviour in children who fail to grow adequately in infancy. Feeding problems, such as oral problems, may result in decreased intake and may lay the basis for disturbed mother-infant interaction. Feeding can become an aversive experience for the infant and increasingly so for the mother, leading to growth faltering in the infant (Polan et al., 1991).

Ramsay et al. (1993) investigated the notion that failure to thrive is secondary to a feeding skill disorder. They did this by comparing 38 infants with non-organic failure to thrive with 22 infants with organic failure to thrive, aged between one and 24 months. Infants were observed in a laboratory setting while being fed by their mother, and afterwards the mother was interviewed on details of the infant's feeding history. Feeding problems were identified as a) abnormal duration of feeding time (over 45 minutes), b) poor or no appetite, such as easily satisfied appetite by a few sips of milk or not demanding food, c) food texture intolerance of age appropriate food textures, and d) deviant feeding behaviours, such as refusing food or gagging easily. The feeding history revealed that feeding problems had started early in infancy and persisted. There was no significant difference in mother-infant interaction between the two groups, which suggests that the observed growth faltering may be due to the feeding problems, rather than disrupted interaction patterns (Ramsay et al., 1993). Whether this data can be extrapolated to be relevant to all infants with failure to thrive is debatable, since the infants studied had all been referred for their growth failure, and may therefore represent the worse cases or just a small detected subsample of infants failing to thrive. In addition, the age range of the infants in the study ranged from one to 24 months, so that infants are assessed at different stages in feeding, i.e. exclusively milkfed, in transition to solid feeding and exclusively weaned onto solids. Furthermore, the study lacked a control group with which to compare the infants in the study. It is possible that the feeding problems reported are present in healthy growing infants to some extent, or that differences in interaction would have appeared in comparison to healthy growing infants.

Method of feeding

The differences between breast and bottlefeeding should be taken into account when investigating weight gain and behaviour. First of all, the composition of milk is different. Although the composition of formula has changed over the years (Dewey et al., 1991b), it is not identical to breast milk. Energy density of breast milk differs between mothers, and infants have been found to adjust their intake according to the energy density of the milk. Infants who received high density milk were found to have lower intake (Nommsen et al., 1991).

Wright et al. (1980) investigated the differences between breast and bottlefed infants. Mothers were asked to complete a three-day diary in the first week of the infant's life. Mothers were also asked to report the infant's intake, which in the case of breastfeeding infants was done by test-weighing the infant before and after the feed. The results showed that in the first week of life breastfeeding infants who had gone a long time without milk were likely to respond by having a large meal following the long interval. This response was seen less in bottlefeeding infants. In addition, over the first two months diurnal rhythms became more pronounced in breastfeeding infants. The largest meal occured after the long night interval, with meal size decreasing throughout the day. Bottlefeeding infants consume uniform meal sizes throughout the day regardless of the length of intervals between feeds (Wright, 1980). It should be noted however that the measurement of intake in breastfed infants by test-weighing is subject to systematic error (Dewey et al.1991a). During feeding there is insensible water loss (IWL), which is not taken into account by simply test-weighing infants before and after feeds. Dewey et al. (1991a) determined an average loss of 0.05 g/kg per minute from a total of 342 measurements. Therefore the discrepancy between smaller and larger meals is dependent on the duration of the meal which influences the amount of IWL over the course of it. At 12 weeks Wells and Davies (1995) also observed substantial differences in daily patterns according to method of feeding. Breast-feeding infants are fed significantly more often over a 24-hour period. Breast-fed infants also spend more time awake in the night and are more likely to be fed during the night between 8pm and 8am (Wells and Davies, 1995).

Interaction between mother and infant is also influenced by the method of feeding (Dunn, 1975). At two weeks of age there are already marked differences in interaction between breastfeeding and bottlefeeding. Breastfeeding mothers displayed more smiling, touching and rocking, and their infant's activity influenced the patterning of this behaviour. With regards to behaviour in relation to the infant's sucking, it was observed that mothers with breast-feeding infants talked during pauses between sucking bouts and touched their infants during sucking. In bottle-feeding infants and their mothers these behaviours occurred more randomly during the feed. Another interesting difference was observed at the end of sucking bouts, when bottle-feeding mothers were the ones likely to end the bout, whereas within the mother-infant dyad of breastfeeding infants, it was equally likely to be either of them (Dunn, 1975).

Infant feeding involves the mother receiving feedback from the infant. Successful actions on the part of the mother, through feedback from the infant, enables the mother to decide whether to continue the action or try something else, for instance, stimulating the infant to continue feeding. There is an important difference in feedback between bottle and breastfeeding, in the knowledge and awareness of the amount consumed. This is obviously more ambiguous in breastfeeding (Wright, 1993).

This points to the issue of control during feeding. An interesting difference between breast and bottlefeeding can been seen in the amount of control that is exerted by the infant during feeding. Observation of feeding behaviour in bottle and breast fed infants from the first week to the 24th week indicates that the mother of the bottlefeeding infant has more control over the infant's feeding behaviour. Bottlefeeding was described as containing more behaviours determined by the mother. The feed was characterised by the mother stimulating the infant, pushing the teat in, or taking the teat out of the infant's mouth, rather than the infant initiating these behaviours. Breastfeeding mothers displayed control behaviours as well, but not nearly as frequently as their infants (Crow et al., 1980). A lack of control during a feed, as seen in bottlefeeding infants, may cause a disruption in the process of intake regulation. Scheduled feeds are postulated to lead to overfeeding, which increases the risk of subsequent obesity (Wright, 1981), although this statement was merely a suggestion of the possible consequences of schedule feeding.

Sucking behaviour

An infant is successful in feeding when sucking, swallowing and breathing are rhythmically co-ordinated. During sucking the infant rhythmically alternates suction and expression. Suction occurs when the oral cavity is sealed off to generate negative pressure to draw the milk into the mouth. Expression is the positive pressure when the nipple is stripped between the hard palate and the tongue (Lau and Schanler, 1996). Infants acquire efficient sucking very soon after birth. Infants suck in burst of sucks and pauses. Ramsey and Gisel (1996) investigated sucking behaviour in breast and bottlefed infants shortly after birth, using a strain gauge attached to the infant's chin. Measurements of sucking behaviour on consecutive feeds two to three days after birth show high correlations for the longest burst (r = 0.78) and sucking time (r = 0.65) (Ramsay and Gisel, 1996). Sucking becomes increasingly efficient with age in the first year. At two months of age a healthy infant consumes approximately 0.40 ml of milk per suck, whereas this has decreased to 0.26 ml by ten months. This corresponds with an increase in suck rate, from 77 sucks per minute at two months of age to 109 sucks per minute at nine months. The combination of the two changes leads to a fairly constant intake of 26 ml per minute across the ages (Silverman McGowan et al., 1991).

In 1963 Kron et al. introduced a method for measuring sucking behaviour using a pressure tranducer, which gives information on the pressure range and the frequency response during sucking. Infants were fed a corn syrup solution through a specialised nipple which was connected to the pressure transducer. This method allowed the assessment of the number of sucks per minute, consumption of liquid per minute and the average pressure per minute (Kron et al., 1963). In a later study, eight bottlefed infants were assessed on their sucking behaviour, starting when they were twelve to 16 hours old (Kron et al., 1968). Four and a half hours after the last routine feeding, the infant received milk formula through a specialised nipple attached to the pressure transducer. The test trial lasted for nine minutes, after which infants were fed the formula in their routine feeding. Over a four day period 18 trials were administered and the results indicate an increasing trend over the trials, i.e. for the average sucking time per minute, the average sucking pressure per minute, and the average consumption per minute. This average increase disguises the variability in individual infant progress over trials. Differences between infants in mean performance explain 60-70% of the variance. There is evidence for an increase in sucking behaviour although infants present great individual variability. This variability is of importance in the assessment of feeding behaviour.

An early study on sucking behaviour in infants showed a relationship between sucking behaviour in the first days of life and milk intake at one month. Forty healthy infants were recruited to measure sucking behaviour using a specialised nipple connected to a pressure transducer (Pollitt et al., 1978b). Sucking behaviour showed stability over two consecutive feeds when the infant was two days old. At one month infants presented a significantly higher sucking rate and had more sucking bursts and a higher intake of formula. The amount of time spent sucking, however, did not differ from the first days. The amount of time spent sucking accounted for most of the variance in intake of milk at one month, which emphasises the importance of time spent sucking in relation to the intake of milk (Pollitt et al., 1978b). This relationship was confirmed by the findings of a study by Dubignon and Cooper (1980) on quality of feeding and sucking behaviour, where sucking behaviour was related to the amount of milk intake. Feeding behaviour was assessed from birth and infants were labelled as 'good' and 'bad' feeders according to their milk intake in the first week. A comparison of the sucking behaviour, measured using a pressure transducer and a specialised nipple, of good and bad feeders showed that bad feeders spend less time sucking and suck less strongly then good feeders. Moreover, bad feeders had shorter sucking bursts containing less sucks, more sucking bursts and longer time between sucking bursts. Bad feeders showed a progressively declining sucking pattern throughout the trials (Dubignon and Cooper, 1980). The authors suggested an insensitivity to intra-oral stimulation on the part of the bad feeders which may result in decreased sucking behaviour and subsequent milk intake.

Oral motor functioning was investigated in a community based sample of infants with failure to thrive (Mathisen et al., 1989). Nine infants with failure to thrive were compared with matched controls and were found to have poorer oral motor functioning. Infants were twelve months old and assessed on their oral motor functioning with different types of foods (ranging from liquid to firm solids). Oral motor functioning includes factors such as oral sensitivity, both inside and outside the mouth, oral reflexes and tongue movement. Infants with failure to thrive were more likely to have hypotonic lips and show aversive responses to tactile stimulation of the body and face. The quality of oral-motor functioning in infants with failure to thrive was poorer compared to the control infants, when given pureed food (Mathisen et al., 1989). These findings must be considered with a certain amount of caution because of the small sample of infants that was investigated in the study. Nevertheless, oral co-ordination assessed in four year old children with and without failure to thrive also presented differences. Oral incoordination was defined as poor lip, jaw and tongue control and oral sensitivity. Incoordination was also characterised by food being thrust in the mouth in large quantities and pushed back with the fingers. Children with failure to thrive presented more oral incoordination which was identified as an adverse factor at mealtimes. The oral motor problems were probably perpetuated by the texture of the food. The infants with oral motor problems were offered mostly processed foods, such as tinned spaghetti, which requires less chewing (Heptinstall et al., 1987).

The presence of subtle neurodevelopmental deficits, in other words oral motor dysfunction, may contribute significantly to growth failure. This made Reilly et al. (1999) suggest that 'non-organic failure to thrive' may be an inappropriate label for these infants. They therefore recruited 47 infants with failure to thrive, aged approximately 15 months, from a whole-population sample of 2510 infants. Infants were fed by one of the researchers and assessed using the Schedule of Oral Motor Assessment (SOMA), which enables the identification of infants with oral motor dysfunction (OMD). Infants were presented with four different 'oral motor challenge categories' (OMC); puree, semisolids, solids and crackers. Seventeen infants were identified as having severe or moderate oral motor dysfunction, and their scores differed significantly from the infants without OMD, on all the OMC categories (Reilly et al., 1999). Interesting in these findings is that quite a high proportion of infants with failure to thrive had oral motor difficulties and that these did not coincide with any developmental delay. This emphasises the need for the investigation of early sucking behaviour as a potential indicator of feeding difficulties.

Differences in sucking behaviour seem to be related to subsequent feeding problems, such as feeding often and long, or excessive crying. Ramsay and Gisel (1996) observed feeding behaviour two to three days after birth and identified differences in early sucking and subsequent feeding. Sucking was measured using a Whitney strain gauge attached to the infant's chin. As the infant lowers and raises her chin the gauge is able to measure sucking movements without interference. Sucking behaviour was assessed at approximately two to three days after birth and at six weeks of age. Infants with feeding problems, as reported by the mother in a questionnaire on feeding problems, were identified as having significantly shorter continuous sucking bursts and shorter sucking times compared to infants without feeding problems (Ramsey and Gisel, 1996).

Agras et al. (1987) set out to investigate factors influencing the development of adiposity. A group of 99 infants was assessed on sucking behaviour and growth at two and four weeks. The infants were fed by their mother in a laboratory setting to assess sucking behaviour. At twelve and 20 weeks the infant's growth was measured again, and at all time points information was gathered on feeding practices. Infants were followed up at one year and two years of age. At one year parental education and shorter intervals between sucking bursts were associated with adiposity. These two variables accounted for 18% of the variance of skinfold thicknesses at one year. At two years of age the degree of adiposity was predicted by higher sucking pressure and fewer feeds per day in the first two months. The vigorous feeding style, characterised by rapid sucking, at a higher pressure, with shorter intervals between longer suck and burst duration, was related to higher caloric intake and greater adiposity (Agras et al., 1987). A subset of the infants investigated in this study was followed up at three years. Fatness was still predicted by a vigorous feeding style in infancy, together with breastfeeding for longer than five months. The authors propose that a vigorous feeding style might reflect an abnormal satiety mechanism, which may predispose an infant to adiposity in childhood and adulthood (Agras et al., 1990).

The infant's sucking behaviour can be modulated by certain behaviours on the mother's part, such as the selection of certain formulas, bottles, and also the way the mother might interrupt the burst-pause pattern of sucking or the way she might reinforce sucking by faster milk delivery. It is possible that these subtle changes, together with irregularities in the infant's sucking may lead to asynchronous interaction of the mother and the infant which can lead to feeding difficulties (Packer and Rosenblatt, 1979). On the other hand some mothers of infants with feeding problems used compensatory methods to increase the infant's milk intake, such as supplementing with bottles or changing from breast to bottle. Infants without compensatory measures spent 89% of their time sucking, had a higher intake and were fed less frequently (Ramsay and Gisel, 1996). Mothers of bottle-fed infants have been found to be influenced by their infants' birthweight, resulting in the mother lengthening the meal for their smaller infant (Crow et al., 1980). These findings indicate that compensatory measures can positively influence the feeding rather than disrupting the infant's pattern. It is likely that the differences in outcome of modulation of feeding behaviour in the early months can be attributed to the mother's sensitivity and responsiveness to the infant's individual needs. This brings us back to the importance of the behaviour of the mother as well as the behaviour of the infant in the feeding situation. Dunn and Richards (1977) emphasise that as feeding is a central part of interaction in the postpartum period the behaviour of the infant during feeding is likely to affect the process of interaction.

Affectionate talk, such as urging the infant to suck or bring back up the wind, are related to sucking rate in both breast and bottlefed infants (Dunn, 1975). In turn, the mother's behaviour is related to sucking behaviour. Dunn and Richards (1977) focused on the mother's behaviours between and during sucking bursts and found that mothers are more likely to talk to the infant when the infant is on the nipple but not sucking, or between sucking bursts, rather than during sucking. Over the initial ten-day period after birth there are changes in the smoothness of feeding, as the infants spends more time sucking and less time with the nipple in its mouth and not sucking or with the nipple out of the mouth. There is also a decrease in the number of times the mother attempts to stimulate her infant sucking (Dunn and Richards, 1977). Looking at the patterns in sucking behaviour of bottle and breast fed infants, there is a decline in the length of bursts, over the first five bursts. However, in bottlefeeding infants this progressive decline is interrupted by an increase in the length of the burst. This may be because the mother of a bottlefeeding infant stimulates her infant more to suck (Wright, 1980).

Research on sucking behaviour is unfortunately mostly confined to the neonatal period. A study on normal development of sucking patterns in infants from 1.5 to 15 months indicates a significant difference in intra-oral pressures during sucking. Infants at two months of age presented higher intra-oral pressures than neonates (Silverman McGowan et al., 1991). Two months therefore seems a more appropriate time to investigate sucking behaviour and its influence on subsequent weight gain. Sucking behaviour has also mostly been investigated in infants in a test situation, giving them limited time to feed. In addition, with the exception of Ramsay and Gisel's study (1996) sucking behaviour has been mostly assessed only in bottlefeeding infants.

Infant temperament

Differences in infant characteristics were referred to as temperament following the New York Longitudinal Study (NYLS) (Thomas et al., 1963), which studied infants from the age of three months. The NYLS generated further research on defining and measuring temperament. Particularly notable was the construction of measures to assess newborn behaviour, such as the Neonatal Behavioral Assessment Scale (Brazelton, 1973). During these examinations the newborn baby is observed for characteristics such as state control and irritability, and these examinations show great variability in behaviours between infants. Even though there is a lack of consensus on the definition of temperament across the studies (Hubert et al., 1982), there are certain features that recur within them. Temperament can be seen as behavioural tendencies from birth that have biological underpinnings. These tendencies are continuous over time but are somewhat modifiable by the environment (Rosenblith, 1992). The majority of studies focus on certain elements of temperament, namely responsivity, irritability and activity (Worobey, 1993).

Recently Wells and Davies included behavioural measures on physical activity in a study on energy expenditure and its relationship with aspects of behaviour (Wells and Davies, 1996). In adults energy requirements are determined by energy expenditure, which in turn, is based on the level of physical activity (FAO/WHO/UNU, 1985). In infants however the energy needs and expenditure have not previously been related to behaviour. Fifty twelve-week-old infants were recruited, their weight and height was measured, and a value was calculated for energy expended on physical activity. Mothers were asked to complete the Infant Behaviour Questionnaire (Rothbart, 1981) and a diary of the infant's activity patterns (Barr et al., 1988). Motion recorders were fitted to the infants over two 24 hour periods. The results showed a negative correlation between energy expenditure and time spent sleeping, and a positive correlation between energy expenditure and distress to limitations as measured by the temperament questionnaire. This indicates that high energy expenditure for activity is associated with high irritability and low time spent asleep. It should be noted that the measurement of energy expenditure is prone to errors, for example one infant's calculations yielded a negative result. The readings from the motion recorder showed a positive relationship with energy expenditure, but only at the 10% level of statistical significance ($r = 0.45$). This may be due to a combination of the methodology used and the sample that was studied. The initial sample of 50 infants was reduced to 38 since the researchers did not measure energy expenditure on twelve infants, and data from actometers on the infant's activity was obtained only for 16 infants. Despite these methodological problems, it is an important finding that irritability is associated with high energy expenditure and therefore high energy needs.

This sample of infants was studied simultaneously in order to relate behavioural characteristics to later body composition in childhood (Wells et al., 1997). At twelve weeks of age the infants were assessed on weight, length and anthropometric measures. Total body water was estimated in order to calculate fat free mass, fat mass and percentage fat. Behavioural characteristics were assessed using the Infant Behaviour Questionnaire (Rothbart, 1981). For this study they focused on measures of irritability, namely 'distress to limitations' and 'soothability'. Mothers were also asked to complete a two day diary of the infant's activity (Barr et al., 1988), from which the categories 'fussy' and 'crying' were used. In a follow-up study at two to three and a half years of age the childrens' weights and lengths and anthropometric measures were obtained, as well as fat free mass, fat mass and percentage fat. The children's diet was reviewed to derive measures of energy intake, carbohydrate intake and fat intake. Behaviour was assessed again, focusing on 'awake and active' and 'awake and quiet' behaviour.

The results show that fussiness in infancy is related to carbohydrate intake in childhood (two to three and a half years), but not to fat intake in childhood; the fussier the infant, the more carbohydrate she consumes in childhood. Distress to limitations positively predicted later percentage fat, although this relationship was not significant when it was adjusted for baseline fat and childhood age. Soothability in infancy was negatively related to subcutaneous fat (connective fat under the skin), and to later behaviour, with easily soothable infants being more active, rather than quiet in childhood. The behavioural characteristics displayed stability over time, in that distress to limitations had a positive relationship with time spent upset in childhood.

An important study relating relative increase and decrease in weight gain to temperamental characteristics was carried out by Carey (1985). He investigated a sample of 200 infants, of which weight and height were obtained monthly. The Infant Temperament Questionnaire (ITQ; Carey, 1970) was filled out by the mothers as part of the standardisation of the ITQ, when the infant was around six months old. The infants were clustered into either a 'difficult' group or an 'easy' group, according to their maternal-assessed temperament. Furthermore mothers were asked to give their perception of their infant as 'about average', 'more difficult than average' or 'easier than average'. The infant's weight gain was reviewed, and infants were grouped according to their relative increase and decrease of weight. Increase and decrease in weight was defined as the top ten percent and the bottom ten percent of the sample, respectively. Using the National Center for Health Statistics growth charts (USA), rapid weight gain was indicated as gaining 30 or more percentile points between six and twelve months, and created a group of 24 children. Decrease in weight was defined as losing 20 or more percentile points in weight for length, and this group consisted of 25 infants.

The results showed that the infants with rapid weight gain were more likely to have negative mood, and were overrepresented in the difficult cluster. The likelihood of rapid weight gain was greater when mothers rated their child as more difficult than average. On the other hand there were no significant findings in association with infants with a decrease in weight gain. The authors suggest that the relationship of difficult temperament with increased weight gain may be due to feeding being used as a way of soothing and quieting the irritable infant. The lack of results regarding decrease of weight may be due to a poorly selected sample. The criteria for decrease in weight gain were reviewed after the initial target of 10% of the extremes only yielded a subsample of nine infants. The criteria were subsequently changed to achieve a subsample of 24 infants. This resulted in investigating a group of infants whose weight decreased relatively less compared to the increase of weight in the other group, which may have influenced the outcome on the behavioural measures.

Kesterman (1981) investigated the behavioural variability in 20 newborns using the NBAS (Brazelton, 1973). The infant's behaviours were investigated on six consecutive days from three to eight days of age, and then evaluations were done between two feeds. Infants that were found to be less alert during the evaluation tended to also be more irritable and show less stability over the six days. The infants level of alertness was related to weight gain over the first eight days. Infants who tended to be less alert were found to have slower weight gain over the first eight days. These findings should be interpreted with caution as the study was not intended to study infant characteristics in relation to weight gain. The study was initiated to evaluate the NBAS and the stability of infant behaviour over time.

The studies by Wells et al. (1996, 1997) investigated temperament in relation to increased weight gain in infancy and fatness in childhood, and indicated the importance of irritability. Carey (1985) studied increased weight gain as well as decreased weight gain, and found difficult behaviour to be associated with a relative increase in weight gain, although no patterns of behaviour were related to a relative decrease in weight gain. It is suggested that temperament can have a direct effect on energy balance, with low activity predicting greater weight gain, or an indirect effect by which the infant's difficult behaviour elicits certain strategies of care in the mother, which subsequently might influence energy balance (Wells et al., 1997). Even though certain relationships have been found in these studies, it is not clear what the cause and effect relationships are. In none of these studies was the method of feeding included as a variable in the analysis. Research has shown differences in reactivity between breastfed and bottlefed infants, in the early neonatal period. Breast-fed infants display more irritable behaviour and are more difficult to console then bottle-fed infants, even though breast-fed infants seem to have more optimal physiological organisation (DiPietro et al., 1987). This illustrates the importance of including feeding method into the analysis of behaviour and its influence on weight gain.

Maternal characteristics and mother-infant interaction

The transition into motherhood is characterised by profound change which can lead to strong feeling of loss, isolation and fatigue (Rogan et al., 1997). Belsky (1984) proposes a model of parenting with the different components influencing the process of parenting. The infant's characteristics, the levels of support the mother receives, and the mother's psychological well-being, are all contributors to the parenting process, and subsequently to the infant's development. An important component is the psychological well-being of the mother since it affects the levels of sensitivity the mother displays to her infant. Studies on postnatal depression illustrate the influence of the mother's well-being on the relationship with her infant. Lundy et al. (1996) showed that from the first days of life, infants of mothers with depressive symptoms demonstrate decreased motor tone and activity, and increased stress behaviour and unavailability. Differences are apparent in facial expressions, with infants of depressed mothers showing fewer interest expressions and more precry expressions (Lundy et al., 1996). Depressed mothers showed increased negative affect, primarily irritation and intrusiveness during face-to-face interaction with their two month old infant (Cohn et al., 1990). The relationship between the mother and her infant was characterised by Cohn et al. as less affectively positive in the first six months.

The influence of depressive symptoms was investigated in a sample of adolescent mothers (Panzarine et al., 1995). The mothers were classified according to their depressive state into reporting no depressive symptoms, mild depressive symptoms or moderate to severe depressive symptoms. The results showed that mothers with mild, moderate or severe depressive symptoms have significantly more negative interaction during feeding than mothers without depressive symptoms. However, mothers did not differ in interaction during a teaching session. A difference in the mothers confidence was reported, so that mothers without depressive symptoms were more confident in their parenting abilities than mothers with depressive symptoms (Panzarine et al., 1995). Differences were found when the two groups of mothers with different levels of severity of depression were collapsed. Even then differences were only found during the feeding situation and not during the teaching situation. Cutrona and Troutman (1986) proposed a mediational model of postpartum depression similar to the model by Belsky (1984). The model illustrates the mediating role of the mother's feelings of competence as a parent through which the infant's characteristics and social support influence maternal depressive mood. The authors hypothesised that difficult temperament in infants would create feelings of incompetence in mothers, resulting in more depressive symptoms, whereas social support functions as a protector, diminishing the influence of the infant's difficult behaviour. Their results show that infant difficulty accounted for 30% of the variance in depressive symptoms. Furthermore the mother's sense of competence and overall sense of well-being were related to the infant's characteristics (Cutrona and Troutman, 1986). A study on infant crying further illustrates the influence of the infant's characteristics on maternal well-being. Infant crying at six weeks was associated with emotional distress in first time mothers. Longer crying duration and more frequent crying bouts were related to increased maternal anxiety.

Increased distress in mothers may lead to less responsive behaviour in the mother, which may result in more distress in the infant (Miller et al., 1993). The accumulative progress of these behaviours can lead to disturbed interactional processes between mother and infant. On the other hand, social support influenced the mother's confidence in her ability as a mother, which effectively deterred depression (Cutrona and Troutman, 1986). Research on failure to thrive investigated the importance of social support. Benoit et al. (1989) showed that the mother of an infant with failure to thrive expressed more dissatisfaction with the relationship with her partner. The relationship with the partner was described as involving more conflict and stress (Benoit et al., 1989). In reviewing wider support systems there was a difference between mothers with infants hospitalised for growth faltering and mothers with normal growing hospitalised infants in their sources of support. Benoit et al. reported less support from family in mothers of infants with failure to thrive and support coming mainly from non-family sources such as friends, social agencies, and church. The reverse was true for the average growing infants, which showed that mothers of infants with failure to thrive did not necessarily lack social support, but differed in where the support came from.

Williams et al. (1987) conducted a prospective longitudinal study of aspects of motherhood in relation to mother-infant interaction. At eight months into the pregnancy 238 women were asked to complete a set of questionnaires. A subset of these women were followed up at one month postpartum and at two years postpartum. The questionnaires covered issues such as emotional state, parenting confidence and feelings of closeness to the infant. The mothers were also observed in interaction with their infant at one month and two years. The results indicated parenting confidence to be the driving force in the transition to motherhood. At one month postpartum parenting confidence, the relationship with the infant and the mother's emotional state were all interrelated. The mother's confidence was found to be more crucial in the adaptation to motherhood than self-esteem, and furthermore, the mother's confidence influenced the ability to care for her infant and read her signals. The mother's interactive behaviours when observed at one month were significantly related to maternal feelings of confidence. Confidence in parenting abilities facilitated the development of the relationship with the infant (Williams et al., 1987). It must be taken into account that not all the women of the initial sample were observed in interaction with their infant. Moreover, most of the correlations found, although statistically significant, were low. The reciprocity in interaction includes maternal perceptions of her capacity as a mother, and objective appraisals of infant health and behaviour (McGrath et al., 1993). Blenke Bullock and Pridham (1988) explored sources of confidence and uncertainty in mothers at one month and three months postpartum. The infant's mood, response to care and physical well-being as well as the mother's success in dealing with a concern or managing care were of influence to maternal confidence. These factors were also of influence on feelings of uncertainty, including the mother not knowing what is happening or what to do. The authors asserted that the mother's confidence influenced how sensitive she was to her infant's cues, which subsequently influences mother-infant interaction (Blenke Bullock and Pridham, 1988).

These studies illustrate the importance of maternal well-being during the first few months of her infant's life, because of the influence on mother-infant interaction. It has previously been shown that interactional behaviours are related to weight gain (Pollit and Wirtz, 1981). More important in the previous findings is the multitude of factors that are of influence on mother-infant interaction. Therefore it seems most sensible to propose a transactional approach which takes into account certain characteristics of the mother and the infant, as well as their interaction with each other.

Mother's eating behaviour

Dietary restraint or the wish to control's one's food intake, has been investigated in obese subjects (Ruderman, 1986). Two hypotheses have been put forward, first of all the *disinhibition* hypothesis (Ruderman, 1985). This hypothesis refers to a disruption in self-control resulting in overeating. The disruption can come for example from strong emotional states so that it leads to restrained eaters either abandoning their diet or seeking refuge in food. Another hypothesis is the *externality* hypothesis: obese people eat in response to external food related cues, whereas other people eat in response to physiological signs of hunger (Herman and Polivy, 1980). The mothers own eating behaviour needs to be considered in relation to her infant's feeding behaviour. For instance, Barnes et al. (1997) found that a woman's concern with her own shape and weight, prenatally, influenced her intention to breastfeed. Mothers with increased concern about their shape and weight were also less likely to breastfeed up to four months of age (Barnes et al., 1997).

Stein et al. (1994) investigated the influence of eating disorders in the mother on the development of their infant. A group of 34 mothers with eating disorders was compared to mothers without eating disorders. The mothers with eating disorders all had extreme concerns about shape and weight of clinical severity during the first year of their infant's life. All mothers and infants were visited at home when the infant was one year old. Mother and infant were observed during a play situation and during a meal. Mothers with eating disorders displayed more negative emotions during the mealtimes, and they were found to be more intrusive, both during the mealtimes and play sessions. They were also more likely to express controlling statements, and there was more conflict in mother-infant interaction in the index group. Not surprisingly therefore, the infants in the index group were rated as less happy than the comparison infants. The infants of the mothers with eating disorders were found to be significantly lighter, and multivariate analysis revealed two variables to be related to the infant's weight. The amount of conflict between mother and infant during mealtimes and the degree of the mother's concern about her own body shape were inversely related to the infant's weight (Stein et al., 1994).

Important in these findings is the fact that the infants with mothers with feeding disorders were less happy and that interaction times were tainted with conflict, which is likely to have influenced feeding behaviour and subsequent weight gain. Differences in attitudes to feeding of infants in mothers with and without feeding disorders were found in a study by Evans and Le Grange (1995). A group of mothers with eating disorders and their infants were compared to mothers without eating disorders and their infants. Mothers were asked to describe their infant's eating behaviour from birth. From interviews it became apparent that mothers with feeding disorders were more likely to adhere rigidly to feeding guidelines provided by health care professionals. This resulted in a high proportion of these infants being schedule fed, whereas more control mothers fed their infants on demand. Ten infants in the index group (n = 16) were schedule fed, as opposed to two out of the control group (n = 20). The difference was highly significant (p = 0.001). Mothers who were schedule feeding their infants reported feeling confused and anxious when their infant displayed signs of hunger outside the recommended time. This indicated a lack of confidence on the mother's part to read her child's signals and respond appropriately. Rigidly keeping to a schedule also enabled the mother to have greater control of her infant's behaviour (Evans and Le Grange, 1995).

The influence of the mother's attitudes to eating has also been studied through children with feeding disorders. The mother's habits and attitudes were related to the extent of her child's feeding disorders. A feeding disorder in children is characterised by refusal of food and extreme faddiness (Stein et al., 1995). Mothers of these children and mothers in a control group were asked to complete a self report questionnaire on eating disorders. Mothers in the index group scored significantly higher on all subscales of the questionnaire. The five subscales measured dietary restraint, bulimia, concern about eating, concern about body shape, and concern about eating. It is clear from these results that mothers' abnormal attitudes to eating and body shape might have an influence on their children's feeding behaviour (Stein et al., 1995).

McCann et al. (1994) investigated maternal eating behaviour in 26 mothers of children with failure to thrive and 26 mothers of children without failure to thrive. The mothers of these four-year old children were assessed on restrained eating behaviour and shape and weight concerns. The results showed that mothers of children with failure to thrive scored higher on restrained eating behaviour than mothers of average growing children. An important finding in this study was that the mothers of the failure to thrive infants were more likely to describe their children as finicky eaters on the one hand, and on the other they were also more likely to restrict intake of certain foods. Fifty percent of these mothers restricted intake of sweet food (such as chocolate and biscuits), and 30% of the mothers restricted intake of foods they considered to be fattening and unhealthy (such as fried foods and meats).

Conclusions

Poor weight gain in infancy has been related to adverse cognitive outcomes (Singer and Fagan, 1984; Dowdney et al., 1987). Infants with poor weight gain in infancy are also more likely to be shorter in childhood (Heptinstall et al., 1987; Corbett, 1998). On the other hand fast weight gain in infancy has been investigated in relation to obesity in childhood and adulthood. Studies investigating obesity in childhood and adulthood have examined the relationship between weight in infancy and weight in childhood. Low but statistically significant positive correlations have been found between weight in the first year and weight at 4 to 5 years of age (Poskitt and Cole, 1977) and between BMI in infancy and in adulthood (Rolland-Cachera et al., 1987;

Gasser et al., 1995). Research on weight gain, and especially research on poor weight gain has suffered from methodological problems.

The main aim of this study was to investigate poor weight gain while seeking to overcome the methodological problems associated with research on failure to thrive. There are three main problems with research on failure to thrive. First of all, a problem lies in the evaluation of weight gain and the classification of infants with failure to thrive. Many studies on failure to thrive classify infants according to their attained weight at a certain time rather than their weight gain over a period of time. Usually infants are classified as having failure to thrive if their weight drops below the fifth (Hutchenson et al., 1993; Black et al., 1994; Benoit et al., 1989) or third centile on a growth chart (McCann et al., 1994; Kotelchuck and Newberger, 1983). This means that the infant's *attained weight* is considered rather than *weight gain*. This method has the potential to lead to misclassification of infants. Infants who are small at birth with average postnatal weight gain can be identified as having failure to thrive (e.g. Benoit et al., 1989) and infants with a high birthweight with slow weight gain are at risk of being missed since their weight never drops below the specified centile (Wright et al., 1994).

A second problem is the use of referred samples; recruiting infants that have been referred to a hospital for failure to thrive. Approximately 1 to 5% of hospital admissions are infants with failure to thrive. However, not all infants with failure to thrive get referred for their slow weight gain, and even fewer infants get admitted to hospital (Dowdney et al., 1987). The proportion of infants with failure to thrive in one study using community samples has been reported as 9.6% (Mitchell et al., 1980). Referred samples are not necessarily representative of the whole population.

Finally, there is a problem of the collection of information on the infant's and the mother's behaviour retrospectively. Since studies have mostly used referred samples of infants with failure to thrive, the infants are investigated at a time when growth failure is already well established. At this point it becomes difficult to ascertain whether malfunction in the mother-infant relationship, or problems in the infant's feeding behaviour, are a cause or an effect of failure to thrive.

Studies have asked mothers to report on their infant's feeding behaviour in the early months (e.g. Tolia, 1995). Not only is this information reported with hindsight, the kind of information requested has not always provided any clear definitions of feeding problems. Mothers have been asked to report on 'feeding difficulties' which are subjective in nature, especially if they are not investigated in relation to observed feeding behaviour, or in comparison to feeding behaviour of infants with average weight gain.

The aim of the current study was to avoid these methodological problems by studying weight gain in young infants in a prospective study. The intention was to recruit infants with different weight gain patterns. Other studies have shown that infants who fail to thrive generally have slow weight gain from birth, showing significantly low weight gain early on (Drewett et al., 1999; Skuse et al., 1994). Therefore the aim was to recruit very young infants with different weight gain patterns. Infants were to be recruited on the basis of their weight gain pattern from birth to eight weeks, which would be either slow weight gain, average weight gain, or fast weight gain. Slow and fast weight gain were defined as the bottom and top 20% of infants in a normal population respectively, and infants with average weight gain were sampled from the remaining 60%. A cut-off point of 20% was chosen because the interest of the study was in the extremes of a population of young infants. The slowest and fastest growing twenty percent would allow the investigation of the development of weight gain up to six months, with a substantial number of infants in each group.

Focusing on early feeding behaviour in a prospective study allows the identification of certain patterns of behaviour that can predict weight gain. At eight weeks mothers receive an appointment from the clinic for the infant's first inoculation. This is a convenient time to be able to target most mother and infant pairs for selection and recruitment for the study.

Another aim of the study was to investigate several factors that may act as predictors of weight gain in early infancy. The objective was to investigate these factors in the young infants and relate them to weight gain in the first six months.

In infancy weight gain is primarily dependent on good nutrition (Davies, 1992). The greatest rate of weight gain in childhood occurs in the first six months of life, so that a great proportion of the infant's energy intake is used for growth (Skuse and Wolke, 1992). Growth is guided by the relationship between the infant's energy intake, energy expenditure and energy stored (Davies, 1992). Since energy intake is essential for adequate growth the infant's feeding behaviour was investigated, in particular sucking behaviour.

Dubignon and Cooper (1980) identified poor feeders who spent less time sucking and sucked less strongly than good feeders. Pollitt et al. (1978b) related time spent sucking with intake of milk, and found that infants who spent less time sucking had a lower intake of milk. On the other hand a vigorous sucking style was found to be associated with increased adiposity later in infancy (Agras et al., 1987). Sucking behaviour can be measured by measuring intra-oral pressures during feeding, or by attaching a strain gauge to the infant's chin. In the present study sucking behaviour was measured by observation. This means of assessing has been reported to be valid (Woolridge and Drewett, 1986) but one aim of the study was to obtain reliability data on this method. The analysis of the sucking behaviour was carried out using a mixture model (Chetwynd et al., 1998) which takes into account the change in sucking behaviour over the course of the feed. This method of analysing sucking behaviour has been used with breastfeeding infants, but not bottlefeeding infants.

In addition to investigating early feeding behaviour the aim was to examine certain factors that can influence the feeding situation. First of all, interaction between mother and infant in the early weeks of life has previously been found to be related with weight gain in the infant. A prospective study showed the importance of observing early interaction, as it found certain different behaviours in the mother and the infant soon after birth which influence somatic growth (Pollitt et al., 1978a). Weight gain was positively related to the number of times the mother replaced the nipple cover and the number of time the infant opened her eyes. A negative relationship with weight gain was found for behaviours such as the frequency and duration of cleaning activities of the mother, and the number of times the infant refuses the nipple (Pollitt et al., 1978a). At one month nutritional behaviour of the mother, and communication behaviour in the infant were positively related to weight gain (Pollitt and Wirtz, 1981).

Research on failure to thrive has included the observation of mother and infant in interaction to detect differences according to the infant's weight gain. Mathisen et al. (1989) observed more ambiguous behaviour in infants with failure to thrive in interaction with their mothers compared to a comparison group of normal growing infants. Polan et al. (1991) reported less positive and more negative affect expression in infants with failure to thrive. Compared to normal growing infants these infants expressed less happiness and interest in things and more sadness and anger (Polan et al., 1991). These finding were confirmed by a community based study on a small sample of infants with failure to thrive (Wolke et al., 1990). Infants with failure to thrive tended to cry more and vocalise less. Their mothers expressed more negative emotions and less physical contact. In early childhood negative interaction still prevailed in children with failure to thrive, as compared with normal growing children (Heptinstall et al., 1987).

Birch et al. (1991) assessed mother-infant interaction in older children, aged around four years, and their mothers and found that fatter children and their mothers spent less time eating and consuming food, and talking significantly less than mothers with thinner children. In a study by DeWitt et al. (1997) comparisons were made between preterm and fullterm infants, relating their weight gain to maternal behaviours. It was found that increased weight gain in the fullterm group was associated with decreased maternal sensitivity. In the first few weeks feeding is characterised by the mothers concern to get enough food into the infant, and to wind the infant adequately (Dunn, 1975). Gradually interaction becomes more established.

Characteristics within the infant have also been found to be related to milk intake and weight gain. Wells and Davies (1996) related temperament to energy expenditure in twelve-week old infants. 'Distress to limitations' (a measure of irritability) and 'Soothability' (a measure of positive emotionality) in the infants were measured by the Infant Behaviour Questionnaire (Rothbart, 1981) Distress to limitations presented a positive correlation with energy expenditure. Infants with high energy expenditure and therefore high energy needs were more likely to be 'difficult' infants as rated by their mother. These infants were followed up to two and three and a half years and it was found that distress to limitations in infancy predicted later percentage fat. Soothability in infancy was negatively related to subcutaneous fat, indicating that easily soothable infants were more active in childhood. Carey (1985) related weight gain to temperament. Infants were classified, according to the weight gain, as either increasing or decreasing in weight gain. Irritability in infants was associated with increased weight gain in infancy (Carey, 1985).

Maternal confidence is influenced by the infant's mood and the infant's well-being, and the mother's ability to manage the care of her infant (Blenke Bullock and Pridham, 1988). Maternal sensitivity increases with confidence, which enables the mother to read her infant's signals more accurately (Williams et al., 1987). Mothers with eating disorders have been found to have significantly lighter children. Mealtimes between these mothers and their infants contain more conflict, and the infants are more likely to be less happy (Stein, 1994). In a study by Evans and Le Grange (1995) mothers with eating disorders were found to be more controlling of their infant's feeding behaviour. McCann et al. (1994) conducted an important study on eating behaviour in mothers and the contribution to failure to thrive in four year old children. The mother's eating habits and attitudes were assessed. This included information on restrained eating, which refers to the tendency to restrict food intake to influence one's shape or weight. Mothers with children with failure to thrive scored significantly higher on the restraint eating subscale of eating behaviour. Interestingly, 50% of mothers reported restricting their child's intake of sweet foods (e.g. sweet, chocolate, biscuits) and 30% restricted foods they considered to be unhealthy and fattening (e.g. fried foods, meat, nuts; McCann et al., 1994).

In the current study these maternal and infant characteristics were assessed and examined in relation to weight gain from birth to eight weeks, and from birth to six months, in a prospective study.

So the aims of the study were the following

1) Investigate the reliability of assessing sucking behaviour in infants using a mixture model (Chetwynd et al., 1998).

2) Investigate early weight gain by selecting infants with different weight gain patterns from birth to eight weeks, and assessing whether any of the selected infants continue to fail to thrive over the first six months.

3) Investigate the relationship between weight gain from birth to eight weeks, and from birth to six months and the following variables:

sucking behaviour

infant temperament and behaviour

maternal eating behaviour

maternal adaptation to motherhood

mother-infant interaction

4) Interrelate the maternal and infant characteristics.

Chapter Two

Methods

General aims

The overall aim of the study was to investigate the extent to which behavioural characteristics of the mother and infant can be used to predict weight gain in a prospective study. Slow weight gain in the early weeks can be an early indication of failure to thrive, whereas rapid weight gain may increase the risk of later obesity. The identification of these characteristics might be useful in studies on prevention and intervention in infants at risk for obesity or failure to thrive.

General Design

The study was designed as a prospective investigation so as to get accurate measures of the behaviour of the mother and the infant in the early months of life. The study monitored weight from birth onwards to identify differing patterns in weight gain. Infants were classified according to their weight gain from birth to eight weeks, and three groups selected; a slow growing, a fast growing and an average growing group.

Mothers can take their infants to well-baby clinics, which are held weekly, to have their infants weighed by the Health Visitor. Mothers are not obliged to visit the clinic and so the number of visits for each infant differs. Some mothers choose to have their infants weighed weekly, whereas others visit the clinic perhaps once a month. However, most infants visit the clinic for their eight-week check, when the infant is seen by the General Practitioner, the Health Visitor and by the Nurse for their first inoculation. This is a very convenient time to recruit mothers and infants because most of them are likely to attend this appointment. Foster et al. (1997) reported that 66% of mothers take their infants for their check up between six and ten weeks, and that this proportion is 63% in the North of England. The mothers of the infants who met the selection criteria for the current study at the eight-week check were asked for their participation in the study, and were visited at home in the following week.

By eight weeks milk feeding is well established and the mother and infant engage in more interactive behaviour (Dunn and Richards, 1977). Mother and infant need several weeks to adapt to each other and to establish a synchronous relationship (Dunn, 1975). Another reason to observe infants between eight and twelve weeks is because of the feeding method. The national recommendation, according to the Committee on Medical Aspects of Food Policy (COMA) Report on weaning and the weaning diet (1994), is for infants not to be introduced to solid food before they are four months old. Table 2.1 presents the proportion of infants introduced to solids before the age of four months, as reported by the Infant Feeding 1995 Survey (Foster et al., 1997).

Table 2.1 Introduction of solids before four months by feeding method and region*

Age of infant	Great Britain	North of England
Breastfeeding		
Eight weeks	2%	3%
Three months	30%	42%
Bottlefeeding		
Eight weeks	17%	17%
Three months	63%	67%
All infants		
Eight weeks	13%	14%
Three months	55%	62%

*Source: Infant Feeding 1995 Survey (Foster et al., 1997)

As shown in Table 2.1 62% of all infants in the North of England have been introduced to solids by the age of three months (Foster et al., 1997), despite the fact that Health Visitors emphasise waiting until four months.

Mothers and infants were visited at home to observe feeds on two consecutive days. The first feed was observed to measure mother-infant interaction and the second feed was observed to measure the infant's sucking behaviour. All mothers and infants were visited at home to allow observation in a natural setting. Mothers are likely to feel most comfortable in their own home, rather than the unfamiliar setting of a laboratory. Furthermore, mothers are more likely to participate in a study for which they are not required to travel. It is most convenient for them to be visited at home, especially in the early months of their infant's life. Conducting home visits is a time-consuming means of collecting data, but the sample of mothers and infants is likely to be more representative, with families from all social classes.

Every infant in the study was weighed at home by the researcher, using the same scales. Scales used in the clinics differ, and some clinics do not require the infant to be undressed before weighing. To avoid inaccuracies in weights all infants were weighed again at home with the same scales. This was appreciated by the mothers since it spared them an extra visit to the clinic. Infants were also weighed during a follow-up visit at six months.

The mother feeding her infant was recorded using a videocamera. This videorecording was made to enable the researcher to review the feed and code the different behaviours at a later date. During the home visit there can be many distractions and interruptions, which would obstruct accurate coding of the behaviours shown. A videorecording can be played several times to ensure that all the information is coded.

In addition to the observation of feeds the mother was asked to fill in several questionnaires relating to her and her infant's behaviour. These questionnaires were left with the mother, allowing her ample time to complete them before the next visit. The questionnaires were retrieved on the second visit, which gave the mothers an opportunity to raise any queries.

Table 2.2 outlines the data collection procedures at different ages. These will be dealt with in more detail in the following paragraphs.

Table 2.2 Summary of data collection procedures at different ages

Child's age	**Procedures**
6-10 weeks	Clinic visit screening recruitment
8-12 weeks	First home visit first videotaping of feeding weighing of infant Infant Behaviour Questionnaire Baby's Day Record Dutch Eating Behaviour Questionnaire Postpartum Self-Evaluation Questionnaire
8-12 weeks	Second home visit second videotaping of feeding collection of questionnaires
6 months	Third home visit weighing of infant

Clinic Visit

Screening

New growth data from a previous study in Newcastle-upon-Tyne (Wright et al., 1994) was used to develop weight charts to assess weight gain from birth in six to ten week old infants. Weights were collected from an annual cohort of 3653 infants, age 18-30 months. Their records were reviewed to collect birthweights, and six subsequent weights up to 18 months. A weight at six weeks was available for 2157 infants, and using regression analysis expected (average) weight at six to ten weeks for infants of different birthweights were calculated.

For a given constant age (age_2) the expected (average) weight of infants of different birthweights can be determined by the regression of weight at age_2 on birthweight. Using standard (Z) scores this is

$$E(Z_2) = \alpha + \beta(Z_1)$$

where Z_1 is the child's birthweight. If age_2 is not an exact age, but a range of ages (so t_2, the child's age, can take a range of values, for example between six and ten weeks) adjustment is needed for the exact age at age_2. The regression becomes

$$E(Z_2) = \alpha + \beta(Z_1) + \delta(t_2) + \gamma(t_2.Z_1)$$

The child's Z score conditional weight gain (ΔZ) is

$$\Delta Z = \frac{Z_2 - E(Z_2)}{s}$$

Here s is the residual standard deviation from the regression.

The regression statistics were estimated in SPSSx using 2157 pairs of infant weights collected as the Newcastle weight data set (restricted to infants with a recorded birthweight and a recorded weight between six and ten weeks), as follows (Table 2.3).

Table 2.3 Regression statistics of z-score conditional weight gain

Variable	B	SE B	Beta	*t*	*p*
constant	0.084327	0.139793		0.603	0.5464
Z_1	0.796962	0.126323	0.917015	6.309	0.0000
t_2	−0.014936	0.016551	−0.014399	−0.902	0.3669
$t_2.Z_1$	−0.025075	0.014882	−0.244976	−1.685	0.0922

Residual standard deviation (s) 0.71974

To establish the criterion values, birthweights from 2000 g to 5000 g were tabulated at intervals of 100 g, e.g. 2000 - 2099, 2100 - 2199 etc, and their midpoint, i.e. 2049.5 etc, used in calculations. Ages used were six, seven, eight, nine and ten weeks, and the expected weight, $E(Z_2)$, calculated for each combination.

Since

$$\Delta Z = \frac{Z_2 - E(Z_2)}{s}$$

to establish the value of Z_2 that cuts off the top and bottom 20% of values for weight gain we need to solve this for a ΔZ of 0.84 (from the tables of the normal distribution).

So we have

$$0.84 = \frac{Z_2 - E(Z_2)}{0.71974}$$

and

$$-0.84 = \frac{Z_2 - E(Z_2)}{0.71974}$$

giving

$$Z_2 = (0.84)(0.71974) + E(Z_2)$$

and

$$Z_2 = (-0.84)(0.71974) + E(Z_2)$$

These values were tabulated separately for males and females, on the original scale of weight (i.e. in g). The tables of the conditional weight standards are given in Appendix One. Average weight gain from birth is dependent on the infant's birthweight, which is the reason that weight gain was not assessed from the difference between birthweight and weight at eight weeks. Ferguson (1980) showed that infants with a relatively lower birthweight tend to have faster postnatal weight gain than infants with a relatively higher birthweight. The reason for assessing slow weight gain is because weight in infants with failure to thrive later in the first year has been found to be slow from birth (Drewett et al., 1999; Skuse et al., 1994). The top and bottom 20% were selected to be able to closely evaluate both extremes in weight gain. The choice of 20% was made, as opposed to for instance five percent or ten percent, in order to include a range of infants with slow and fast weight gain. Choosing for example the bottom 10 percent has the potential of ignoring infants with relatively slow weight gain in the first few months, who may be classified as failing to thrive later in the first year. The cut-off point of 20% would also provide a big enough sample to evaluate weight gain in a substantial sample.

When an infant was seen in the clinic the infant's birthweight was noted, together with the infant's age in weeks. The infant's weight as determined in the clinic enabled them to be classified using the table in Appendix One as having a weight gain (a) in the bottom 20%, indicating slow weight gain or (b) in the top 20%, indicating fast weight gain or (c) in the middle 60%, constituting average weight gain. An example of an infant with slow weight gain is a girl born with a birthweight of 3100 g, with a weight of 4220 g at eight weeks. An example of fast weight gain is a girl with a birthweight of 2800 g, with a weight of 4900 g at eight weeks.

Recruitment

In order to visit baby-clinics in the Durham area the Health Visitor Manager was approached through a local Paediatrician. The procedures of the study were discussed and the co-operation of the Health Visitor Manager enabled us to approach the clinics. Clinics were selected on their average number of births per year. Clinics covering a large area within a town were preferred. At the outset three clinics were selected as they had a total number of 300 births per year. The target was to recruit approximately 30 infants for each weight gain group, so around 300 infants needed to be screened. Twenty percent of 300 infants (for both the slow and fast growing infants) is 60, of which 50% were estimated to refuse to participate, resulting in 30 infants to recruit for each group. Only a third of all average growing infants were recruited, since the focus of the study was more on infants with extreme weight gain patterns, rather than average weight gain patterns.

A letter (Appendix Two) and an information sheet (Appendix Three) was sent to the GP Manager of the selected clinics to request permission to conduct the recruitment in their clinic. Once their permission was granted the clinic's Health Visitors were contacted to ask their co-operation and to discuss the procedures during the baby clinics. The Health Visitors received an information sheet (Appendix Four), and a copy of the questionnaires so that they were familiar with the information presented to their clients. All Health Visitors gladly offered their co-operation. Although the three clinics had a total number of 300 births a year, the number of mothers and infants that visited the clinics was fewer. Moreover, a large number of infants were not eligible (twins, preterm infants, low birthweight infants, and infants with medical problems). This reduced the number of infants that were available for recruitment. After the initial three months of the study another three clinics were approached to allow extra screening of infants for the study.

The researcher paid weekly visits to the well-baby clinics, when all infants are weighed. Infants are weighed by the clinic's Health Visitor. The infants' weight gain was assessed using the new conditional weight standards, and infants could be classified into the three groups (bottom 20%, middle 60%, and top 20%). For every infant aged six to ten weeks that visited the clinic, the birthweight, birthdate and gestational age was recorded, and their most recent weight and its date. Since 60% of the infants fall into the middle category not all of them were recruited for the study. They were recruited on a first come first serve basis, depending on time available for visits in the following week. Priority lay with recruitment of infants who displayed either slow or fast weight gain.

All infants recruited for the study were singletons, with a gestational age ≥ 37 weeks. Low birthweight (<2500 g) infants were excluded and none of the infants in the study presented any congenital abnormalities, or other conditions that could impair somatic growth. Twins were excluded because for them the feeding situation is different from that of other infants. If a mother is breastfeeding each infant can only be fed on one breast, and the feeding situation may be more scheduled than demand feeding, because of time constraints. In addition when assessing mother-infant interaction, the situation is not directly comparable with mothers who have one infant to feed. Preterm and SGA (small for gestational age) infants were excluded because their lower birthweight is likely to influence their subsequent weight gain, as found by Ferguson (1980). Finally, infants with congenital medical problems were excluded because their condition may potentially influence their feeding behaviour and therefore their weight gain.

When an infant met the inclusion criteria the Health Visitor briefly explained the aims of the study to the mother and asked whether she was interested in hearing more about the study. The researcher then informed the mother about the procedures of the study and asked her whether she would like to take part. If the mother decided not to take part in the study she was asked to give her reasons. These reasons were recorded together with the infant's growth details.

In the case of a positive response the mother was asked to fill out a consent form (Appendix Five), which clearly stated that she had given consent to take part in the study but that she was able to withdraw from the study at any time. An appointment was made for the two home visits, and an information sheet (Appendix Six) was provided outlining the procedures in more detail, including the researcher's telephone number and the date and time of the home visits.

Home visits

First home visit

The mother and infant were visited at home to enable the researcher to observe the feeding situation in a natural setting. The visits were scheduled at a time which was most convenient for the mother. This involved calling the mother early in the morning to ascertain at what time the infant was most likely to feed. This depended on the times the infant had woken in the night, and on the time the infant had demanded the early morning feed. Infants of two months of age display variable feeding patterns and so the researcher made sure to arrive slightly earlier at the home. Depending on the infant's hunger cues she was weighed either before or after the feed, when the mother was satisfied that her child was content enough to be stripped and weighed. The infants were weighed using portable digital baby scales, Seca 724 (CMS Weighing LTD, London), which measures weight accurate to 20 g. The weight was recorded in the infant's Child Health Record (Yellow Book). This book is provided by the clinic and contains developmental information on the infant, growth data and information on inoculations.

Before the videotaping of the feed the mother was asked not to change anything about the feeding routine. Furthermore, she should try and ignore the researcher as much as possible and to try to not be too concerned with the videocamera since it was only used to enable the researcher to review the feed. The feeding was recorded using a portable camera (Canonvision E110). Afterwards the mother was asked some questions relating to her and the father's educational and occupational status (Appendix Seven). The questions relating to education and occupation were used to ascertain the Socio-Economic Status (SES) of the family. Finally, at the end of the visit the mother was given several questionnaires on her and her infant's behaviour, which she was asked to complete for the next visit.

First of all, the mother was asked to complete a questionnaire on her infant's behaviour to be able to assess temperamental characteristics. All the questionnaires that assess temperament were designed for infants of three months and older (Hubert et al., 1982). However, Worobey (1986) conducted research on temperament in the first month and found the Infant Behaviour Questionnaire (IBQ; Rothbart, 1981) suitable for use before three months. Worobey asked 43 mothers of two to three week old infants to complete the entire questionnaire and extracted the items for which more than seven mothers answered 'does not apply' to a particular item. The reduced version of the questionnaire (37 items) was compared to scores of 48 mothers of infants aged three months who completed the entire questionnaire. The part-whole correlations for the different dimensions of temperament were 0.95 for *activity* level, 0.95 for *distress to limitations*, 0.66 for *fear*, and 0.90 for *soothability* (Worobey, 1986). This led the author to conclude that the IBQ is suitable for use in infants younger than three months.

The IBQ (Appendix Eight) measures individual differences in reactivity and self-regulation. Mothers were asked to complete the questionnaire about the infant's behaviour in the previous week. Since the questionnaire is also for older infants, certain items were not relevant to their infant, and mothers were instructed to answer these items as 'X = does not apply'.

The IBQ measures six dimensions of temperament; *activity*, *smiling and laughter*, *fear*, *distress to limitations*, *soothability*, and *duration of orientation*. There are 91 questions to assess these different dimensions. Mothers are posed questions relating their infant's behaviour in different situations, for example feeding, sleeping, bathing and playing. The questions are answered using the following response options: 1 = never; 2 = very rarely; 3 = less than half the time; 4 = about half the time; 5 = more than half the time; 6 = almost always; 7 = always; X = does not apply. The last response option would be chosen if a situation had never occurred, for example if a child had not been introduced to new food or liquid. The reliability at three months for the different dimensions was reported in the following alpha's: *activity* 0.73; *smiling and laughter* 0.85; *fear* 0.80; *distress to limitations* 0.84; *soothability* 0.84; *duration of orientation* 0.72 (Rothbart, 1981). The raw scores for items pertaining to a certain subscale were pooled and then averaged, with the exclusion of items that did not apply. The mean scores on each subscale, for each infant were used in the analysis.

Additional information on the infant's behaviour was acquired with a two-day diary (Barr et al., 1988) which mothers were asked to keep (Appendix Nine). The diary requested information on sleeping, feeding, fussing and crying, and periods that the infant was awake and content. Most infants were visited on two consecutive days which did not give the mothers enough time to complete the diary before the next visit. A stamped envelope was provided so the mother could send the diary at a later date.

In the diary five infant behaviours could be filled in on a continuous time bar, with fifteen minute time slots. The behaviours measured were: sleeping, feeding, fussing, and crying (Barr et al., 1988). Barr et al. compared data on crying and fussing from the diary and from a taperecording of the same period, to evaluate the accuracy of the diary. They reported a correlation of $r = 0.64$ for the frequency of crying and fussing and a correlation of $r = 0.45$ for the duration of crying and fussing. The authors of the diary (Barr et al., 1988) suggest assessing the frequency of a certain behaviour, in episodes, and the duration in minutes of a certain behaviour. For each infant the number of episodes was counted for each behaviour. If two episodes of the same behaviour were separated by less than five minutes they were added and analysed as one episode. Over the two-day period, the mean number of episodes for sleeping, feeding, fussing, and crying were measured, as well as the mean duration of these behaviours.

Thirdly mothers completed a questionnaire on her eating behaviour to assess levels of restrained eating. Dietary restraint refers to the intention to diet to achieve or maintain a desired weight (Laessle et al., 1989). There is evidence that the mother's attitudes to feeding have an influence on the infant's food intake (McCann et al., 1994). The Dutch Eating Behaviour Questionnaire (DEBQ; van Strien et al., 1986) was chosen rather than the Three-Factor Eating Questionnaire (Stunkard and Messick, 1985) and the Restraint Scale (Herman and Mack, 1975) since a comparison of the three showed the DEBQ to be superior (Allison et al., 1992). Its internal consistency was highest of the three (r = 0.95), and test-retest reliability was high as well (r = 0.92). In addition, the DEBQ proved the most homogenous scale. The DEBQ assesses levels of restrained, emotional and external eating behaviour (Appendix Ten).

The first ten questions of the DEBQ were related to restrained eating behaviour, for example 'Do you watch exactly what you eat?'. The following thirteen questions inquired about emotional eating behaviour, like 'Do you have a desire to eat when you are feeling lonely?'. The last ten questions were related to external eating, for example 'If you have something delicious to eat, do you eat it straight away?'. The response categories and the equivalent scores for each question were as follows: 'Never' (1), 'Seldom' (2), 'Sometimes' (3), 'Often' (4) and 'Very often' (5). An additional response category was added 'Not relevant' (6), for some questions. If this response category was circled the score was not added in the overall score. The answers for each question on a subscale were added, which generated three scores for each mother.

Finally, mothers were asked to fill in a questionnaire on their experience and adaptation to motherhood. The Postpartum Self-evaluation Questionnaire (PSQ; Lederman et al., 1981) is a seven-scale questionnaire which objectively measures maternal adaptation. The mother's attitudes to her abilities as a mother may be of influence on the interaction with the infant. For instance, a mother may have the knowledge to console a distressed infant, but may be unable to do so because of self-doubt (Teti and Gelfand, 1991). Another important aspect is the level of support. Kotelchuck and Newberger (1983) reported less perceived positive support from family and neighbours in mothers of infants with failure to thrive than in mothers of control infants.

The seven scales of the PSQ assessed 'Quality of the relationship with the husband' (alpha 0.90), 'Mother's perception of the father's participation in child care' (alpha 0.87), 'Mother's gratification from her labour and delivery experience' (alpha 0.87), 'Mother's satisfaction with her life circumstances' (alpha 0.73), 'Mother's confidence in her ability to cope with the tasks of motherhood' (alpha 0.74), 'Mother's satisfaction with motherhood and infant care' (alpha 0.78) and 'Support for the maternal role from parents and from friends and family members' (alpha 0.84). The reliability scores, reported above in brackets for each subscale, indicated a provision of unique information by each of the subscales. The questions were answered on a four-point scale, with answers ranging from 'Very much so (A)' to 'Moderately so (B)', Somewhat so (C)' and 'Not at all (D), with scores 4, 3, 2 and 1 respectively. Scores on certain questions were reversed and the scores on each subscale were added and resulted in seven scores for each mother. These scores were used in further analysis.

The first feed was observed for mother-infant interaction using the Nursing Child Assessment Feeding Scale (NCAFS; Barnard and Eyres, 1979). The NCAFS consists of 76 items divided into four subscales on maternal behaviour and two subscales on infant behaviour. The mother's behaviour was clustered into the subscales 'sensitivity to cues', 'response to distress', 'social-emotional growth fostering' and 'cognitive growth fostering'. The infant's behaviour was clustered into 'clarity of cues' and 'responsiveness to caregiver'. Each item is scored with either 'yes' or 'no' on statements such as 'Caregiver positions child so that eye-to-eye contact is possible' and 'Child has periods of alertness during the feeding'. Within each subscale there were certain items, referred to as *contingency* items, which constituted items in which both partners in the interaction respond to each other, for example, 'Caregiver verbally responds to child's sound within five seconds after the child has vocalised'. Internal consistencies on the different scores were adequate; alpha 0.83 for the total maternal score, alpha 0.73 for the total child score, and alpha 0.86 for the total combined score (Sumner and Spietz, 1994).

For each subscale the total score of 'yes' answers was calculated, with a score of one for each occurrence of a certain behaviour ('yes'). The total scores were also calculated for the answers on the contingency items within each subscale. Next to these, a total score for the mother, a total score for the infant and an overall total score were calculated. The higher the scores, the better the interaction between the mother and the infant. The raw scores on the subscales were used in further analysis.

The researcher trained in the use of this scale for three days, in May 1997. The training was provided by Pauline Raynor, from the Department of Community Child Health at the University of Leeds. The training course included observation of interaction between mother and infant, from videorecordings. Definitions of mother and infant behaviours, and reciprocal episodes were presented and scoring procedures were outlined. A reliability test was taken at the end of the three day training period. The test consisted of three feeds, and the scores were reviewed by the American authors of the Feeding Scales, to assess their reliability. To be allowed the use the scales a reliability score of at least 85% had to be attained. This meant that disagreement on no more than 11 items out of 76 was allowed. The researcher was found to be reliable for more than 85% and was able to reliably code the feeding interactions. The reliability test was retaken the following year (October, 1998), and passed once again.

The videorecording was made so that the mother and infant were both in view, and an attempt was made to film their faces as close as possible to detect eye-to-eye contact. The feeds were observed for specific behaviours in the mother and in the infant, and contingent behaviour in both of them.

Second home visit

The second visit was usually the day after the first one, or at least within a week, at which time a second recording was made of a feed. However, this time the focus was on the infant's mouth to closely observe the infant's sucking behaviour. The researcher retrieved the questionnaires, and answered any questions the mother might have about them. At the end of the visit the mother was reminded of the final visit at six months, at which time the infant was weighed again.

The second feed was used to code the infant's sucking behaviour. Measuring sucking behaviour provides an objective measure of the infant's feeding behaviour, and sucking behaviour is related to subsequent weight gain (Young and Drewett, 1998). The sucking behaviour was coded at a later date from the videorecording.

The infant's sucking behaviour was coded using a special computer program, called MINKEY (Marsh, 1988), which coded different behaviours on a time sequence (Table 2.4). For every behaviour a different key was pressed on the keyboard, and the program recorded the behaviour with time accurate to ten milliseconds. Since the infant's mouth might sometimes be out of view, an extra code was added to distinguish between times when the sucking was not visible and time when the infant was pausing between sucking. Before recording the different behaviours, a code was entered to identify the method of feeding, which would be either breast (Y) or bottle feeding (u). The information coded by the Minkey program was labeled as a **.obs* file, with the infant's identifier as the file name, for example, *1ABC.obs*. The **.obs* output file consisted of a list of the coded behaviours including the time that each behaviour was coded, accurate to ten milliseconds. An example of an **.obs* output file is shown in Appendix Twelve.

Table 2.4 Description of codes for sucking behaviour

Subject	**Label**	**Code**	**Description**
mother	give	a	brings breast/bottle to infant's mouth and places it in infant's mouth
	take off	y	withdraws breast/bottle from infant's mouth
infant	suck left breast / right breast	z/v	repetitive act of releasing lower jaw accompanied by upward movement of the larynx* (coded z for all bottlefed infants)
	reject	j	expels breast/bottle from mouth
	release	k	releases breast/bottle from mouth
	invisible	m	infant's mouth cannot be seen
	visible	n	infant's mouth can be seen (recorded only after infant's mouth was out of view)

* Johnson and Salisbury, 1975

For breastfeeding infants who had fed on both breasts the file was split in two separate files for the feed on each breast. The same procedure was used for an infant who was given a top up with bottlemilk, after having been breast fed on both breasts, or for an infant who had received additional solids half way through a bottlefeed. All these changes were regarded as different feeds and separated into single files. Since SPSS is unable to read the time format in the **.obs* output files, these were converted into **.rl* files in SPSS in Unix. SPSS was able to assess the intervals between the behaviours in the converted files. The intervals between the behaviours were used in further analyses. These intervals were analysed in S+ using a mixture model (Chetwynd et al., 1998), which is discussed in more detail in Chapter Four.

Third home visit

The mother was contacted when her infant was six months old for a final home visit. A large proportion of mothers work by this time, but did not object to a brief visit in the evening. The infant was weighed during this final home visit. The weight was recorded in the infant's Yellow Book. As a sign of gratitude the infants received a certificate thanking the infant for their participation in the project (Appendix Eleven). Mothers greatly appreciated the certificate, as a memory for their child.

Data handling procedures

The data were analysed using Statistical Package for Social Sciences, version 8.0. T-tests and Mann Whitney tests (for non-parametric data) were used to assess differences between female and male infants, as well as differences between breast and bottlefeeding infants. Pearson and Spearman correlations were used to investigate relationships among behaviour variables.

Regression analysis was used to assess the relationship between the scores which were obtained from observation and from the questionnaires, and weight gain from birth to eight weeks, and birth to six months. Finally, the reliability of assessing sucking behaviour using the mixture model (Chetwynd et al., 1998) was evaluated.

Ethics Committee

In June 1997 a proposal for the current study was sent to the County Durham Health Authority Ethics Committee for approval. The proposal was reviewed and approved in July 1997 (Study 11/APR97).

Chapter Three

Participants

Participants

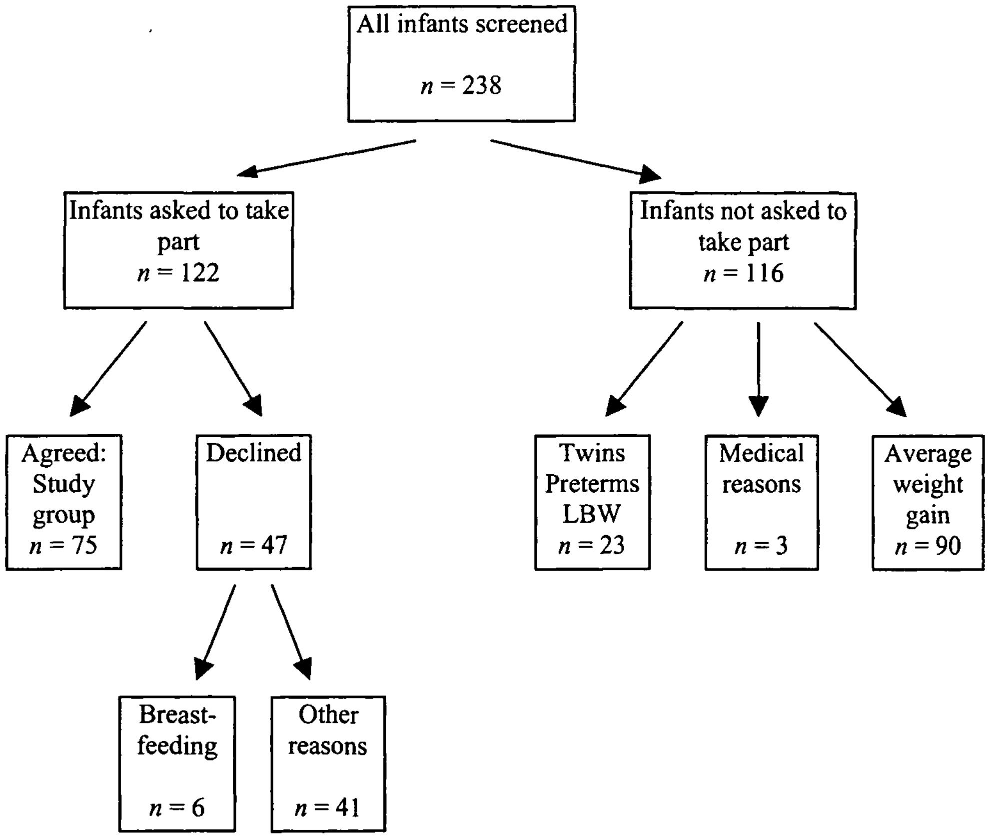
For this study 75 infants and their mothers were recruited, in well-baby clinics in the Durham area, according to their weight gain from birth over the first six to ten weeks. Weight gain was classified as either slow, average or fast. Slow and fast weight gain were represented by the bottom 20% and top 20%, respectively. The remaining infants were classified as average growing infants, and approximately a third of these infants were asked to participate in the study.

Figure 3.1 shows the different groups of infants who participated in the study, and those who did not. As mentioned in the previous chapter (Chapter Two) the objective was to screen approximately 300 infants, 60 with slow weight gain (bottom 20%), 60 with fast weight gain (top 20%) and 180 with average weight gain (remaining 60%). With the possibility of a 50% rejection rate the slow and fast weight gain groups would comprise 30 infant each. A total number of 238 infants were screened on their weight gain at the clinics. Infants who were twins, born preterm, or born with a low birthweight were excluded from the study. A small group, consisting of infants with certain medical problems (i.e. heart problems, infection, hernia), was excluded as well. Finally, a proportion of infants who were classified as having average weight gain was excluded. The group of infants who were not asked to participate in the study, for these reasons, consisted of 116 infants.

The mothers of infants who were eligible to take part in the study (122) were asked for their participation. Of these 75 mothers and infants agreed to take part and 47 declined. Within the group of mothers who declined to take part, six did so because they did not wish to be videotaped while breastfeeding. The other reasons for declining to take part were a lack of interest or camera shyness. A record was kept of all infants that were not included in the study and this group consisted of 163 infants. So although the objective was to have

30 infants in each group this aim was not met due to a lower number of infants actually screened, 238 infant as opposed to the expected number of 300 infants.

Figure 3.1 Infants screened for participation



Collected weights

The study was designed to screen infants during a clinic visit at eight weeks. In County Durham mothers receive an appointment for a clinic visit when their infant is eight weeks old. The infant's birthweight was obtained from the Child Health Record (Yellow Book). It is customary and correct for infants to be weighed by the Health Visitor without their clothes on. However, in one of the clinics (clinic Y) this was not the case. The lack of space and the number of infants attending the clinic, forced the Health Visitors to weigh all infants in the waiting room. There was no opportunity for the infants to be undressed so they were all weighed with their clothes on. This obviously creates a discrepancy in the weights collected at the clinics. The study group included nine infants recruited from this clinic.

Infants were also weighed during the first home visit, using a portable digital baby scale. This provided an extra weight, always made with the same scales and so avoiding differences that might occur because of the differing scales in individual clinics. This additional weight also made it possible to calculate the average error resulting from nine infants being weighed in the clinic in their clothes. A dummy variable was created to indicate at which clinic the infants were recruited, which is referred to as *clinic*. Infants who were weighed with their clothes on at clinic Y were coded 1 on the indicator variable *clinic*, and infants weighed at the remaining clinics were coded 0. The difference accounting for the clothes of the infants at clinic Y was calculated in a regression analysis, using the weight at the clinic and the weight at eight weeks as measured at home. Another variable recorded the number of days between the weighing at the clinic and the weighing at home, *days difference*. This variable is the measure of the length of time between the two weighings (at the clinic and at home) and needs to be taken into account when assessing the difference between the weights.

A regression using the clinic weight as the dependent variable was carried out on the weight recorded in the home at eight weeks, and the difference in days between the dates the infants were weighed (*days difference*), and the infant's sex. The results of the analysis are shown in Table 3.1.

Table 3.1 Regression of clinic weight (g) on weight at eight weeks (g), *clinic* (1 clinic Y, 0 other clinics), *days difference* (difference in days between the dates of weighing at the clinic and weighing at home) and *sex* (0 female, 1 male)

	B	SE B	*t*	*p*
Constant	381.05	110.13	3.46	.001
Weight at eight weeks	.93	.02	43.39	.000
Clinic (clinic Y)	251.93	46.42	5.43	.000
Days difference	−22.93	3.47	−6.60	.000
Sex (male)	−35.14	33.95	−1.03	.304

Analysis of Variance	DF	Sum of squares	Mean square	F	*p*
Regression	4	38668965.9	9667241.5	581.39	.000
Residual	70	1163946.8	16627.8		
Total	74	39832912.7			

Multiple R	.98
R square	.97
Adjusted R square	.97
Standard error	128.9

The results in Table 3.1 show an average additional weight of 252 g for infants weighed with their clothes on (clinic Y). The standard error is 46, so 250 g was used as an estimate of the additional weight that can be accounted for by the clothes. For all infants who were weighed at clinic Y, 250 g was subtracted from the weight obtained at the clinic. The table also shows a negative regression coefficient for the variable *days difference* (−22.93), which indicates that the clinic weight is on average 23 grams lower with every day increase in the difference between the two weighings. Although it seems counterintuitive, it is clarified by the fact that the clinic weight is estimated from weight at eight weeks. The increase in *days difference* means an increase in difference between the two weights. This in turn means an increase in the weight at eight weeks with an increase in age. Therefore the regression shows 23 g less for the clinic weight with each day increase between the two weight measurements.

Returning to the initial screening method, it was expected that the average birthweight of the different groups would not differ as infants were not selected on their birthweight, but rather on their weight gain over the first two months. It is essential to establish whether this is true for the screened sample. This is important since a difference may imply that weight at birth was more influential in the selection of infants than their weight gain from birth. As can be seen in Figure 3.1 participants were initially divided into those who were asked for their participation and those who were not asked. The mean birthweight for the group that was asked to participate (n = 122) was 3493 g and for the group that was not asked to participate (n = 93; excluding twins, preterms and low birthweight infants) was 3455 g. The mean birthweights were compared for these two groups and there was no significant difference (t = 0.645, df = 213, $p > 0.05$). A further separation is made, for those participants who were asked to take part, between those who agreed to take part (mean birthweight 3526 g) and those who declined to take part (mean birthweight 3439 g). The mean birthweight for these groups was not significantly different (t = 1.068, df = 120, $p > 0.05$). The fact that no differences were found between infants who were screened and infants who were selected indicates that the results in the study are somewhat generalisable to other infants with similar weight gain patterns.

The screening method used in the study allowed the selection of infants on their weight gain. Although the conditional weight standards should work in theory, they have not been used previously, and it is important to verify whether the screening method was successful in selecting infants with either slow, average, or fast weight gain, (i.e. the bottom 20%, middle 60% and top 20% of a normal population). This was examined by comparing the expected distribution of infants with different weight gain patterns with the distribution of the infants who were screened. The group of twins, preterm infants and low birthweight infants was excluded from this analysis. The distribution of infants in the different groups for the entire screened sample was 15.3% for slow weight gain, 60.0% for average weight gain, and 24.7% for fast weight gain. Even though this distribution of the proportions differs from the theoretical distribution (20%, 60%, 20%) a goodness of fit analysis demonstrated that the difference was not statistically significant ($\chi^2 = 4.64$, df = 2, n = 215, $p > 0.05$). The finding that the distribution of the screened population is not significantly different from the theoretical distribution is consistent with the screening method being successful in selecting according to weight gain. However, the fact that the proportions were found to be correctly distributed does not eliminate the possibility that the screening method was picking out the wrong infants. This will become clearer in the following section when weight gain in the infants is more closely investigated.

Infants' characteristics

In this section the characteristics of the infants in the study group are discussed. In Table 3.2 four rows of weights are presented for each sex. These are firstly the infant's birthweight as obtained from the Child Health Record. Secondly, the infant's weight at the clinic, as measured by the Health Visitor. The third row of weights are the same as the clinic weights, except that the weights for clinic Y have 250 g subtracted, adjusting for the weight of their clothes. The fourth row of weights are those which were measured at about eight weeks during the home visit. The sample consisted of 75 infants (study group in Figure 3.1), comprising 32 females and 43 males.

Table 3.2 Distribution of weights (g): birthweight, weight at the clinic, weight at the clinic adjusted for clinic Y, and weight at eight weeks at home

Age	Min	25th	Median	75th	Max	Mean	SD
Males							
Birthweight	2700	3374	3635	3960	4380	3626	421
Clinic weights	3960	5100	5670	6000	6650	5529	731
Adjusted clinic weights	3960	4950	5600	6000	6640	5506	725
Weight at eight weeks	3960	5240	5860	6320	7120	5732	779
Females							
Birthweight	2560	3055	3345	3697	4500	3392	475
Clinic weights	3680	4532	4675	5270	6130	4897	568
Adjusted clinic weights	3680	4412	4850	5232	6130	4858	588
Weight at eight weeks	3480	4520	5080	5350	6300	4996	621
All infants							
Birthweight	2560	3150	3520	3856	4500	3526	457
Clinic weights	3680	4650	5273	5850	6650	5260	734
Adjusted clinic weights	3680	4650	5260	5840	6640	5229	740
Weight at eight weeks	3480	4840	5360	5940	7120	5418	800

Male infants had a mean birthweight of 3626 g and a mean weight at eight weeks of 5732 g. Female infants had a mean birthweight of 3392 g and a mean weight of 4996 g at eight weeks. Infants were classified according to their weight gain over the first six to ten weeks. The slow growing group consisted of 22 infants, the average growing group of 27 infants, and the fast growing group of 26 infants.

Figure 3.2 shows a scatterplot of weight at eight weeks against birthweight, for the infants in the different weight gain groups.

Figure 3.2 The relationship between weight at eight weeks and birthweight, with cases identified by weight gain group

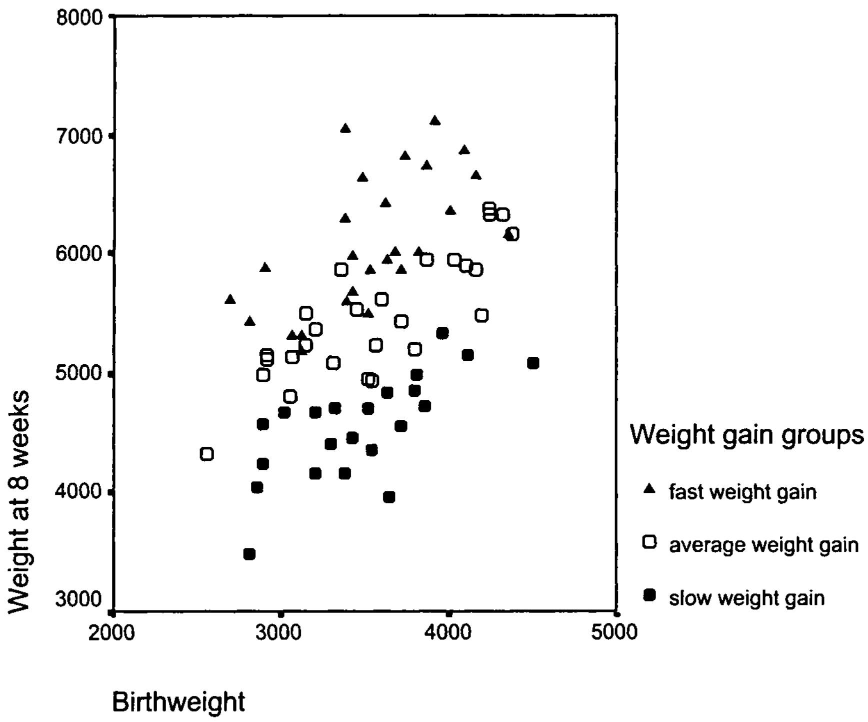


Figure 3.2 illustrates the effectiveness of the screening method employed to select infants. A high weight at eight weeks is not equivalent to fast weight gain, since it might simply reflect a high birthweight. For instance, an infant with a relatively low birthweight and an average weight at eight weeks, might be classified as fast growing. Conversely, an infants with a relatively high birthweight and average weight at eight weeks might be classified as slow growing.

On the other hand infants with the same birthweight might have completely different weight gain patterns. For example, taking infants with a birthweight of approximately 3500 g, one infant hardly gained any weight (500 g) over eight weeks (X ~ 3500, Y ~ 4000), whereas another infant gained around 2000 g over eight weeks (X ~ 3500, Y 5500). This is what constitutes the difference between slow and fast weight gain. There are certain points that need to be taken into account when examining Figure 3.2. As can be observed there is an overlap for certain infants in differing groups, which might be interpreted as a misidentification of a weight trajectory. But the figure does not allow for the infant's sex or exact age, whereas the screening method did take these into account.

The distribution of males and females within the weight gain groups is shown in Table 3.3.

Table 3.3 Distribution of males and females in weight gain groups

	Female	**Male**	**Total**
Slow weight gain	13	9	22
Average weight gain	11	16	27
Fast weight gain	8	18	26
Total	32	43	75

To assess whether the proportion of males and females within the three groups are significantly different from the expected proportion, a Chi-square test of association was carried out to compare the observed proportion with the expected distribution. A 3x2 Chi-square analysis showed that there was not a significant difference in the distribution of males and females over the weight gain groups ($\chi^2 = 3.963$, df = 2, $p > 0.05$). This finding indicates that although there were slightly more females in the slow weight gain group, and slightly more males in the fast weight gain group, the association was not statistically significant.

Parents' characteristics

Information on the infant's mother and father was obtained during the first home visit. The mother's age was derived from her date of birth, at the time of the first home visit. A summary of the ages is given in Table 3.4. Three of the mothers in the sample were 19 years old by the time they were visited at home. Nine mothers were between 20 and 24 years old. The largest group of mothers, 28, were between 25 and 29 years of age. A further 21 mothers were between 30 and 34 years old, and 14 mothers were between 35 and 39 years old. None of the mothers in the index group were older than 40 years old.

Table 3.4 Maternal age at date of the first home visit

Mother's age (years)	Number of mothers	%
≤19	3	4
20-24	9	12
25-29	28	37
30-34	21	28
35-39	14	19
≥40	0	0
n	75	100

For 38 mothers this was their first child. Twenty-six mothers already had another child, eight mothers had two other children and three mothers already had three children.

During the first home visit the mother was interviewed about her own and the father's education and occupation. Table 3.5 indicates the age at which the mother and father left full-time education. Information is missing on three fathers, as they were not part of the infant and mother's life, and the mother was unable to provide information on his education or occupation. Forty-three percent of the mothers had been in full-time education until the age of 16 years or less, 20% until they were 17 or 18 years, and 37% until the age of 19 years or over. In the case of the fathers 51% attended full-time education until 16 years or less, 12% until they were 17 or 18 years old, and 33% attended until the age of 19 or over.

Table 3.5 Summary of parents' age at leaving full time education

Age of leaving education (years)	**Mother**		**Father**[a]	
	n	%	n	%
≤ 16	32	43	38	51
17 or 18	15	20	9	12
≥ 19	28	37	25	33
n	75	100	72	96

[a] missing information on 3 fathers

Socio-economic status was derived from the parents' occupation as classified by the Standard Occupational Classification (SOC, 1990). Table 3.6 shows the occupational status of the infants' mother and father. Levels I, II, and IIINM, are 'middle class', i.e. non-manual occupations, and levels IIIM, IV and V are 'working class', i.e. manual occupations. According to the father's level of occupation 49% of families were middle class and 47% were working class. Information was missing on three fathers (four percent), therefore their social class status is unknown.

Table 3.6 Parental levels of occupation as defined by the Standard Occupational Classification (SOC, 1990)

Classification	Mother		Father[a]	
	n	%	n	%
non-manual				
I	5	7	15	20
II	24	32	18	24
III NM	30	40	4	5
manual				
III M	4	5	23	31
IV	8	11	10	13
V	4	5	2	3
Total	75	100	72	96

[a] missing information on 3 fathers

Table 3.7 shows that breastfeeding infants were more likely to come from 'middle class' families, and bottlefeeding infants were more likely to come from 'working class' families. In our sample only 25% of breastfed infants came from working class families, whereas 60% of bottlefed infants did.

Table 3.7 Cross tabulation of the infant's feeding method and the family's social class according to the father's occupation

	Breastfeeding	Bottlefeeding
Middle class: non-manual occupations	18 (75%)	19 (40%)
Working class: manual occupations	6 (25%)	29 (60%)
n	24 (100%)	48 (100%)

Follow-up at six months

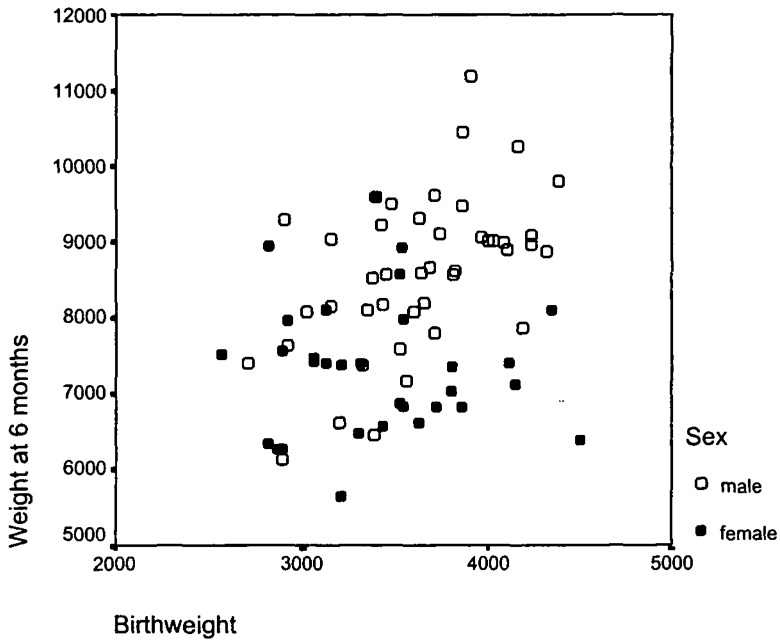
All infants in the study group were followed up at six months and weighed again. The infants were visited at home and weighed with the same scales that were used at eight weeks.

Table 3.8 Distribution of weights (g) at six months

	Min	25th	Median	75th	Max	Mean	SD
Males							
Weight	6140	8080	8660	9220	11200	8607	1033
Females							
Weight	5640	6670	7390	7865	9580	7337	874
All infants							
Weight	5640	7360	8080	8980	11200	8066	1152

The mean weight for males at six months was 8607 g, and the mean weight for females at six months was 7337 g. The distribution of weights in Figure 3.3 shows the differing weight trajectories of males and females. The figure shows that for infants with high birthweights (>3500 g) males clearly grow faster than females. This difference is less apparent in infants with a relatively lower birthweight (<3500 g).

Figure 3.3 The relationship between birthweight and weight at six months, with cases identified on sex



Conclusions

The results in this chapter show that the screening method that was used to identify the infant's weight gain velocity in the early months was effective in selecting infants with different weight gain patterns, as intended. A group of 75 infants was recruited with 22 infants with slow weight gain, 27 infants with average weight gain, and 26 infants with fast weight gain. The group of infants that was recruited did not differ significantly from the group of infants who were screened but not recruited. No differences were found on birthweight for infants who were asked to take part and those who were not, or between the group of infants who agreed to take part and the group who declined. Interestingly, through recruiting mothers and infants at different clinics we found that clinics do not all follow the proper process for weighing infants. One clinic weighed all infants with their clothes on, because of a lack of space and time to get the infants undressed. Presumably, it will be more difficult to monitor the weight gain of infants after birth if their weights are always substantially higher due to their clothes. The difference in weight accounted for by the clothes in our sample was found to be on average 250 g, which is a substantial amount.

The average age of the infants' mothers was 29 years, with most mothers being between 25 and 35 years old. Forty-three percent of mothers and 51% of fathers had left full-time education before the age of 17. The sample consisted of an equal number of working class families and middle class families. This is an encouraging finding, which indicates that research involving home visits based on voluntary participation are not necessarily biased towards the participation of mainly middle class families. In the current study breastfeeding infants were more likely to come from middle class families (75%) than from working class families (25%).

Chapter Four

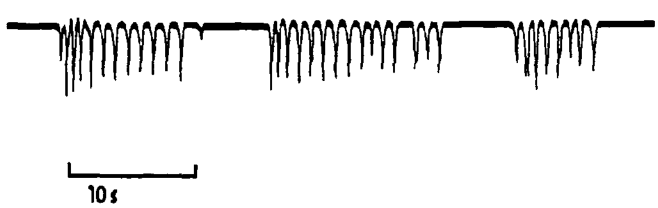
Sucking behaviour

Sucking behaviour

In this chapter the infant's sucking behaviour is investigated. Sucking behaviour was observed in a natural environment in the infant's home, without any changes made to the feeding situation. A reliability study on the method of assessing sucking behaviour was carried out from which the results are presented. In addition, the chapter focuses on the differences in sucking behaviour of breastfeeding and bottlefeeding infants.

Both bottle-fed (Wolff, 1968) and breast-fed (Drewett and Woolridge, 1979) infants suck in bursts, with pauses between the bursts. In Figure 4.1 an example is shown of an infant's sucking behaviour recorded using a pressure transducer. From the figure it can be clearly seen that infants do not suck continuously, but have pauses between burst of sucks.

Figure 4.1 Example of the suck-burst sequence [1]

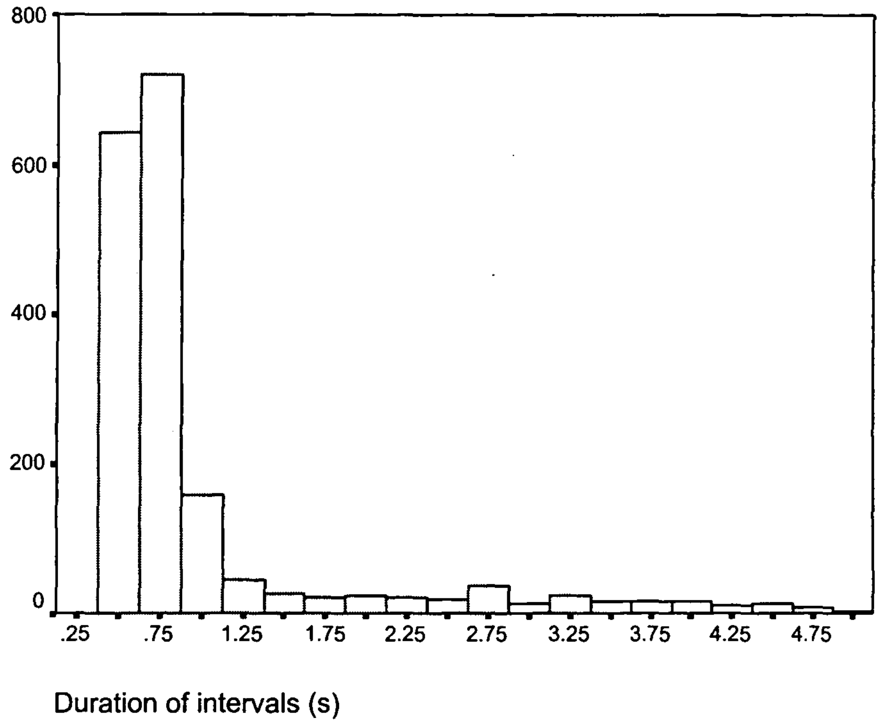


Summarising sucking patterns in an infant is rather complex, and might involve, for example, summarising the number of sucks per burst, the suck durations, and the pause durations. Suck durations are characteristically < 1 s, but pause durations are very variable in length and overlap with the suck durations (Bowen-Jones et al., 1982), as shown in Figure 4.2. The histogram

[1] Reproduced with permission from Drewett and Woolridge (1979)

shows the suck to suck intervals in s. The duration of the intervals was derived from the sucking behaviour of a randomly selected infant in the study.

Figure 4.2 Histogram of the duration of suck to suck intervals in s, of a randomly selected infant in the study



In analysing sucking behaviour it is important to establish which intervals can be identified as the suck durations, and which can be identified as the pause. One way of establishing which intervals relate to the suck and which to the pause is defining a cut-off point. For example, one summary method (Wolff, 1968; Drewett and Woolridge, 1979) uses a cut-off point of 1.3 s, and assumes that all intervals ≤ 1.3 s are suck durations, and all intervals > 1.3 s are pause durations. Pollitt et al. (1978b) used a cut-off point of 2 s to differentiate between sucks and pauses.

Since the intervals in fact overlap, this method must misclassify some intervals. Another method (Chetwynd et al., 1998) estimates the summary statistics simultaneously for the two distributions, using a mixture model. The duration of sucks is modelled as a normal distribution, and the pause durations as an exponential distribution. Since the mixture model assesses the sucking behaviour as distributions, the changes over the course of the feed can be taken into account as changes in the parameters of the distribution. This is the method used here, using software written for the purpose in S+ (Chetwynd et al., 1998). The mixture model is discussed in more detail in the following section.

The current research provides information on the reliability of summaries of sucking behaviour using this method. Sucking was observed in a natural situation without any intrusion or changes to the feeding situation. The video recording enabled another researcher to code a proportion of the feeds to establish the method's reliability. Validity of examining sucking behaviour from observation had already been established in previous research (Woolridge and Drewett, 1986). The reliability of measuring sucking behaviour from observation and analysing sucking using a mixture model has not previously been established. Moreover, the sucking behaviour was investigated in both breast and bottlefed infants. Breastfeeding infants are subject to changes in milk flow and composition (Akre, 1989) which are not present for bottlefeeding infants. An assessment of differences between breast and bottlefeeding infants will enable us to better understand feeding behaviour in infants.

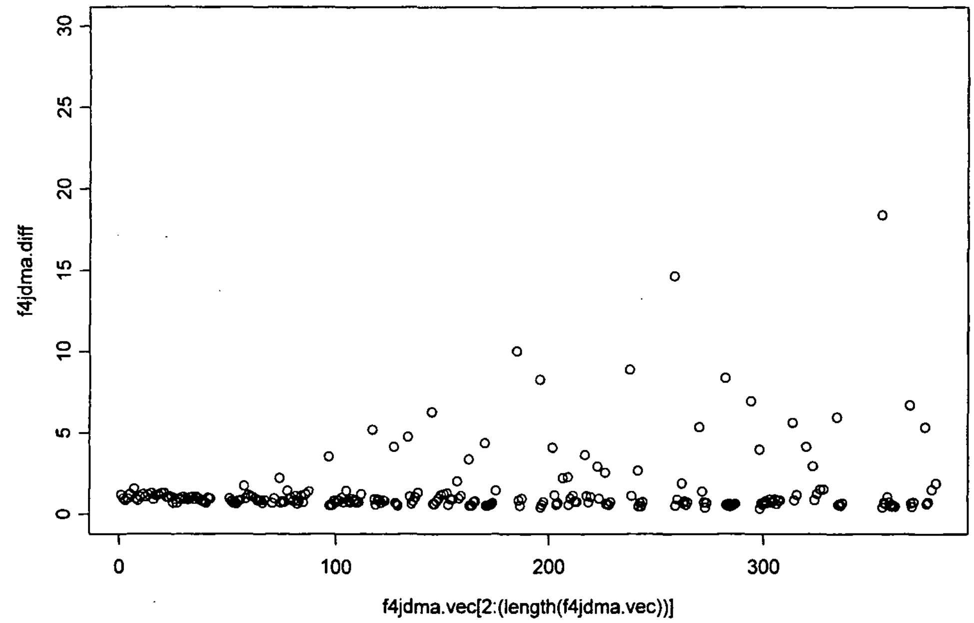
Data handling

Sucking behaviour was coded from a videorecording of the infant feeding on the breast or the bottle. A specialised program (Marsh, 1988) was used to code feeding behaviour from the videorecording. Behaviours were recorded by pressing a certain key, which simultaneously recorded the time accurate to ten ms. The behaviours that were assessed are detailed in Chapter Two.

Summarising, the mother can give (a) the infant the breast or bottle and take the infant off it (y). The infant can suck (z/v), reject (j) or release (k) the bottle or breast. In case the infant's mouth was obscured from view a key was pressed to indicate that feeding was invisible (m), and another key could be pressed if feeding was visible again, but the infant was not feeding (n). Finally a key could be pressed if a mistake was made (b) in order to be able to correct it when checking the file. The program produces an output file as shown in Appendix Twelve. For each behaviour a time was available which made it possible to assess the duration of the interval between codes, in particular the intervals from suck to suck. To attain the duration of the intervals the files were converted in SPSS so that the timing (00.00) started at the first suck of the feed. Every following behaviour has an accumulated time in s. A new time variable constructed in SPSS, lagged by one event, allowed the interval between codes in seconds to be calculated. Since it is presumed that sucking occurs in a burst-pause fashion, certain information can be obtained from the intervals between suck codes. Suck to suck intervals within bursts and intervals between bursts, i.e. the pause durations can be established (Drewett and Young, 1998).

The statistical analysis in S+ provided information about the length of the intervals from suck to suck. The duration of each interval was plotted against the summed time over the course of the feed, in order to illustrate the changes occurring over the feed. Figure 4.3 shows an example of a feed, of a breastfeeding infant in the study. The Y-axis represents the duration of the intervals from suck to suck (s) and the X-axis represents time over the course of the feed (s). The graph is presented in the original form, with the filename included in the figure. It can be seen that the intervals between sucks are short at the beginning of the feed, and that longer intervals occur progressively throughout the feed.

Figure 4.3 Graph of the duration of intervals from suck to suck over the course of the feed, with the Y-axis representing the duration of intervals (s) and the X-axis representing the summed time over the feed (s)



The mixture model (Chetwynd et al., 1998) assumes that suck durations are normally distributed with mean μ and standard deviation σ; that the pause lengths are exponentially distributed with mean ζ $[= \lambda^{-1}]$; and that the number of sucks per burst is geometrically distributed with mean ν $[= 1/(1-\varphi)]$. It also assumes that these parameters may vary over the course of the feed, for example, the suck durations are likely to decrease and the pause durations to increase (Drewett and Woolridge, 1979). If t is the proportionate number of sucks, and increases from 0 to 1 over the feed, time trends in the parameters μ, σ and λ are assumed to follow a log-linear trend in t, for example $\mu(t) = \exp(m_1 + m_2t)$. This ensures that they are always positive. The parameter φ is assumed to follow a logistic-linear trend, $\varphi(t) = [\exp(p_1 + p_2t)] / [1+ \exp(p_1 + p_2t)]$. This ensures that it varies between 0 and 1.

The summary statistics were transformed into interpretable units as follows:

$\nu(0)$	mean number of sucks per burst	*start of feed*
$\nu(1)$		*end of feed*
$\mu(0)$	mean suck duration	*start of feed*
$\mu(1)$		*end of feed*
$\sigma(0)$	standard deviation of suck durations	*start of feed*
$\sigma(1)$		*end of feed*
$\zeta(0)$	mean pause length	*start of feed*
$\zeta(1)$		*end of feed*

For each infant summary statistics were available on each of these variables, which are referred to as sucking parameter estimates. In further analysis the variable names are as follows.

Sucking parameters	**Variable name**
1) Mean number of sucks per burst at the start of the feed	*Sucks per burst, start*
2) Mean number of sucks per burst at the end of the feed	*Sucks per burst, end*
3) Mean suck duration at the start of the feed	*Suck duration, start*
4) Mean suck duration at the end of the feed	*Suck duration, end*
5) Standard deviation of suck durations at the start of the feed	*SD suck duration, start*
6) Standard deviation of suck durations at the end of the feed	*SD suck duration, end*
7) Mean pause length at the start of the feed	*Pause length, start*
8) Mean pause length at the end of the feed.	*Pause length, end*

The parameter estimates were read into SPSS in order to be able to use them in analyses in relation to weight gain. The sucking parameter estimates for all infants are shown in Appendix Thirteen.

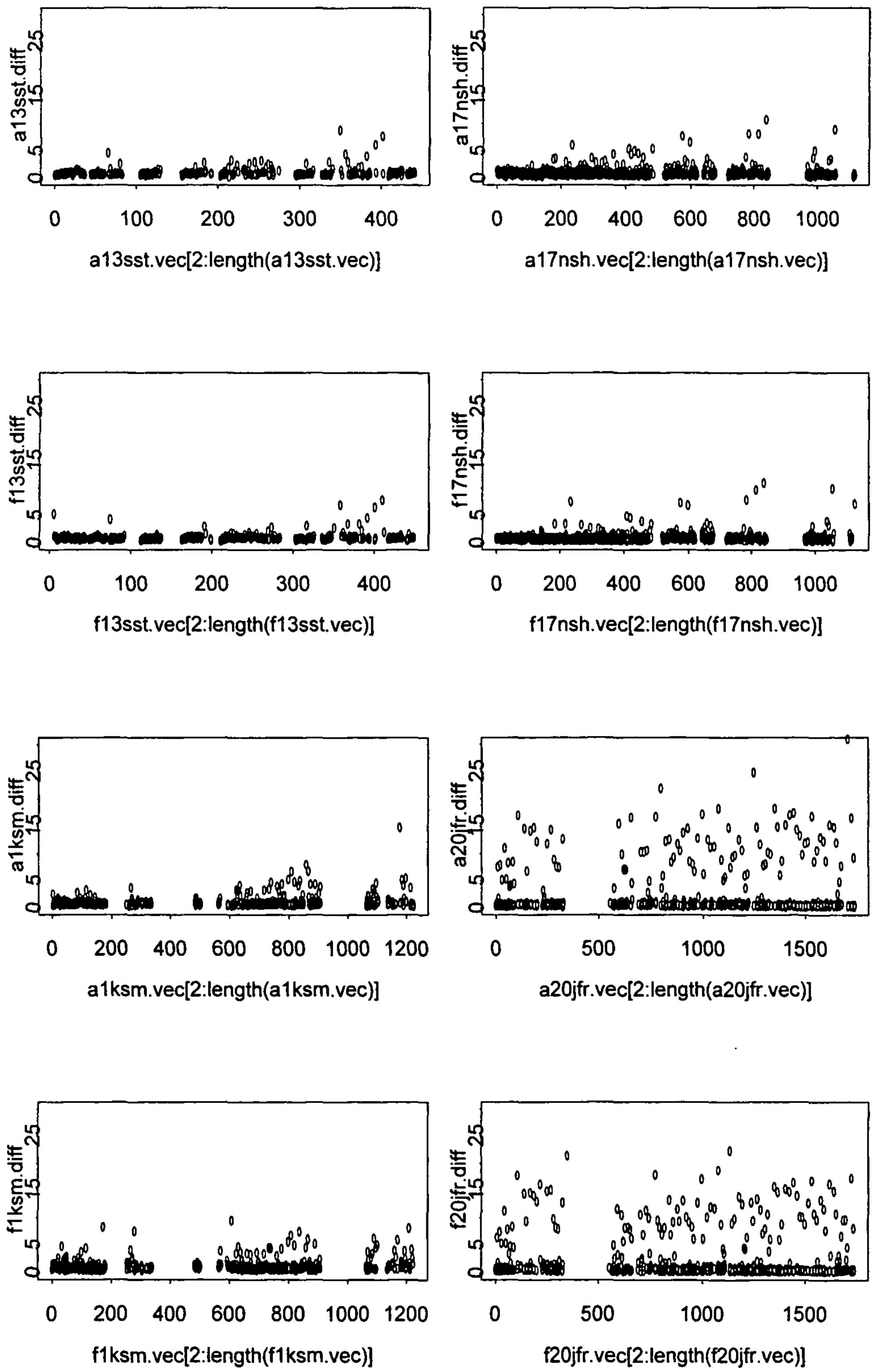
Reliability study

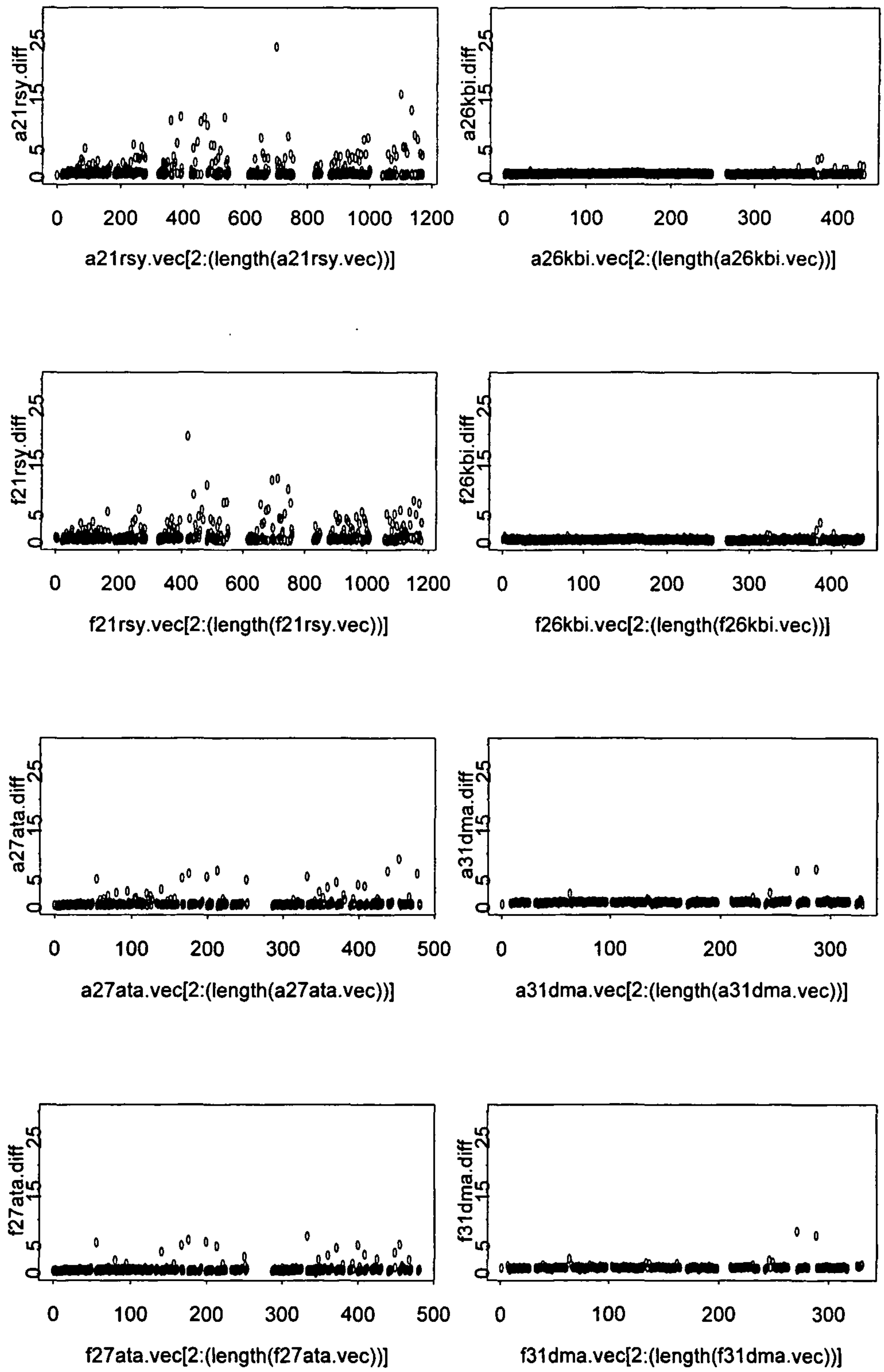
The assessment of sucking behaviour from direct observation has previously been found to be valid (Woolridge and Drewett, 1986). Correlations between sucks per burst as measured through observation and through intraoral pressure measurements were high. However, the reliability of the sucking parameter estimates, as derived from the mixture model (Chetwynd et al., 1998), has not been previously assessed. This is a key issue, since it is these parameter estimates that summarise the feed. Sucking behaviour was expressed in parameter estimates in a study by Young (1997) on breastfeeding infants, but in that particular study the sucking behaviour was coded at the time the feed was observed rather than videorecorded to be coded at later date, as in the current study.

Method

A research psychologist (researcher 2) in the Department of Psychology at the University of Durham was trained to use the coding program during two training sessions. She then coded a random sample of 20 feeds. Figure 4.4 shows the graphs for each of the 20 feeds coded by two researchers. The graph of the feed coded by researcher 2 is shown underneath the graph of the same feed coded by researcher 1. The original output graphs are presented, and the filename is included underneath the graph. Filenames starting with the letter ‘a’ refer to the coding of researcher 1, and filenames starting with the letter ‘f’ refer to the coding of researcher 2. Each graph shows the intervals between the sucks over the course of the feed. The Y-axis shows the duration of the intervals in s, and the X-axis shows the summed time in s over the course of the feed. In reviewing the two graphs of the same feed, one can observe striking similarities. The dots in the graphs represent the intervals between sucks, and the clustering and spread of the two graphs of the same feed are visibly very similar. The parameter estimates obtained from the feeds by both researchers were subsequently investigated to establish the reliability of each sucking parameter estimate.

Figure 4.4 Graphs of the sucking patterns of the infants in the reliability study. The two graphs (starting with 'a' and 'f') for each feed are shown above and underneath each other




a21rsy.diff
0 5 15 25
0 200 400 600 800 1000 1200
a21rsy.vec[2:(length(a21rsy.vec))]
a26kbi.diff
0 5 15 25
0 100 200 300 400
a26kbi.vec[2:(length(a26kbi.vec))]
f21rsy.diff
0 5 15 25
0 200 400 600 800 1000 1200
f21rsy.vec[2:(length(f21rsy.vec))]
f26kbi.diff
0 5 15 25
0 100 200 300 400
f26kbi.vec[2:(length(f26kbi.vec))]
a27ata.diff
0 5 15 25
0 100 200 300 400 500
a27ata.vec[2:(length(a27ata.vec))]
a31dma.diff
0 5 15 25
0 100 200 300
a31dma.vec[2:(length(a31dma.vec))]
f27ata.diff
0 5 15 25
0 100 200 300 400 500
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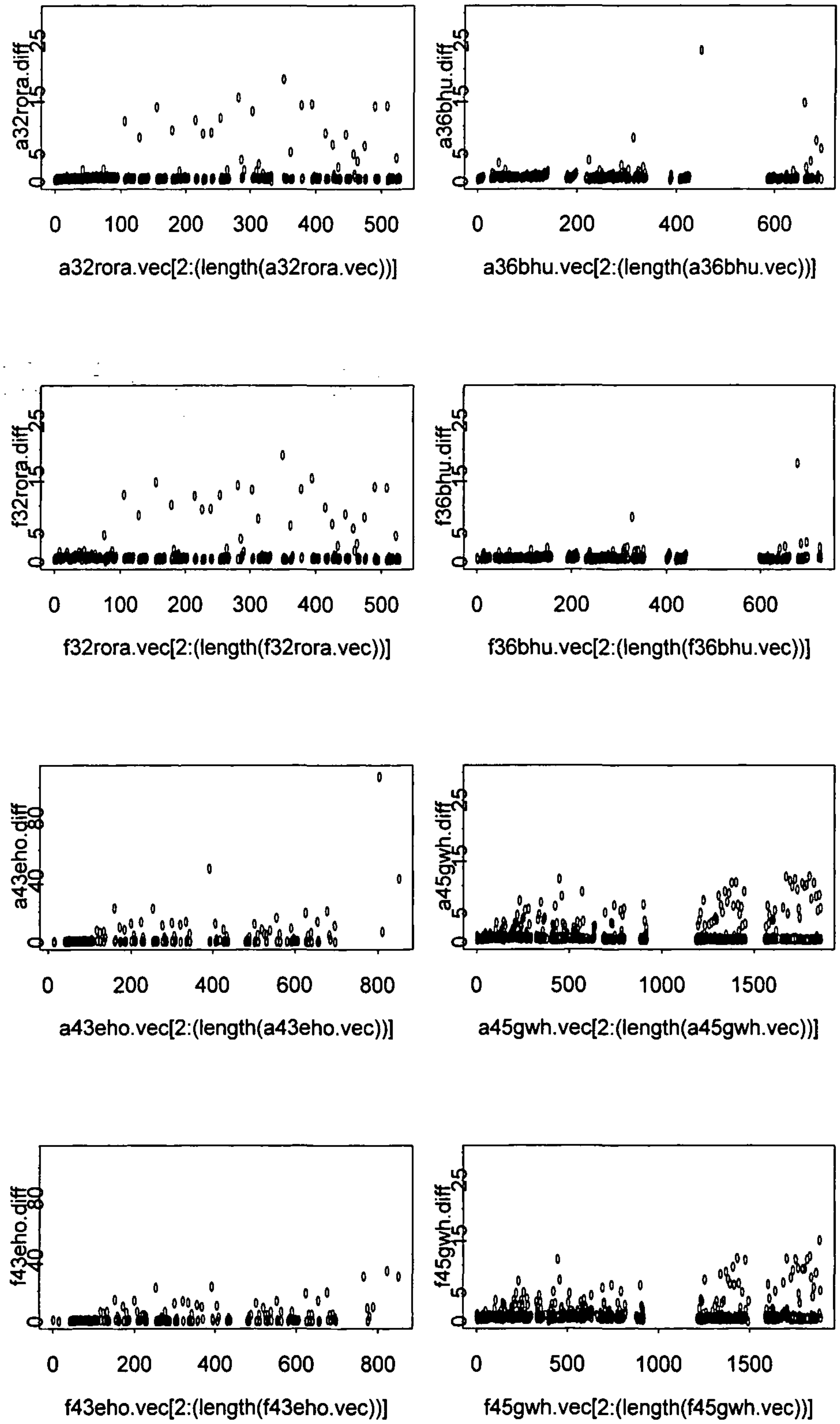
f31dma.diff
0 5 15 25
0 100 200 300
f31dma.vec[2:(length(f31dma.vec))]


a32rora.diff
0 5 15 25
0 100 200 300 400 500
a32rora.vec[2:(length(a32rora.vec))]
a36bhu.diff
0 5 15 25
0 200 400 600
a36bhu.vec[2:(length(a36bhu.vec))]
f32rora.diff
0 5 15 25
0 100 200 300 400 500
f32rora.vec[2:(length(f32rora.vec))]
f36bhu.diff
0 5 15 25
0 200 400 600
f36bhu.vec[2:(length(f36bhu.vec))]
a43eho.diff
0 40 80
0 200 400 600 800
a43eho.vec[2:(length(a43eho.vec))]
a45gwh.diff
0 5 15 25
0 500 1000 1500
a45gwh.vec[2:(length(a45gwh.vec))]
f43eho.diff
0 40 80
0 200 400 600 800
f43eho.vec[2:(length(f43eho.vec))]
f45gwh.diff
0 5 15 25
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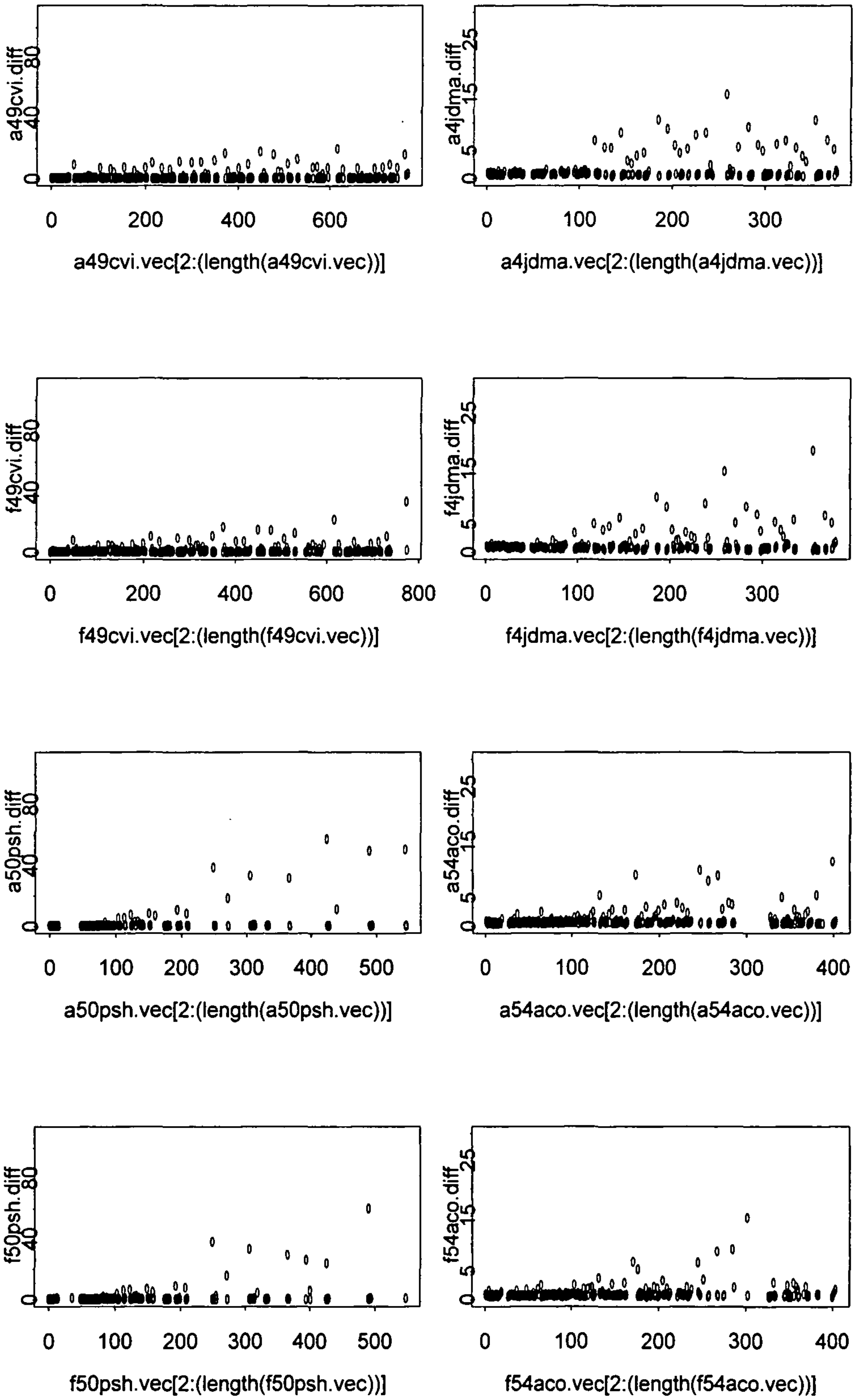
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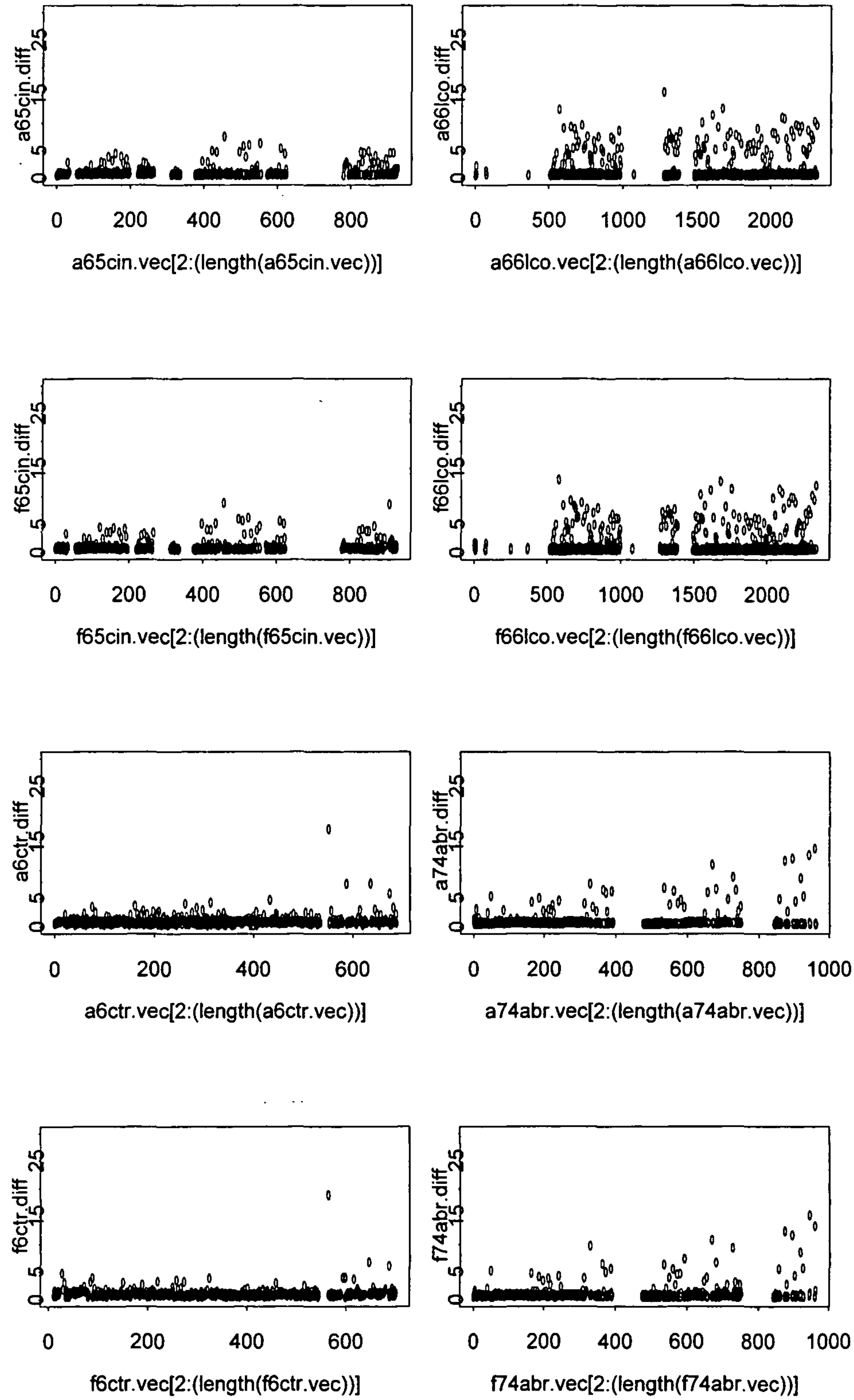
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a65cin.vec[2:(length(a65cin.vec))]
a66lco.diff
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0 500 1000 1500 2000
a66lco.vec[2:(length(a66lco.vec))]
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0 200 400 600
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a74abr.diff
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0 200 400 600 800 1000
a74abr.vec[2:(length(a74abr.vec))]
f6ctr.diff
0 5 15 25
0 200 400 600
f6ctr.vec[2:(length(f6ctr.vec))]
f74abr.diff
0 5 15 25
0 200 400 600 800 1000
f74abr.vec[2:(length(f74abr.vec))]

Results

The sucking parameters from the twenty feeds coded by two researchers were compared to assess their reliability. First, the distributions of the sucking parameter estimates are shown in Table 4.1.

Table 4.1 Distribution of sucking parameter estimates of researcher 1 and researcher 2

	Min	25th	Median	75th	Max	Mean	SD
Sucks per burst, start							
researcher 1	1.07	3.21	4.24	11.14	578.72	38.23	128.03
researcher 2	1.57	3.72	6.00	8.80	26.94	8.54	7.39
Sucks per burst, end							
researcher 1	2.15	3.63	5.14	6.89	17.89	6.09	3.75
researcher 2	2.15	2.84	4.88	6.41	17.44	5.56	3.96
Suck duration, start							
researcher 1	.51	.71	.77	.84	1.02	.77	.12
researcher 2	.58	.73	.78	.86	1.05	.80	.12
Suck duration, end							
researcher 1	.50	.63	.68	.75	1.14	.71	.14
researcher 2	.53	.65	.69	.84	1.19	.74	.16
SD suck duration, start							
researcher 1	.06	.09	.11	.17	.22	.13	.05
researcher 2	.05	.11	.15	.19	.32	.16	.07
SD suck duration, end							
researcher 1	.07	.09	.13	.17	.21	.13	.04
researcher 2	.10	.14	.16	.19	.26	.17	.04
Pause length, start							
researcher 1	.01	.26	.50	2.77	5.9	1.4	1.7
researcher 2	.10	.28	1.00	1.61	5.50	1.22	1.26
Pause length, end							
researcher 1	1.2	2.88	4.47	7.09	215.26	15.78	47.09
researcher 2	.46	1.81	3.26	7.00	34.63	5.71	7.54

Table 4.2 shows the correlations between the parameter estimates of the two researchers. The table shows the non-parametric correlations since the distributions of the estimates are not normal.

Table 4.2 Spearman correlations between sucking parameter estimates for researcher 1 and researcher 2

		Spearman's ρ	*p*
Sucks per burst	*start*	.295	.207
	end	.677	.001
Suck duration	*start*	.806	.000
	end	.809	.000
SD suck duration	*start*	.531	.016
	end	.521	.019
Pause length	*start*	.841	.000
	end	.905	.000

The correlations for the *suck duration* at the start and end of the feed, and the *pause length* at the start and end of the feed are high. The correlations for the *SD suck duration* at the start and the end, are not very high. The correlations for *sucks per burst* at the end of the feed is adequate. However, the correlation for *sucks per burst* at the start of the feed is very low, and not statistically significant. In reviewing Table 4.1 it can been seen that the distributions of this sucking parameter estimate is very variable. For instance the maximum for this parameter estimate, as recorded by each researcher is very different (578.72 vs. 26.94).

It can be concluded that the parameter estimates *SD suck duration* at the start and end of a feed are adequately reliable, and that the remaining parameter estimates can be considered highly reliable in measuring the infant's sucking behaviour, except for *sucks per burst* at the start of a feed which is not a reliable measure in assessing sucking behaviour. From the graphs (Figure 4.4) one would expect high correlations for all the parameter estimates, as the graphs of both researchers for each feed appear very similar. When the intervals between the sucks were modelled in S+, using Chetwynd et al.'s (1998) mixture model, seemingly similar sucking behaviour did not yield the same parameter estimates, for *sucks per burst* at the start of the feed. Reviewing the mean parameter estimates for this variable, the difference becomes apparent (38.23 vs. 8.54). One explanation is that in the beginning of the feed sucking occurs without long pauses so that the difference between *suck duration* and *pause length* becomes smaller. As can be seen in Table 4.1 the *suck duration* at the start of the feed is longer than the *suck duration* at the end of the feed. Increased hunger and higher milk flow may be influencing the sucking behaviour at the start of the feed. Since the difference between the suck duration and the pause length is small the mixture model may identify the period as one burst since the pauses are relatively small. Alternatively, it may be that the start of the feed does not have the same burst-pause pattern as is true for the rest of the feed, and assuming such a pattern is not appropriate. Since the reliability of *sucks per burst* at the start of the feed was low, results using this measure should be treated with particular caution.

Feeding method and sucking behaviour

In this section the infant's sucking behaviour was investigated in relation to *feeding method*. Breastfeeding infants experience changes in milk flow and composition (Akre, 1989) which have the potential to influence the infant's sucking behaviour. Therefore, the difference between breast and bottlefeeding infants was examined in relation to their sucking behaviour. First of all, the distributions of the sucking parameter estimates as coded for bottlefeeding and breastfeeding infants separately were investigated and are presented in Table 4.3.

Table 4.3 Distribution of sucking parameter estimates of breastfeeding (n = 24) and bottlefeeding (n = 51) infants

	Min	25th	Median	75th	Max	Mean	SD
Sucks per burst, start							
breast	1.07	3.36	4.68	9.11	35.98	7.59	8.57
bottle	1.00	4.18	5.76	10.98	578.72	24.87	84.13
Sucks per burst, end							
breast	2.15	4.50	5.08	6.63	18.33	6.21	3.52
bottle	1.38	3.12	4.65	6.04	152.33	8.27	20.86
Suck duration, start							
breast	.47	.67	.79	.84	1.01	.75	.02
bottle	.61	.71	.77	.83	1.02	.78	.10
Suck duration, end							
breast	.48	.57	.64	.69	.88	.64	.09
bottle	.58	.66	.73	.82	1.24	.76	.13
SD suck duration, start							
breast	.06	.10	.11	.17	.21	.13	.04
bottle	.07	.09	.11	.14	.27	.12	.04
SD suck duration, end							
breast	.06	.09	.11	.16	.21	.12	.04
bottle	.07	.09	.12	.15	.23	.12	.02
Pause length, start							
breast	.00	.31	.62	1.76	8.80	1.62	2.19
bottle	.06	.43	.81	1.93	10.30	1.45	1.74
Pause length, end							
breast	1.02	3.00	5.00	9.36	215.26	15.27	43.02
bottle	.30	2.09	3.20	4.45	13.91	3.50	2.36

The sucking parameter estimates were not normally distributed. Therefore, in the analysis of the differences between breast and bottlefed infants a non-parametric test, a Mann-Whitney test, was used. The group of breastfed infants (24) was compared to the group of bottlefed infants (51) on all the sucking parameters. The results are outlined in Table 4.4.

Table 4.4 Mann-Whitney test of sucking parameters on *feeding method*

		Feeding method	N	Median	Z	*p*
Sucks per burst	*start*	breast	24	4.68	–1.33	ns
		bottle	51	5.76		
	end	breast	24	5.08	–1.35	ns
		bottle	51	4.65		
Suck duration	*start*	breast	24	0.79	–.31	ns
		bottle	51	0.77		
	end	breast	24	0.64	–3.80	.000
		bottle	51	0.73		
SD suck duration	*start*	breast	24	0.11	–1.05	ns
		bottle	51	0.11		
	end	breast	24	0.11	–.46	ns
		bottle	51	0.12		
Pause length	*start*	breast	24	0.63	–.57	ns
		bottle	51	0.81		
	end	breast	24	5.00	–2.84	.005
		bottle	51	3.20		

In Table 4.4 it can be seen that certain sucking parameters differed for breast and bottlefeeding infants. First of all, the *suck du*ration at the end of a feed is highly significantly different for the two feeding methods, with the suck duration at the end of a feed being on average lower for breastfeeding infants (median = 0.64), than for bottlefeeding infants (median = 0.73). In addition, *pause length* at the end of the feed differed for breast and bottlefeeding infants, with breastfeeding infants on average having longer pauses at the end of a feed (median = 5.00) than bottlefeeding infants (median = 3.20). There are eight possible comparisons and one in twenty will be significant by chance at $p < 0.05$. However, both differences were significant at $p < 0.01$.

These findings indicate that it was not the entire feed, but different aspects, that are different for infants according to their feeding method. For both sucking parameters (*suck duration* and *pause length)* the end estimates showed a significant difference according to feeding method. Since the start estimates did not show any significant differences it suggests that there are certain changes that occur over the course of the feed. In order to investigate this further the differences between the start and end estimates for each sucking parameter were calculated. The start estimate was subtracted from the end estimate to yield the *difference* for each sucking parameter. A negative value indicated a decrease in the estimate, which means that the duration or frequency decreases over the course of the feed. For instance, a negative score in the difference for suck duration means that the duration of the sucks becomes shorter towards the end of the feed. Conversely, a positive score in the difference between pause length indicates that the pauses become increasingly longer over the course of the feed. The differences were examined in relation to feeding method, shown in Table 4.5.

Table 4.5 Mann-Whitney comparison of differences between the estimates of the start and end of each sucking parameter on *feeding method*

		Feeding method	N	Median	Z	*p*
Sucks per burst	*difference*	breast	24	.85	−1.98	.048
		bottle	51	−1.57		
Suck duration	*difference*	breast	24	−.11	−2.31	.021
		bottle	51	−.01		
SD suck duration	*difference*	breast	24	−.02	−1.28	ns
		bottle	51	.01		
Pause length	*difference*	breast	24	3.20	−2.82	.005
		bottle	51	2.06		

Table 4.5 shows a comparison of the differences between breast and bottlefed infants for the *difference* between the start and end of each parameter estimate. All the parameter estimates differ according to the feeding method, except for the SD of the suck duration. First of all, breastfeeding infants showed an increase in sucks per burst (median = 0.85) over the course of the feed, whereas bottlefeeding infants showed a decrease (median = −1.57) in sucks per burst. Secondly, suck duration decreased more over the course of the feed for breastfeeding infants (median = −0.11) than for bottlefeeding infants (median = −0.01). Thirdly, the length of the pause over the course of the feed increased more for breastfeeding infants (median = 3.20) than for bottlefeeding infants (median = 2.06).

In summary, the suck duration decreased over the course of the feed, while the length of the pauses increased, both for breast and bottlefed infants, although the changes were significantly greater for breastfeeding infants. Sucks per burst increased for breastfeeding infants, but decreased for bottlefeeding infants over the course of the feed.

Conclusions

In this chapter sucking behaviour was analysed, and the differences in sucking behaviour between breast and bottlefeeding infants were investigated.

Firstly, the reliability study showed that all the sucking parameters, as assessed by the two researchers, were significantly correlated, except for the parameter measuring the number of sucks per burst at the start of a feed. Correlations of the SD of the duration of sucks at the start and end of a feed were not high, so that these estimates were not highly reliable. In the following analysis of sucking behaviour in relation to other variables of infant characteristics, these sucking parameter estimates are treated with some caution. On the other hand the duration of sucks and the pauses at the start and end of the feed are reliable measures of the infant's sucking behaviour. It is very encouraging to find the procedure of analysing sucking behaviour using the mixture model (Chetwynd et al., 1998) provided reliable mean estimates for different features of sucking behaviour at the start and end of the feed, i.e. suck duration, sucks per burst, and pause length.

Secondly, sucking behaviour was investigated in relation to the feeding method, either breast or bottlefeeding. It was found that breast and bottlefeeding infants differ in several ways. The suck duration at the end of the feed and the pause length at the end of the feed differed for breast and bottlefeeding infants. Suck durations at the end of the feed were longer for bottlefeeding infants, whereas the pause length at the end of the feed was longer for breastfeeding infants. This indicates that the changes that occur over the course of the feed differ according to the feeding method. Sucking behaviour appeared not to differ at the start of the feed, according to the feeding method. The changes that occur over the course of the feed were investigated by calculating the difference between the start and end estimates for each parameter, by subtracting the start estimate from the end estimate (the variable was referred to as *difference*). Suck duration decreased, and pause length increased over the course of the feed for both breast and bottlefeeding infants, but the difference was greater for the breastfeeding infants. Another difference was found, in that sucks per burst increased in breastfeeding infants and decreased in bottlefeeding infants.

It is an important finding that the sucking behaviour changes over the course of the feed were different according to feeding method. In further investigations of the infant's sucking behaviour (for instance in relation to weight gain) the infant's feeding method should be included in the analysis to take these differences into account.

Chapter Five

Weight gain and failure to thrive

Weight gain

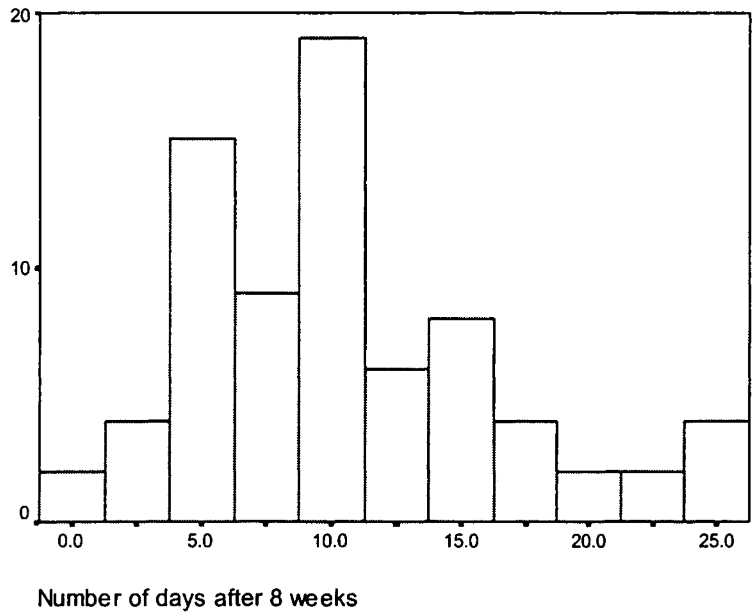
The objective of the study was to examine behavioural determinants of weight gain in infancy. For all infants in the study three weights were available for analysis. First of all, a birthweight, which was obtained from the Child Health Record (Yellow Book). Secondly a weight measured at the first home visit, and finally a weight at six months measured during a follow-up visit. The first section of the analysis is concerned with the development of a regression model to describe weight gain from birth to eight weeks, and birth to six months. The development of the model allows analysis of weight gain in relation to behavioural characteristics in the following chapters, by the elaboration of the model.

Weight gain up to eight weeks

Weight gain was investigated by assessing weight at two time points. First of all, the infant's birthweight was obtained from the Child Health Record. Weight at eight weeks was obtained during the first home visit. The initial aim was to visit all infants at home at the age of eight weeks, but this was not always practically possible, and the limits specified in the protocol were eight to twelve weeks of age.

The infants' age at the time they were weighed must be taken into account in the analysis. A new variable was created called *age*, referring to the number of days after eight weeks when the infant was actually weighed at home. The variable was created by subtracting 56 (eight weeks in days) from the age in days when the infant was weighed at the first home visit. The earliest time for the first visit was on the day the infant was eight weeks old, and the latest time was 25 days after eight weeks, with a mean of ten days between eight weeks and the first home visit. The distribution of *age* is shown in Figure 5.1.

Figure 5.1 Distribution of *age,* which is the number of days after eight weeks the infant's weight was measured



The regression model used the eight-week weight as the dependent variable. As males grow faster than females, *sex* was also entered as an indicator variable coded 0 for females and 1 for males. *Age* was entered as an adjustment to allow for the exact age of the infant when they were weighed. The results are shown in Table 5.1.

The table shows that all the independent variables were significantly related to weight at eight weeks. For every 100 g increase in birthweight there is an average 72 g additional weight at eight weeks. After allowing for birthweight males are on average ~ 650 g heavier than females. Weight at eight weeks is significantly associated with *age,* so that for each day after eight weeks an average of 40 g is added. For example, a male with a birthweight of 3460 g, being weighed seven days after the infant was eight weeks old, has an average weight of 5502 g (2079.73 + 0.72*3460 + 650.90*1 + 40.09*7= 5502.46).

Table 5.1 Regression of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), and *age* (days)

	B	SE B	*t*	*p*
Constant	2079.73	572.30		
Birthweight	.72	.16	4.51	.000
Sex (male)	650.90	148.06	4.40	.000
Age (days > 56)	40.09	11.87	3.38	.001

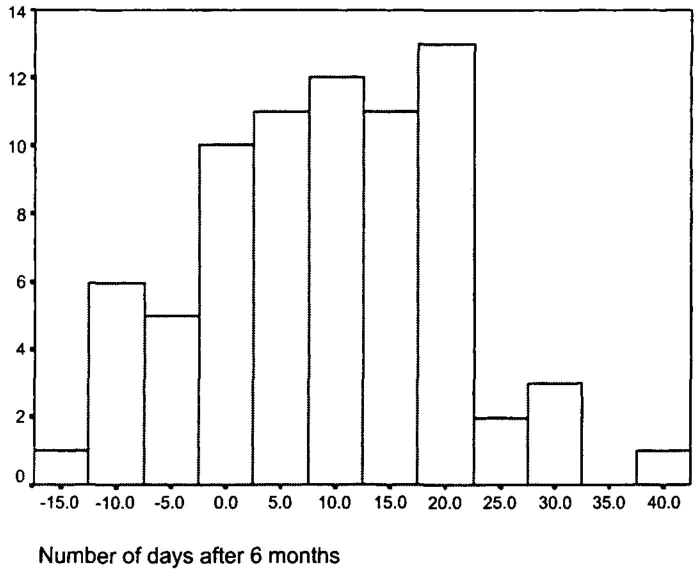
Analysis of Variance

	DF	Sum of squares	Mean square	*F*	*p*
Regression	3	21303962.5	7101320.84	19.37	.000
Residual	71	26032005.5	366647.96		
Total	74	47335968.0			

Multiple R	.67
R square	.45
Adjusted R square	.43
Standard error	605.51

Next the predictors of weight gain from birth to six months were considered. All infants were weighed on a follow-up visit when the infant was approximately six months old. However, infants were not all exactly the same age at this follow-up visit. A new variable was created, called *age-6*, to adjust for the exact age at the time of the weighing. The age was calculated by subtracting 183 (six months in days) from the infant's age in days. Some infants received a negative score, if they were visited earlier than six months. The minimum was −14 days, and the maximum 39 days; on average infants were weighed nine days late. The distribution is shown in Figure 5.2.

Figure 5.2 Distribution of *age-6*, the number of days after six months the infant was weighed



A similar regression model to the one for weight gain to eight weeks was used for weight gain to six months. An estimation of weight at six months from *birthweight* (g), taking into account the infant's sex and age is show in Table 5.2. From the results in Table 5.2 an estimate of weight at six months can be made, for example, for a female born with a weight of 2830 g and weighed two days after she was six months old: the estimate is 6844 g (4834.78 + .70*2830 + 1095.18*0 + 14.34*2 = 6844.46).

Birthweight and *sex* were significant predictors of weight at six months. For every additional 100 g in birthweight there was an additional 70 g in attained weight at six months. After allowing for birthweight, males were on average 1095 g heavier than females. An infant gained on average 14 g a day around six months as opposed to approximately 40 g at two months. However, the exact age at which the infant was weighed is not a statistically significant predictor of weight at six months.

Table 5.2 Regression of weight at six months (g) on *birthweight* (g), *sex* (female, 1 male), and *age-6* (days)

		B	SE B	*t*	*p*
Constant		4834.78	894.40		
Birthweight		.70	.25	2.78	.007
Sex (male)		1095.18	225.37	4.86	.000
Age-6 (days > 183)		14.34	9.69	1.48	.143
Analysis of Variance					
	DF	Sum of squares	Mean square	*F*	*p*
Regression	3	36901743.7	12300581.2	14.26	.000
Residual	71	61258504.3	862795.83		
Total	74	98160248.0			
Multiple R		.61			
R square		.38			
Adjusted R square		.35			
Standard error		928.87			

To conclude, in this section a regression model was used to estimate weight gain from birth to eight weeks, and birth to six months. Weight at eight weeks and six months was predicted by birthweight, taking into account the infant's sex, as males grow faster than females, and the infant's exact age. Although the previous analysis showed that the infant's age is not a statistically significant predictor for weight at six months it was included in following analyses since not all infants were weighed at exactly the same age. This model for weight gain, predicting a later weight given a birthweight, is used throughout the thesis to assess the predictive value of different behavioural characteristics.

Weight gain and feeding method

The sample included infants who were breastfed and infants who were bottlefed, with twice as many infants being bottlefed (51) as breastfed (24). Previous research has shown that weight gain in the first year differs for breast and bottlefed infants (Dewey et al., 1992). A dummy variable was created to represent the method of feeding at eight weeks, called *feeding method* (0 breast, 1 bottle). To assess whether the feeding method had a significant influence on weight gain this variable was included in a multiple regression. The regression with weight at eight weeks as the dependent variable was carried out in two steps; firstly relating it to *birthweight*, *sex*, and *age*, as in the previous section, and secondly adding *feeding method*. Table 5.3 shows the change statistics of the regression.

Table 5.3 Change statistics for regression of weight at eight weeks on *birthweight*, *sex*, *age*, with the second step addition of *feeding method*

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age*	.450	19.368	3	71	.000
2 *Feeding method*	.012	1.526	1	70	.221

The change statistics show that adding *feeding method* did not significantly improve the prediction of weight at eight weeks. The regression statistics are shown in Table 5.4. The parameter estimate associated with the initial predictors of weight gain, *sex* and *age*, are essentially unaltered by taking *feeding method* into account.

Table 5.4 Regression of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), *age* (days), and *feeding method* (0 breast, 1 bottle)

		B	SE B	*t*	*p*
Constant		1923.18	584.11	3.29	.002
Birthweight		.73	.16	1.61	.000
Sex (male)		655.12	147.96	4.49	.000
Age		37.31	12.04	3.10	.003
Feeding method (bottle)		189.88	153.71	1.23	.221
Analysis of Variance					
	DF	Sum of squares	Mean square	*F*	*p*
Regression	4	21859297.0	5464824.26	15.01	.000
Residual	70	25476671.0	363952.44		
		47335968.0			
Total	74				
Multiple R		.68			
R square		.46			
Adjusted R square		.43			
Standard error		603.28			

Table 5.4 shows that the contribution of the independent variable *feeding method* is not statistically significant. However, bottlefed infants are on average approximately 190 g heavier than breastfed infants. Weight at eight weeks is still significantly predicted by *birthweight*, *sex*, and *age*.

Once again, summarising the prediction of weight at eight weeks, a bottlefed male born with a weight of 3460 g, and weighed seven days after eight weeks weighed on average approximately 5555.15 g (1923.18 + .73*3460 + 655.12*1 + 37.31*7 + 189.88*1 = 5555.15). A breastfed male with the same birthweight and age, weighed on average 5365.27 g (1923.18 + .73*3460 + 655.12*1 + 37.31*7 + 189.88*0 = 5365.27). The difference (189.88 g) corresponds to the value of the coefficient for *feeding method.*

Next the infant's feeding method was evaluated in relation to weight at six months. As in the previous analysis of weight gain to eight weeks, *feeding method* was added as a second step to a regression analysis of weight gain from birth to six months to ascertain its influence.

Table 5.5 Change statistics for the regression of weight at six months on *birthweight, sex, age-6,* with the addition of *feeding method*

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age-6*	.376	14.257	3	71	.000
2 *Feeding method*	.000	.036	1	70	.850

The change statistics in Table 5.5 show that the change due to *feeding method* is not statistically significant ($F_{1,70}$ = .036, p = .850). Table 5.6 shows the coefficients for this regression.

Table 5.6 Regression of weight at six months (g) on *birthweight* (g), *sex* (0 female, 1 male), *age-6* (days), and *feeding method* (0 breast, 1 bottle)

	B	SE B	*t*	*p*
Constant	4791.29	929.22	5.16	.000
Birthweight	.70	.25	2.77	.007
Sex (male)	1099.92	228.29	4.81	.000
Age-6	14.29	9.76	1.46	.148
Feeding method (bottle)	44.46	234.22	.19	.850

Analysis of Variance

	DF	Sum of squares	Mean square	*F*	*p*
Regression		36933261.2	9233315.29	10.56	.000
Residual		61226986.8	874671.24		
Total		98160248.0			

Multiple R	.61
R square	.38
Adjusted R square	.34
Standard error	935.24

Table 5.6 shows that a bottlefed infant weighs on average 44 g more at six months, although the relationship between the feeding method and weight at six months is not statistically significant.

In conclusion, the results have shown that the addition of the infant's feeding method does not significantly account for weight gain from birth to eight weeks, or birth to six months. However, in further analysis the feeding method was included as a control variable in the estimation of weight gain in relation to different behavioural variables. The feeding method was included in these further analyses as it could become important when other behavioural variables were considered.

Weight gain and failure to thrive

One of the objectives of the study was to select infants on their weight gain from birth to eight weeks, i.e. the 20% slowest growing, and the 20% fastest growing infants of a population, and average growing infants. For each infant weights were available at birth, eight weeks, and six months. In this section whether any of the slow growing infants went on to develop failure to thrive by six months was investigated.

The measure employed to identify infants with failure to thrive was the 'thrive index' (Wright et al., 1994). It was constructed to assess growth failure in infancy. Most studies on growth failure define failure to thrive as having a weight below the fifth centile (Hutchenson et al., 1993; Black et al., 1994; Benoit et al., 1989) or below the third centile (McCann et al., 1994; Kotelchuck and Newberger, 1983) at a certain age. These infants are assessed on an attained weight at a certain point in time, rather than assessed on weight gain between two time points. Using that method can result in infants being missed, such as infants who have experienced substantial weight loss, but do not fall below the third centile (for instance, infants with a high birthweight). Infants can also be misidentified as failing to thrive, such as infants with low weight at birth.

The 'thrive index' is based on Standard Deviation Scores (SDS) of the distribution of weight in a population. Infant's weights at different time points can be plotted against centiles of average weight. Infants who remain on the same centile will have the same SD scores at different time points. A fall or gain in centile position relative to the previous centile position will be seen in a change in SD score. Wright et al. (1994) define this change as follows,

$$SDS_{time2} - SDS_{time1}$$

It should however be taken into account that infants with extreme weights (either high or low) at the outset tend to move towards the median over time (Cole, 1995). This is referred to as 'regression to the mean'. To take this into account, Wright et al. used regression methods to predict weight at time2 from weight at time1

$$SDS_{predict} = r * SDS_{time1}$$

with r as the correlation between SDS at time 1 and time 2. A difference from the average change over time can be defined as

$$SDS_{time2} - SDS_{predict} = SDS_{time2} - r*SDS_{time1}$$

This difference is the 'thrive index'.

For this study Dr Charlotte Wright transformed the infants' birthweights at weights and six months into SD scores using the new UK 1990 standards (Freeman et al., 1995; revised standards: Preece et al., 1996), as well as the regression coefficient for weight gain from birth to six months, which was 0.4. For each child the SDS were inserted into the equation with the regression coefficient to derive the thrive index.

In addition, Dr Wright provided the cut-off points of the thrive index for percentiles up to the 50th (5th, 10th, 25th and 50th). The cut-off for the slowest growing 5% is −1.488, and an infant with a thrive index score of ≤ -1.488 is considered to be failing to thrive at six months (Wright et al., 1994).

In the current study six infants were identified as failing to thrive, i.e. six infants had a thrive index score of < -1.488. This is the usual criterion used in the Newcastle clinical service. Table 5.7 shows a crosstabulation of the three weight gain groups and whether infants were identified as having failure to thrive at six months.

Table 5.7 Cross tabulation of weight gain patterns from birth to eight weeks and infants with failure to thrive at six months

Weight gain pattern	**Number of infants with failure to thrive**	**N**	**%**
Fast	0	26	0
Average	0	27	0
Slow	6	22	27.3

As can be seen in Table 5.7 the six infants who were identified as having failure to thrive at six months, all had slow weight gain from birth to eight weeks. So 27.3% of infants with slow weight gain continued to fail to thrive up to six months.

A Fisher Exact test was carried out to ascertain whether the difference of the number of infants with failure to thrive in each group was statistically significant. A Fisher Exact test was carried out since some of the cells in the above crosstabulation had expected frequencies lower than five, and since this is a 2x2 test, the average and fast weight gain groups were combined. Table 5.8 shows the cross tabulation.

Table 5.8 Cross tabulation for a 2x2 Fisher Exact test, of infants with and without failure to thrive at six months against the slow weight gain group and the group combining infants with average and fast weight gain

	Eight weeks		
Six months	*Slow weight gain*	*Average and fast weight gain*	Total
Failure to thrive	6	0	6
Others	16	53	69
Total	22	53	75

The Fisher Exact test showed that the difference of the proportion of infants with failure to thrive in the weight gain groups was highly statistically significant ($p = 0.000$).

This finding indicates first of all that the infants with failure to thrive in our sample had slow weight gain over the first eight weeks. In addition it shows that the conditional weight standards that were used to identify the 20% slowest growing infants were successful in selecting infants with an increased risk of continuing failure to thrive.

Conclusions

In this chapter a regression model was developed to predict weight at eight weeks and weight at six months, which is used throughout the thesis to investigate infant and maternal characteristics in relation to weight gain. Weight is predicted from the infant's birthweight, sex and exact age at weighing. On the other hand the feeding method, either breast or bottle, did not contribute significantly to the prediction of weight gain.

Six infants in the study sample were failing to thrive at six months, and these six infants were identified as having slow weight gain from birth to eight weeks. The sample of 22 slow growing infants included six infants who were failing to thrive at six months, which constitutes over a quarter of the subsample. A Fisher Exact test showed that the proportion of infants with failure to thrive in the slow weight gain group was significantly greater than the proportion of failure to thrive infants in the average and fast weight gain group combined. This means that the screening method selecting the 20% slowest growing infants at eight weeks was successful in selecting infants that have a higher chance of going on to develop failure to thrive.

Chapter Six

Sucking behaviour and weight gain

Sucking behaviour and weight gain

Sucking behaviour was measured from natural observation of feeding, in bottle and breastfed infants, in order to investigate sucking behaviour as a predictor of weight gain from birth to eight weeks and birth to six months. As outlined in Chapter Four the sucking parameters are the following:

Sucking parameters	Variable name
1) Mean number of sucks per burst at the start of the feed	*Sucks per burst, start*
2) Mean number of sucks per burst at the end of the feed	*Sucks per burst, end*
3) Mean suck duration at the start of the feed	*Suck duration, start*
4) Mean suck duration at the end of the feed	*Suck duration, end*
5) Standard deviation of suck durations at the start of the feed	*SD suck duration, start*
6) Standard deviation of suck durations at the end of the feed	*SD suck duration, end*
7) Mean pause length at the start of the feed	*Pause length, start*
8) Mean pause length at the end of the feed.	*Pause length, end*

First of all, the relationship between weight gain from birth to eight weeks and sucking behaviour was examined using regression analysis. A multiple regression, with weight at eight weeks as the dependent variable, was carried out in three steps:

1) with *birthweight*, *sex*, *age* as independent variables

2) adding *feeding method*

3) adding the eight sucking parameter estimates.

The change statistics (Table 6.1) show a significant change with the inclusion of the eight sucking parameters, $F_{8,62} = 2.27$, $p = 0.034$. The F statistic is an overall test of statistical significance which takes into account that the regression analysis includes eight additional variables.

Table 6.1 Change statistics for the regression analysis of weight gain from birth to eight weeks on *feeding method* and the sucking parameters

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age*	.450	19.368	3	71	.000
2 *Feeding method*	.012	1.526	1	70	.221
3 *Sucks per burst, start* *Sucks per burst, end* *Suck duration, start* *Suck duration, end* *SD suck duration, start* *SD suck duration, end* *Pause length, start* *Pause length, end*	.122	2.270	8	62	.034

The results (Table 6.2) show that the mean length of the pauses at the end of a feed predicted weight gain from birth to eight weeks (p = 0.005). Every increase of 1 s in the mean *pause length* at the end of a feed, is associated with a lower weight of 8 g on average. This means that relatively longer pauses at the end of a feed are associated with slower weight gain.

Table 6.2 Regression of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), *age* (days), *feeding method* (0 breast, 1 bottle) and the sucking parameters

	B	SE B	*t*	*p*
Constant	1178.96	737.37	1.60	.114
Birthweight	.71	.16	4.46	.000
Sex (male)	710.63	145.93	4.87	.000
Age	34.78	11.53	3.02	.004
Feeding method (bottle)	42.01	172.31	.24	.808
Sucks per burst, start	–.84	.98	–8.5	.397
Sucks per burst, end	–7.67	4.67	–1.64	.106
Suck duration, start	198.71	704.76	.28	.779
Suck duration, end	820.31	784.65	1.04	.300
SD suck duration, start	955.52	1982.23	.48	.631
SD suck duration, end	952.64	2097.96	.45	.651
Pause length, start	53.22	38.24	1.39	.169
Pause length, end	–8.42	2.92	–2.88	.005

Analysis of Variance	DF	Sum of squares	Mean square	*F*	*p*
Regression	12	27631766.4	2302647.2	7.24	.000
Residual	62	19704201.6	317809.7		
Total	74	47335968.0			

Multiple R	.76
R square	.58
Adjusted R square	.50
Standard error	563.75

The following analysis is similar but is concerned with weight gain up to six months. The change statistics (Table 6.3) indicate that the sucking parameters do not significantly improve the estimation of weight gain over this period ($F_{8,62}$ = 1.382, p = 0.222).

Table 6.3 Change statistics for the regression analysis of weight gain from birth to six months on *feeding method* and the sucking parameters

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age-6*	.376	14.257	3	71	.000
2 *Feeding method*	.000	.036	1	70	.850
3 *Sucks per burst, start* *Sucks per burst, end* *Suck duration, start* *Suck duration, end* *SD suck duration, start* *SD suck duration, end* *Pause length, start* *Pause length, end*	.094	1.382	8	62	.222

Sucking behaviour was observed during a feed on the second home visit. Most infants in the study were observed during a continuous feed, which means for bottlefeeding infants being fed a bottle, and for breastfeeding infants being fed on one breast. However, there are six infants for whom this is not the case. Four of these infants were fed on one breast and then changed over to the other. One infant was fed on both breasts and fed formula milk at the end of the feed. Another infant was fed from the bottle and received semi-solids (baby-rice) in the middle of the feed, and was then put back on the bottle. For these six infants the feeds have been separated into several individual feeds rather than one continuous feed. The whole feeding session will be referred to here as a 'meal', which can consist of different 'feeds' (e.g. each breast). For example, for a breastfeeding infant fed on both breasts there are data from two feeds. In the previous analysis of the sucking parameters and weight gain the entire meal was examined except for the six infants for whom the meal was not continuous. For these infants the first feed, before a change in feeding, was examined.

The sucking parameters estimate sucking patterns at the start and the end of a meal. The end parameters, for the six infants who experienced a change in feeding, refer to the end of the first feed, and therefore not to the actual end of the entire meal. Rather than using the sucking parameters for the end of the first feed, in the following analysis they were taken from the end of the second feed, which constitutes the actual end of the meal. There was one exception, for the infant who was breastfed on both breasts and then bottlefed formula milk, the second feed (rather than the last one) was examined to avoid confounding due to change in feeding method. An additional regression analysis was carried out relating weight gain to the sucking parameters with these alterations. Sucking parameters were otherwise entered as before to establish whether handling these parameter estimates in this way would change the outcome. This analysis is referred to as 'analysis 2', and the initial analysis as 'analysis 1', and both are shown in Table 6.4.

The results indicate that the same variables are still significantly related to weight gain. Weight gain from birth to eight weeks is predicted by the pause length at the end of the feed ($t = -3.149$, $p = 0.003$). The results are similar to the previous findings, with a slight increase in significance level. Since weight gain was still predicted by the same sucking parameter it was decided to adhere to analyses with the original sucking parameters from the first feed.

Table 6.4 Comparison of regression coefficients and the F change statistics of 'analysis 1' (i.e. the initial analysis with start and end parameters from the first feed) and 'analysis 2' (i.e. the analysis with start parameters from the first feed and end parameters from the second feed) of weight gain from birth to eight weeks and the sucking parameters

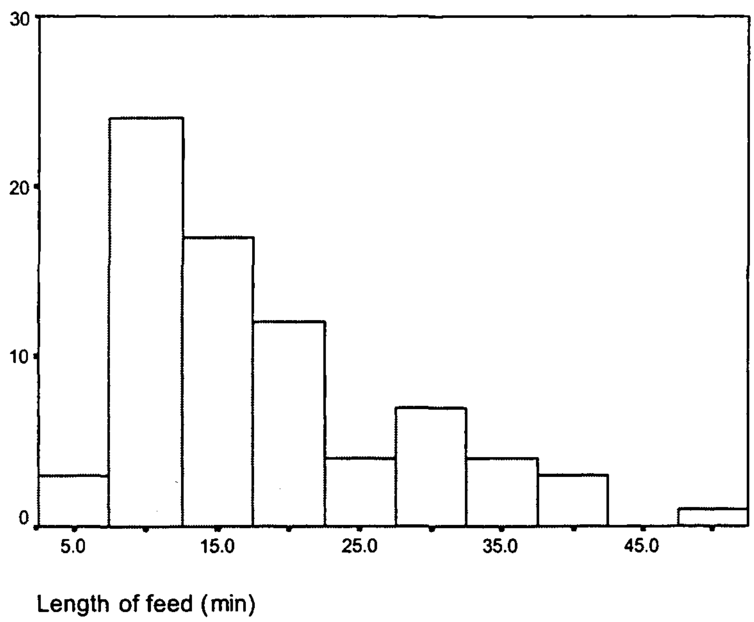
Analysis 1	B	SE B	*t*	*p*	ΔF	*p*
Constant	1178.96	737.37	1.60	.114		
Birthweight	.71	.16	4.46	.000		
Sex (male)	710.63	145.93	4.87	.000		
Age	34.78	11.53	3.02	.004		
Feeding method (bottle)	42.01	172.31	.24	.808		
Sucks per burst, start	–.84	.98	–8.5	.397		
Sucks per burst, end	–7.67	4.67	–1.64	.106		
Suck duration, start	198.71	704.76	.28	.779		
Suck duration, end	820.31	784.65	1.04	.300		
SD suck duration, start	955.52	1982.23	.48	.631		
SD suck duration, end	952.64	2097.96	.45	.651		
Pause length, start	53.22	38.24	1.39	.169		
Pause length, end	–8.42	2.92	–2.88	.005	2.270	.034

Analysis 2	B	SE B	*t*	*p*	ΔF	*p*
Constant	1156.45	724.00	1.60	.115		
Birthweight	.73	.16	4.56	.000		
Sex (male)	703.41	143.19	4.91	.000		
Age	34.17	11.30	3.02	.004		
Feeding method (bottle)	25.67	173.33	.15	.883		
Sucks per burst, start	–.76	.96	–.78	.435		
Sucks per burst, end	–8.21	4.69	–1.75	.085		
Suck duration, start	37.59	706.15	.05	.958		
Suck duration, end	849.84	799.75	1.06	.292		
SD suck duration, start	748.97	1931.24	.39	.699		
SD suck duration, end	2189.39	1780.28	1.23	.223		
Pause length, start	60.91	37.89	1.61	.113		
Pause length, end	–9.02	2.86	–3.15	.003	2.647	.014

Duration of feeding and weight gain

The previous analyses have not included the duration of feeds. Data are available on the duration of the feed from which the sucking behaviour was recorded, referred to as *length of feed.* Figure 6.1 shows the histogram of the distribution of the variable *length of feed.*

Figure 6.1 Distribution of *length of feed* (length of the feed from which the sucking behaviour was recorded)



The median of the variable *length of feed* was 14.80 min. In the next analysis the influence of this variable was investigated in relation to weight gain. The length of the feed was added into the regression analysis as the fourth step.

The multiple regression, with weight at eight weeks (g) as the dependent variable consisted of four steps:

1) with *birthweight* (g), *sex*, and *age*
2) adding *feeding method*
3) adding sucking parameters
4) adding *length of feed* (min)

The change statistics (Table 6.5) indicate that the addition of the variable *length of feed* significantly improved the prediction of weight gain ($F_{1,61} = 8.52$, $p = 0.005$)

Table 6.5 Change statistics for the regression analysis of weight gain from birth to eight weeks on *feeding method*, sucking parameters, and *length of feed*

	Change Statistics				
Step	ΔR^2	ΔF	Δdf regression	df residual	p
1 *Birthweight* *Sex* *Age*	.450	19.368	3	71	.000
2 *Feeding method*	.012	1.526	1	70	.221
3 *Sucks per burst, start* *Sucks per burst, end* *Suck duration, start* *Suck duration, end* *SD suck duration, start* *SD suck duration, end* *Pause length, start* *Pause length, end*	.122	2.270	8	62	.034
4 *Length of feed*	.051	8.524	1	61	.005

The results (Table 6.6) show that the variable *length of feed*, is significantly related to weight gain over the first eight weeks. For every one minute increase there is a reduction of approximately 22 g in attained weight at eight weeks.

Table 6.6 Stepwise regression of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), *age* (days), *feeding method* (0 breast, 1 bottle) and sucking parameters, including *length of feed*

	B	SE B	t	p
Constant	2260.94	788.81	2.87	.006
Birthweight	.69	.15	4.56	.000
Sex (male)	801.63	141.28	5.67	.000
Age	32.26	10.92	2.95	.004
Feeding method (bottle)	180.59	169.50	.06	.291
Sucks per burst, start	−1.054	.93	−1.13	.262
Sucks per burst, end	−6.45	4.43	−1.45	.151
Suck duration, start	46.26	667.58	.07	.945
Suck duration, end	−271.10	829.93	−.33	.745
SD suck duration, start	1296.17	1875.53	.69	.492
SD suck duration, end	1966.03	2011.36	.98	.332
Pause length, start	62.43	36.25	1.72	.090
Pause length, end	−8.89	2.76	−3.22	.002
Length of feed (min)	−22.90	7.84	−2.92	.005

Analysis of Variance	DF	Sum of squares	Mean square	F	p
Regression	13	30047594.4	2311353.41	8.15	.000
Residual	61	17288373.6	283415.96		
Total	74	47335968.0			

Multiple R	.80
R square	.63
Adjusted R square	.56
Standard error	532.37

Interestingly, the prediction of weight from the length of the pause at the end of the feed is independent of the length of the feed. The predictive value of the *pause length* at the end of the feed becomes more significant with the addition of the *length of feed*. The regression coefficient for the *pause length* at the end of the feed, −8.89, is virtually unchanged, as compared with the regression coefficient in the analysis of sucking behaviour in Table 6.2, with a value of −8.42.

Next the same analysis was used for weight gain from birth to 6 months. The change statistics in Table 6.7 indicate that the addition of the variable *length of feed* did not improve the prediction significantly ($F_{1,61} = 3.759$, $p = 0.057$). This means that weight at six months was not predicted by the infant's sucking behaviour or *length of feed.*

Table 6.7 Change statistics for regression analysis of weight gain from birth to six months on *feeding method*, sucking parameters, and *length of feed*

	Change Statistics				
Step	**ΔR²**	**ΔF**	**df regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age-6*	.376	14.257	3	71	.000
2 *Feeding method*	.000	.036	1	70	.850
3 *Sucks per burst, start* *Sucks per burst, end* *Suck duration, start* *Suck duration, end* *SD suck duration, start* *SD suck duration, end* *Pause length, start* *Pause length, end*	.094	1.382	8	62	.222
4 *Length of feed*	.031	3.759	1	61	.057

Next a more thorough investigation was carried out of the previously described relationship between weight at eight weeks and the infant's sucking behaviour, including the length of the feed. A forward stepwise regression was carried out with all the relevant variables to select the key variables which predict weight at eight weeks. The following variables were used in the forward stepwise regression:

Birthweight
Sex
Age
Feeding method
Sucks per burst, start
Sucks per burst, end
Suck duration, start
Suck duration, end
SD suck duration, start
SD suck duration, end
Pause length, start
Pause length, end
Length of feed

The variables that were found to independently estimate weight at 8 weeks, shown in Table 6.8, were *birthweight*, *sex*, *age*, pause length at the end of the feed (*pause length, end*), and the length of the feed from which the sucking parameters were determined (*length of feed*). Table 6.8 outlines the variables and their regression coefficients.

Table 6.8 Forward stepwise regression of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), *age* (days), *pause length, end* (s), and *length of feed* (min)

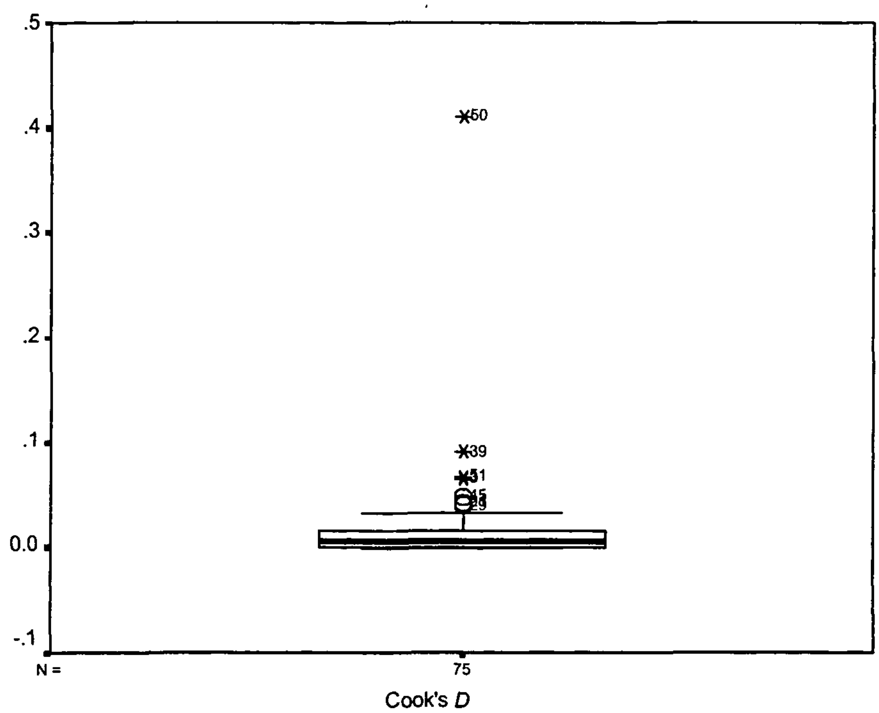
	B	SE B	*t*	*p*
Constant	2722.37	562.33	4.84	.000
Birthweight	.63	.15	4.30	.000
Sex (male)	752.35	135.16	5.57	.000
Age	37.78	10.68	3.54	.001
Pause length, end (s)	–9.70	2.58	–3.76	.000
Length of feed (min)	16.80	6.68	–2.51	.014

Analysis of Variance	DF	Sum of squares	Mean square	*F*	*p*
Regression	5	26967964.5	5393592.91	18.27	.000
Residual	69	20368003.5	295188.46		
Total	74	47335968.0			

Multiple R	.75
R square	.57
Adjusted R square	.54
Standard error	543.31

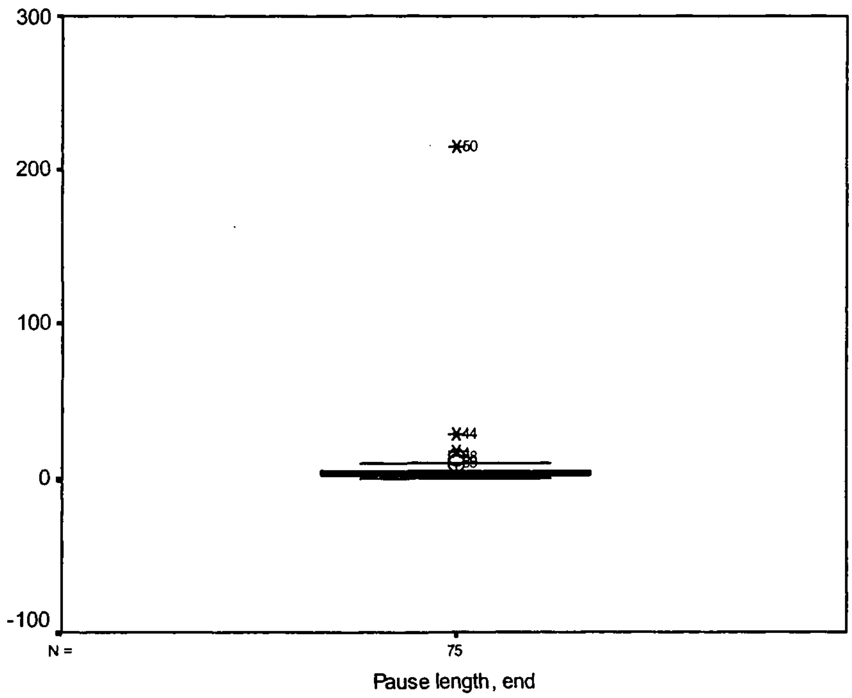
After the regression Cook's *D* was calculated (Howell, 1997). The *distance* statistics indicate potential outliers in the dependent variable, and *leverage* statistics indicate potential outliers in the independent variable. A combination of the two, i.e. a high value on *distance* as well as high value on *leverage*, is referred to as *influence*, which is measured by high values of Cook's *D*. So in effect Cook's *D* measures the effect of removing a single case (an infant) from the data set and rerunning the analysis without it (Howell, 1997). The values on Cook's *D* are presented in Figure 6.2. It is clear that there is one extreme outlier, infant number 50, with a very high value on *D*.

Figure 6.2 Boxplot of Cook's D from the regression analysis shown in Table 6.8



An investigation of the medians of the sucking parameters shows that infant 50 had an extreme parameter estimate for one of them. The median for *pause length* at the end of the feed was 3.61 s, whereas infant 50's estimate for pause length at the end of the feed was 215.26 s. Figure 6.3 shows that this infant's *pause length, end* estimate is extreme relative to the rest of the sample's estimates.

Figure 6.3 Boxplot of the parameter estimate *pause length* at the end of a feed



The sucking behaviour for infant 50 was plotted in Figure 6.4. The figure shows the duration of intervals between sucks (Y-axis) over the course of the feed (X-axis). The duration of the feed is summed in s along the X-axis. Figure 6.5 shows the intervals between sucks for a randomly selected infant and is an example against which to compare the sucking behaviour of infant 50. Looking at the Y-axis of the two graphs is can be seen that Figure 6.4 goes up 50 and Figure 6.5 goes up to 30. The longest interval in the latter figure is around 20 s, and the longest interval in the figure of infant 50 is above 50. As mentioned above, the parameter estimate for *pause length* at the end of the feed for infant 50 was 215.26 s. The median for the whole sample on this sucking parameter was 3.61 s which emphasises that this infant's estimate was indeed extreme. The figures in which the sucking behaviour is shown have a cut-off point of 60 s for the intervals which explains why the intervals for infant 50 do not reach at least 200 s. The sucking behaviour of the random infant is more representative of average sucking behaviour. A comparison of the two figures also shows that, in addition to the previously mentioned difference in duration of intervals, the random infant sucks more consistently. This infant's sucking behaviour gradually slows down towards the end of the feed, which is less the case for infant 50, where sucking becomes scarce at the end of the feed.

Figure 6.4 Graph of the duration of the intervals between sucks over the course of the feed of infant 50

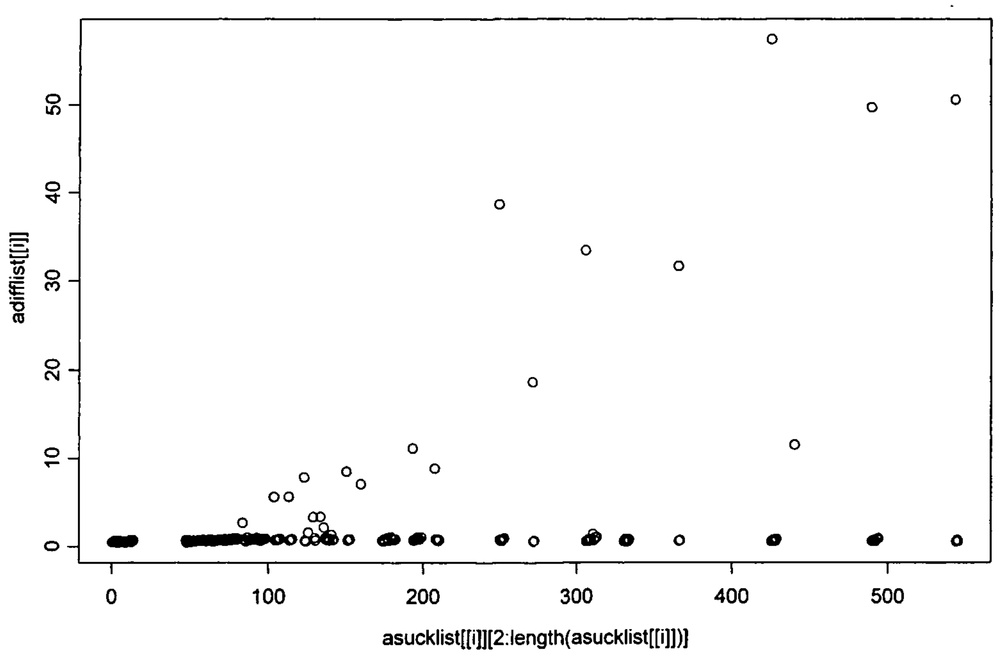
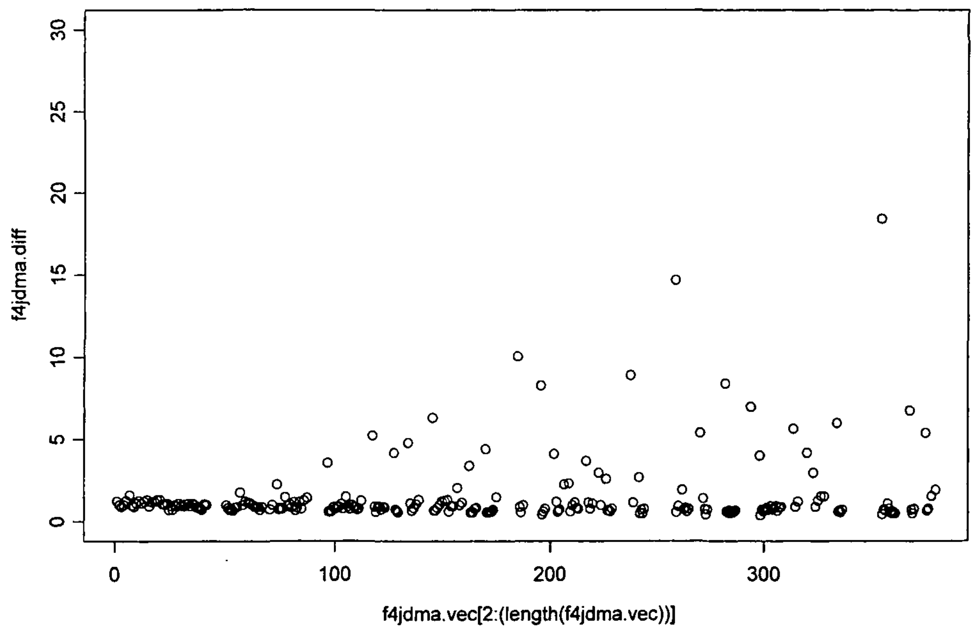
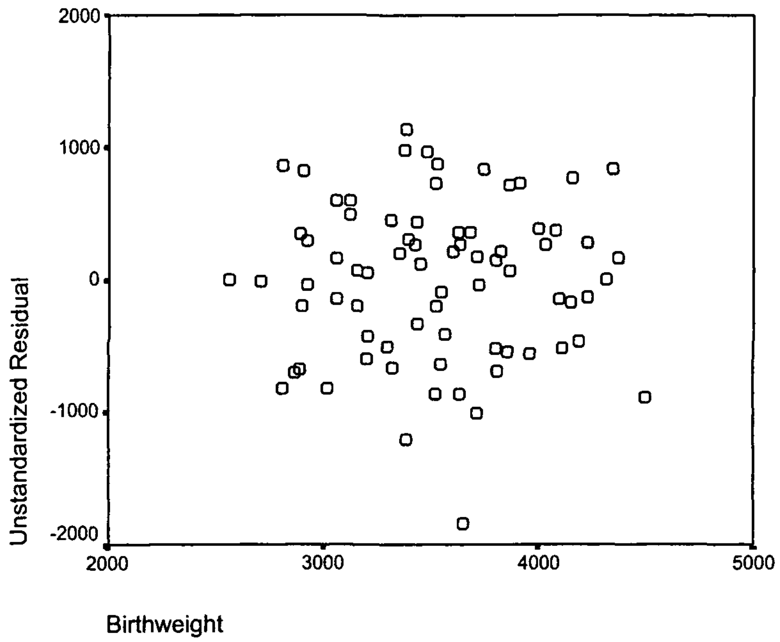


Figure 6.5 Graph of the duration of the intervals between sucks over the course of the feed of a randomly selected infant



In addition, this infant's weight gain was examined more closely through additional diagnostic statistics. For the regression of weight at eight weeks on *birthweight*, *sex* and *age*, the unstandardised residuals were plotted against birthweight to provide Figure 6.6. The residuals are the difference between the expected value of the dependent variable (as calculated from the regression coefficient) and the measured value of the dependent variable.

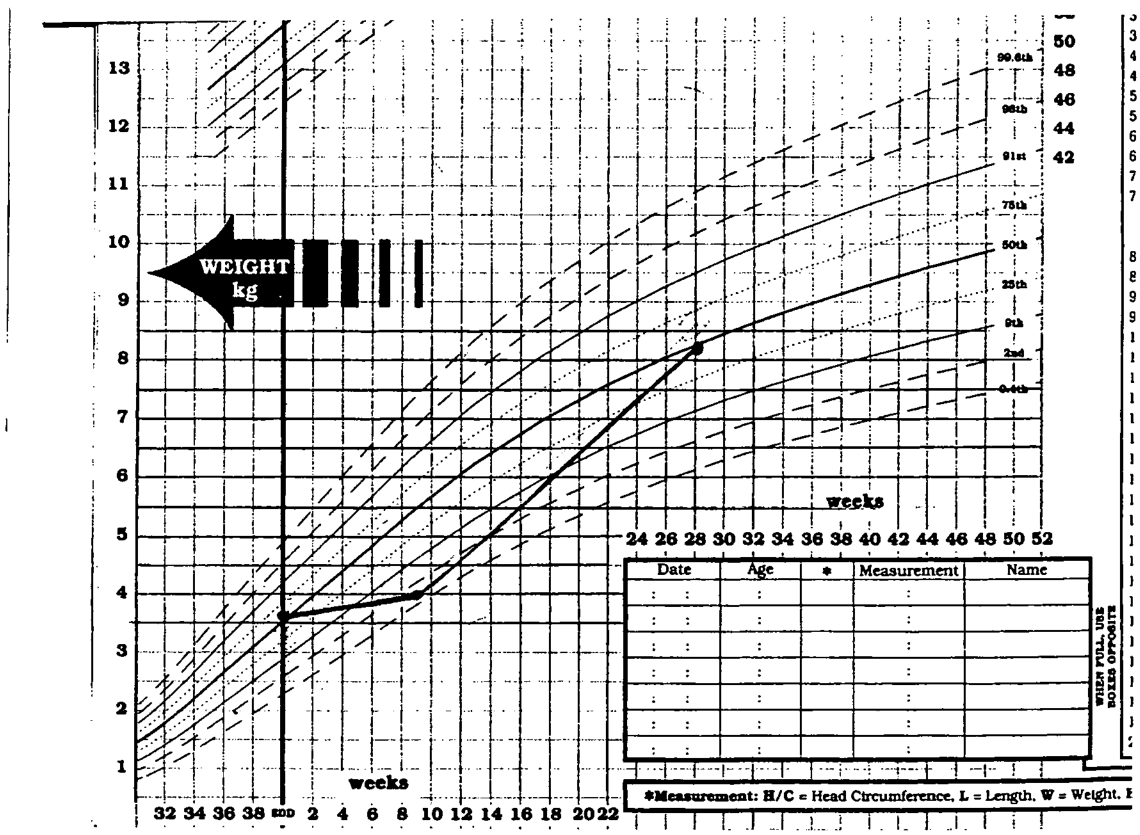
Figure 6.6 Scatterplot of the relationship between the unstandardised residuals of the regression (of weight at eight weeks on *birthweight*, *age*, and *sex*) and *birthweight*



In Figure 6.6 it can be seen that there is one outlier, at the bottom of the Figure (X ~ 3750, Y ~ –2000). This is the infant with the extreme estimates for the sucking parameter *pause length* at the end of the feed (infant 50). So in the sample, there is an infant with extremely slow weight gain from birth to eight weeks, with extremely long pauses at the end of feed in its sucking record.

This infant's birthweight was 3650 g and the weight at eight weeks 3960 g, which means that this infant only gained 310 g over approximately eight weeks. The mean weight gain over the first eight weeks was 1603 g for females, and 2106 g for males (infant 50 is a male). This infant's weights were plotted on a growth chart in Figure 6.7. The growth chart is based on UK 1990 growth data (Freeman et al., 1995). It shows that the infant had very slow weight gain in the first few months, but that there was definite catch up growth, as the infant's weight at six months (8200 g) was around the same centile as the birthweight.

Figure 6.7 Growth chart showing the plotted weights of infant 50. Birthweight 3650 g, weight at eight weeks 3960 g, and weight at six months 8200 g



The question now remains whether the relationship between the parameter estimate *pause length, end* and weight at eight weeks is still statistically significant, with the exclusion of this infant's parameter estimates. The regression coefficients of the multiple regression similar to the one in Table 6.6 to investigate the influence of the sucking parameters on weight at eight weeks are presented in Table 6.10, together with the change statistics in Table 6.9. This analysis was carried out excluding infant 50.

Table 6.9 Change statistics for regression analysis of weight gain from birth to eight weeks on *feeding method*, sucking parameters, and *length of feed*, excluding infant 50

	Change Statistics				
Step	ΔR^2	ΔF	df regression	df residual	p
1 *Birthweight* *Sex* *Age*	.501	23.388	3	70	.000
2 *Feeding method*	.004	.602	1	69	.440
3 *Sucks per burst, start* *Sucks per burst, end* *Suck duration, start* *Suck duration, end* *SD suck duration, start* *SD suck duration, end* *Pause length, start* *Pause length, end*	.062	1.095	8	61	.379
4 *Length of feed*	.052	8.146	1	60	.006

The overall significant relationship between the sucking parameters and weight at eight week (step 3) has disappeared with the exclusion of the estimates of infant 50 ($F_{8,61} = 1.095, p = 0.379$).

Table 6.10 Stepwise regression of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), *age* (days), *feeding method* (0 breast, 1 bottle), sucking parameters, and *length of feed*, excluding infant 50

	B	SE B	t	p
Constant	2329.64	806.48	2.89	.005
Birthweight	.68	.15	4.49	.000
Sex (male)	801.35	142.18	5.64	.000
Age	31.35	11.15	2.81	.007
Feeding method (bottle)	166.48	173.06	.96	.340
Sucks per burst, start	−1.08	.94	−1.15	.255
Sucks per burst, end	−.602	4.55	−1.32	.191
Suck duration, start	94.43	679.18	.14	.890
Suck duration, end	−365.14	857.63	−.43	.672
SD suck duration, start	1231.43	1892.19	.65	.518
SD suck duration, end	2231.25	2097.39	1.06	.292
Pause length, start	64.08	36.64	1.75	.085
Pause length, end	−17.40	17.84	−.97	.334
Length of feed (min)	−22.60	7.92	−2.85	.006

Analysis of Variance

	DF	Sum of squares	Mean square	F	p
Regression	13	27961151	2150847.8	7.49	.000
Residual	60	17221508	287025.14		
Total	73	45182659			

Multiple R	.79
R square	.62
Adjusted R square	.54
Standard error	535.75

It is clear from Table 6.10 that the relationship between weight at eight weeks and *pause length* at the end of the feed is no longer statistically significant.

On the other hand the relationship between weight at eight weeks and the length of the feed is still significant. For every minute increase in the length of the feed the infant's weight at eight weeks was on average 25 g less.

In conclusion it can be said that the previously found relationship between the sucking parameter estimates and weight at eight weeks was predominately attributable to the extreme parameter estimates of one infant. This infant had extreme sucking behaviour as well as an extreme weight gain pattern. The infant's sucking behaviour was marked by very long pauses at the end at the feed and poor weight gain over the first eight weeks.

Conclusion

A relationship was found between the infant's sucking behaviour and weight at eight weeks, namely a negative relationship between the *pause length* at the end of the feed and weight at eight weeks. Infants that had relatively longer pauses at the end of the feed were more likely to have slow weight gain in the first eight weeks. In addition, longer feeds were also associated with slow weight gain. However, it was found that one infant had extreme feeding behaviour as determined by an evaluation of Cook's *D* which measures the relative influence of a single case in the sample, in the regression analysis of weight at eight weeks on sucking behaviour and *length of feed*. This infant (infant 50) presented a high estimate for the parameter *pause length, end*. Additional analysis revealed that this infant also had an extreme weight gain pattern. The infant had very long pauses at the end of the feed in comparison with the other infants and very slow weight gain from birth to eight weeks. To assess the infant's influence on the overall analysis this infant was excluded from the regression analysis of weight gain from birth to eight weeks on the feeding method, the sucking parameters and *length of feed*. It was found that the relationship between *pause length* at the end of the feed and weight at eight weeks was no longer statistically significant. However, the relationship between the length of the feed and weight at eight weeks was still significant.

The findings are interesting as they showed that the length of the feed influences weight gain. It is not the case that infants who have longer feeds grow faster, as might be expected. Infants with longer feeds are more likely to have slow weight gain. Another intriguing finding is that an infant who had extremely slow weight gain had an extremely unusual sucking pattern. The results did not demonstrate any general relationship between slow weight gain and sucking behaviour, as the analysis did not show any significant differences after the exclusion of infant 50.

No relationship between the sucking parameters and weight at six months was found, or between *length of feed*, and weight at six months.

Chapter Seven

Infant temperament

Infant temperament

In this chapter the infant's temperament is investigated in relation to weight gain. Wells and Davies (1996) found irritability in infants to be related to energy expenditure, and stored energy (weight gain) is the difference between energy intake and energy expenditure. Wells et al. (1997) found fussiness in infancy to predict carbohydrate intake in childhood, and irritability in infancy to predict percentage fat in childhood. Fat deposition also results in weight gain. Carey (1985) related weight gain in six-month old infants to temperament characteristics and found that rapid weight gain was associated with difficultness in infants. In other words there is some evidence for a relationship between the infant's fussy and irritable behaviour and increased weight in infancy and early childhood.

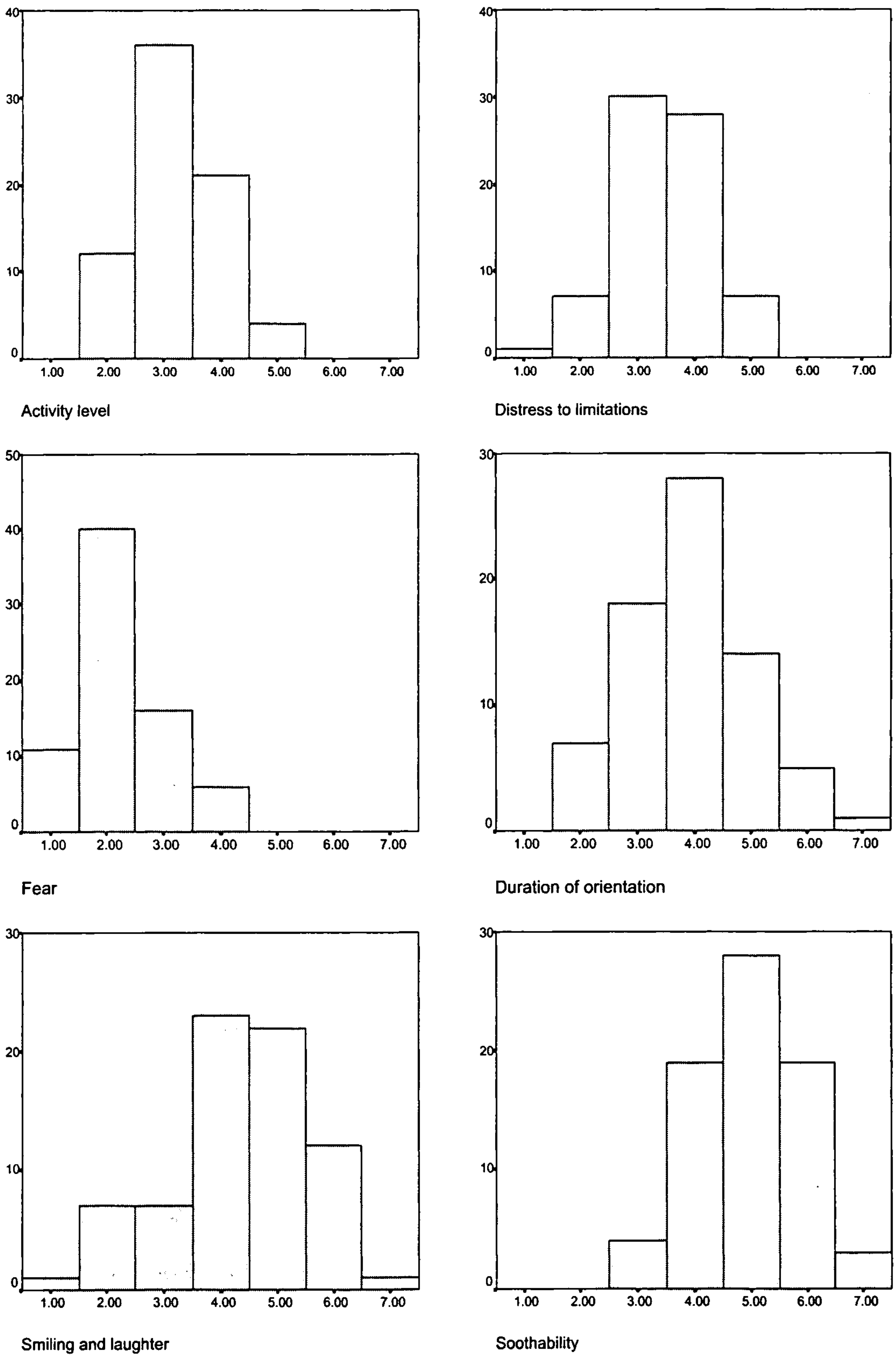
In the study reported here mothers completed a questionnaire to assess the infant's temperament, identical to the one used in the studies by Wells et al. (1996, 1997). Mothers also completed a two-day diary assessing specific infant behaviours (Barr et al., 1988), such as feeding and sleeping. The relationship between these infant characteristics and weight gain is discussed in this chapter, and the relationship between temperament and other infant behavioural characteristics is examined.

Temperament and weight gain

The temperament questionnaire, the Infant Behavior Questionnaire (IBQ; Rothbart, 1981) consists of six subscales each assessing different dimensions of temperament (as discussed in Chapter Two). The reported characteristics refer to behaviour over the last seven days, at the time the questionnaire is completed. First of all *activity* is assessed, which refers to the level of gross motor activity. *Distress to limitations* assesses negative emotionality and the infant's reaction to frustrating situations. *Fear*, or distress and extended latency to approach intense or novel stimuli, refers to the infant's acceptance or rejection of new objects or persons. *Duration of orientation* measures the infant's attention span and distractibility. The variable *smiling and laughter* assesses positive emotional reactivity. Finally, *soothability*, also referred to as threshold, intensity and adaptibility of response, assesses how well the infant can be soothed. For each subscale an infant obtained an average score, which was used in the analysis.

In their studies Wells et al. (1997, 1996) focused mainly on the dimensions *distress to limitations* and *soothability*. These two dimensions refer to whether the infant is seen as 'difficult' or 'easy'. Infants would be classified as 'easy' if the have a low score on *distress to limitations* and a high score on *soothability*, and as 'difficult' for the reverse scores. In the analysis all the temperament variables were included to control for any relationships among the variables. Information was missing on two infants, as the questionnaires failed to reach the researcher; according to the mothers the questionnaires were posted, but they never arrived. The distributions of the scores of all the temperament dimensions are shown in Figure 7.1.

Figure 7.1 Distribution of scores of the temperament variables measured by the Infant Behaviour Questionnaire (IBQ; Rothbart, 1981)



Pearson correlations between the infant's scores on each of these variables were examined to assess the relationship between the variables (Table 7.1).

Table 7.1 Pearson correlations between the temperament variables (*ns* indicates a non-significant correlation)

		Activity level	*Distress to limitations*	*Fear*	*Duration of orientation*	*Smiling and laughter*	*Soothability*
Activity level	*r*						
	p						
Distress to limitations	*r*	.433					
	p	.000					
Fear	*r*	.263	.457				
	p	.025	.000				
Duration of orientation	*r*	.129	-.254	-.090			
	p	*ns*	.030	*ns*			
Smiling and laughter	*r*	.088	-.314	-.093	.474		
	p	*ns*	.007	*ns*	.000		
Soothability	*r*	.292	.097	-.075	.423	.465	
	p	.021	*ns*	*ns*	.000	.000	

In Table 7.1 the correlations are shown between the temperament variables. Certain associations were found between the different temperament dimensions. First of all, the infant's *activity* level is most strongly correlated with *distress to limitations*, so that infants with high activity levels are more likely to be more easily distressed. Infants with high levels of *fear* are also more likely to have higher scores on the variable *distress to limitations*. Infants who have high scores on the variable *duration of orientation* on average have higher scores on *smiling and laughter* and *soothability*. This means that infants with longer attention spans are more likely to smile and laugh more, and be more easily consoled. Although some of the correlations are highly significant the correlations are not very high, as none of them exceed r > 0.50. Since 15 correlations were calculated there is a 15/20 probability that one is significant by chance. This needs to be taken into account when assessing the results.

Table 7.2 Pearson correlations between temperament variables and *feeding method* (0 breast, 1 bottle; *ns* indicates a non-significant correlation)

		Activity level	*Distress to limitations*	*Fear*	*Duration of orientation*	*Smiling and laughter*	*Soothability*
Feeding method	*r*	-.103	-.154	.008	.304	.191	.158
	p	*ns*	*ns*	*ns*	.009	*ns*	*ns*

Table 7.2 shows the correlations between the scores on the different temperament variables and the infant's *feeding method.* DiPietro et al. (1987) make a case for including the feeding method in the analysis of infant behaviour. In their study infant characteristics were investigated in early infancy and breastfeeding infants were found to be more irritable, and less able to complete tasks on orientation, than bottlefeeding infants. On the other hand breastfeeding infants demonstrated a more optimal physiological state, with slower heart rate and higher vagal tone. Worobey (1993) also emphasised the importance of the examination of the influence of the feeding method when studying early infant behaviour, as he found differences in responsiveness and activity in young infants according to feeding method (Worobey, 1993). One of the temperament variables, *duration of orientation,* is significantly correlated with *feeding method.* A comparison of the means shows that breastfeeding infants (mean = 3.14) present lower scores than bottlefeeding infants (mean = 4.13) on this variable. In other words infants who are being breastfed are more likely to have shorter attention spans.

Tests comparing infants on the temperament variables according to their sex showed no significant differences for any of the variables.

The relationship of the temperament dimensions and weight gain was then analysed using the model to assess the predictors of weight gain, as laid out in Chapter Five. First of all, weight at eight weeks was related to all the temperament variables, with the variables entered as the first step in the regression consisting of *birthweight* (g), *sex* (0 female, 1 male), and *age* (days) and with all the temperament variables added as the second step. Table 7.3 shows the change statistics relating to this analysis.

Table 7.3 Change statistics of regression of weight at eight weeks on *birthweight*, *sex*, *age* and temperament variables

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age*	.466	20.054	3	69	.000
2 *Activity* *Distress to limitations* *Fear* *Duration of orientation* *Smiling and laughter* *Soothability*	.109	2.679	6	63	.022

The change statistics show a significant effect of the temperament variables ($F_{6,63} = 2.679$, $p = 0.022$). From Table 7.4 it is clear that two dimensions of temperament are related to weight gain over the first eight weeks of life. The infant's level of *activity* and *fear* are both negatively related to weight gain over the first eight weeks. For every unit increase in score on *activity* level as reported by the mother infants weigh on average 213 g less. For every unit increase in score for *fear* infants weigh on average 233 g less.

Table 7.4 Regression of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), and *age* (days) and the temperament variables

		B	SE B	*t*	*p*
Constant		1650.38	729.11	2.26	.027
Birthweight		.73	.15	4.76	.000
Sex (male)		691.86	140.18	4.93	.000
Age		39.73	11.66	3.41	.001
Activity		-212.83	104.19	-2.04	.045
Distress to limitations		180.99	112.14	1.61	.112
Fear		-232.57	100.65	-2.31	.024
Duration of orientation		59.54	74.17	.80	.425
Smiling and laughter		104.25	76.16	1.37	.176
Soothability		62.16	97.86	.63	.528
Analysis of Variance					
	DF	Sum of squares	Mean square	*F*	*p*
Regression	9	27073528.0	3008169.78	9.45	.000
Residual	63	20061288.5	318433.15		
Total	72	47134816.4			
Multiple R		.76			
R square		.57			
Adjusted R square		.51			
Standard error		564.30			

Next a regression, similar to the previous one, was carried out but with *feeding method* entered as the second step, and the temperament variables as the third step, as show in table 7.6. The *feeding method* was added into the regression since a significant difference (r = 0.304, *p* = 0.009) was found, as shown in Table 7.2 between bottle and breast feeding infants on the dimension *duration of orientation*.

Table 7.5 Change statistics of regression of weight at eight weeks on *birthweight*, *sex*, *age*, *feeding method* and the temperament variables

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age*	.466	20.054	3	69	.000
2 *Feeding method*	.012	1.576	1	68	.214
3 *Activity* *Distress to limitations* *Fear* *Duration of orientation* *Smiling and laughter* *Soothability*	.100	2.437	6	62	.035

The change statistics in Table 7.5 show that weight at eight weeks is still significantly associated with the temperament variables, after allowing for the infant's feeding method ($F_{6,62}$ = 2.437, p = 0.035).

Table 7.6 Regression of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), *age* (days), *feeding method* (0 breast, 1 bottle) and the temperament variables

	B	SE B	*t*	*p*
Constant	1590.63	737.55	2.16	.035
Birthweight	.74	.16	4.79	.000
Sex (male)	699.58	141.25	4.95	.000
Age	38.39	11.88	3.23	.002
Feeding method (bottle)	106.86	157.65	.68	.500
Activity level	-199.75	106.41	-1.88	.065
Distress to limitations	184.13	112.72	1.63	.107
Fear	-240.06	101.68	-2.36	.021
Duration of orientation	47.78	76.49	.63	.534
Smiling and laughter	103.61	76.49	1.36	.180
Soothability	56.40	98.65	.57	.570

Analysis of Variance	DF	Sum of squares	Mean square	*F*	*p*
Regression	10	27221106.8	2722110.68	8.48	.000
Residual	62	19913709.6	321188.87		
Total	72	47134816.4			

Multiple R	.76
R square	.58
Adjusted R square	.51
Standard error	566.74

The relationship of weight at eight weeks and temperament changed with the inclusion of *feeding method.* The relationship between weight at eight weeks and *fear* became stronger. For every unit increase in score of *fear* infants weighed on average 240 g less. The earlier reported significant relationship between weight at eight weeks and *activity* disappeared, although *feeding method* is not itself significantly related to weight at eight weeks. The earlier reported correlations between temperament and *feeding method* (Table 7.2) showed that activity level did not differ for breastfed and bottlefed infants.

Next the relationship between weight at six months and the infant's temperament was investigated. A regression similar to the previous one of weight gain up to eight weeks, was carried out. The regression of weight at six months on *birthweight* (g), *sex* (0 female, 1 male), *age-6* (days) and *feeding method* (0 breast, 1 bottle), and the temperament variables produced the change statistics in Table 7.7 which show that temperament does not have an overall significant relationship with weight gain over the first six months ($F_{6,62} = 1.523$, $p = 0.185$). Temperament dimensions, which were assessed at eight weeks, are better predictors of weight gain over the first eight weeks, rather than weight gain over the first six months.

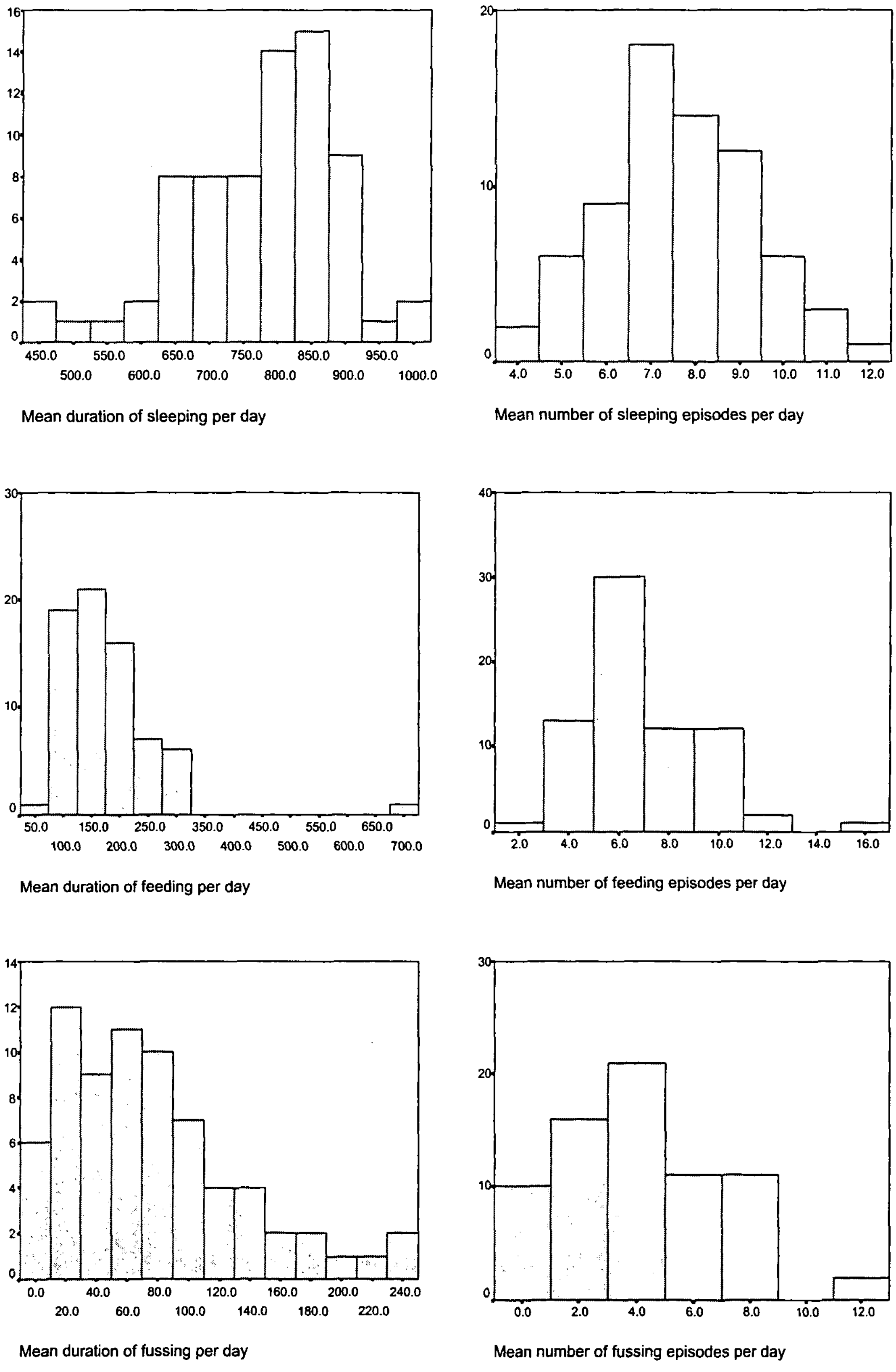
Table 7.7 Change statistics of regression of weight at six months on *birthweight*, *sex*, *age-6*, *feeding method* and temperament variables

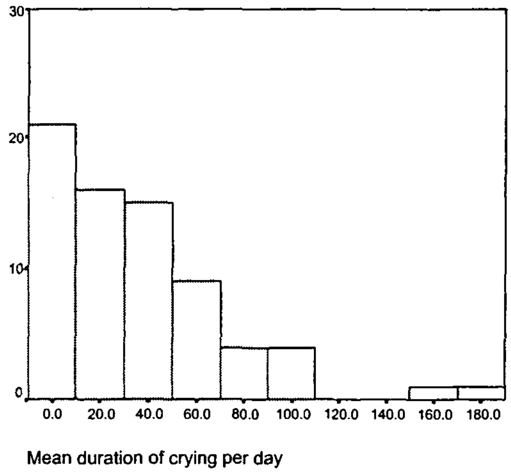
	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age-6*	.368	13.421	3	69	.000
2 *Feeding method*	.001	.058	1	68	.811
2 *Activity* *Distress to limitations* *Fear* *Duration of orientation* *Smiling and laughter* *Soothability*	.081	1.523	6	62	.185

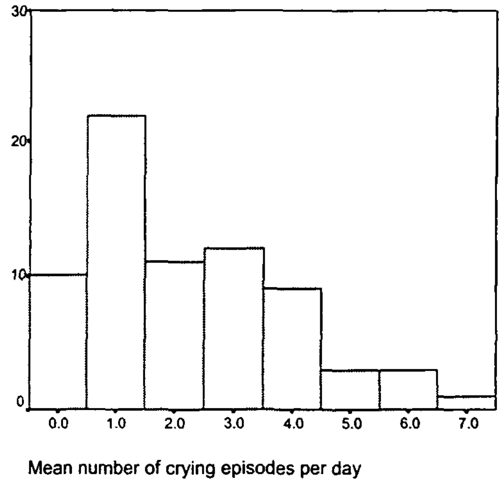
Infant behaviour

Additional data on the infant's behavioural characteristics were gathered from a diary completed by the mother over two days (Barr et al., 1988). Data were missing for four infants. The diary provided information on four behaviours; feeding, sleeping, crying and fussing. For each of these behaviours the average time spent (minutes per day) and the average number of episodes per day were calculated. An episode was defined as the occurrence of a certain behaviour (by Barr et al., 1988). In instances where behaviours were separated from the same behaviour for less than five minutes, the episode would include both occurrences. Data on each behaviour was averaged over the two days; the mean number of minutes per day, and the mean number of episodes per day were generated by dividing the total by two. Figure 7.2 shows the distribution of the *mean duration* per day in minutes and the *mean number of episodes* per day for the eight behaviour variables.

Figure 7.2 Distributions of the *mean duration* and *mean number of episodes* per day for each infant behaviour variable



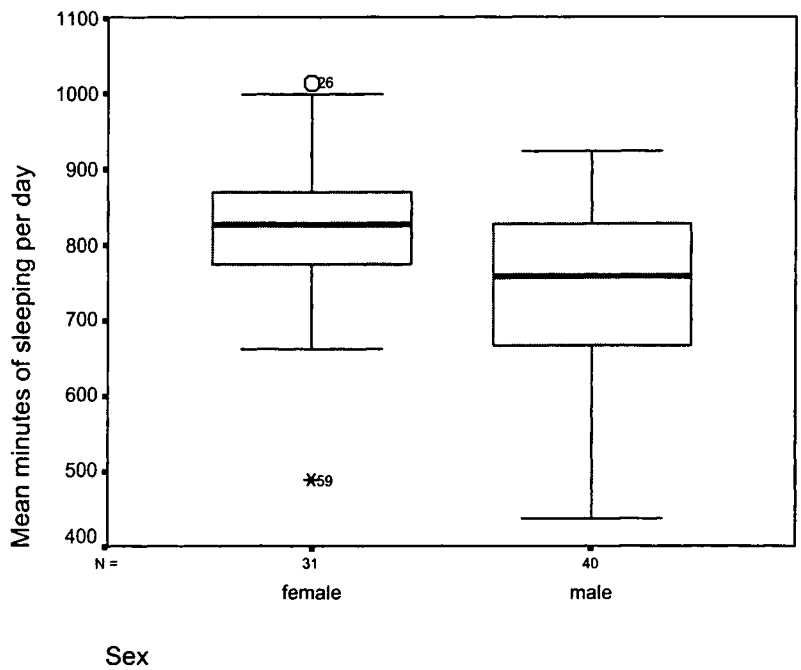




The median of the *mean duration of sleeping per day* was approximately thirteen hours (median = 800 minutes) and the median of the *mean number of sleeping episodes* was approximately seven (median = 7.5). The median of the *mean duration of feeding per day* was 157 minutes, and the median *mean number of feeding episodes* per day was six. The median of the *mean duration of fussing per day* was approximately twice the median of the *mean duration of crying per day* (60 min vs. 25 min). The median of the *mean number of episodes of fussing per day* (4) was twice as much as the median of the *mean number of episodes of crying per day* (2).

Differences in these infant behaviours were assessed according to the infant's sex and feeding method. A Mann-Whitney test was carried for the eight variables, first of all to assess the differences between females and males. A significant differences was only found for the *mean duration of sleeping per day* ($Z = -2.64$, $p = 0.008$), with girls sleeping significantly more than boys (825 mins vs 757.5 mins). The boxplots in Figure 7.3 illustrates the differences in sleeping behaviour between the sexes.

Figure 7.3 Boxplots of *mean duration of sleeping per day* for males and females



The boxplot in Figure 7.4 shows two outliers (nr 26, nr 59) for sleeping behaviour in two females. One female infant spent more than 16 hours a day sleeping (26), whereas the other female spent a little more than eight hours a day sleeping (59).

Differences on the behaviour variables between breast and bottlefeeding infants were examined. The results of a Mann-Whitney test are shown in Table 7.8. Breastfeeding infants differ significantly from bottlefeeding infants on sleeping and feeding behaviour. Breastfeeding infants spend less time per day sleeping but have more episodes per day compared to bottlefeeding infants. Breastfeeding also spend more time a day feeding and in comparatively more episodes than bottlefeeding infants. No differences were found on fussing and crying behaviour in this analysis.

Table 7.8 Results of a Mann-Whitney test of the *mean duration* and the *mean number of episodes* for infant behaviour according to the feeding method

Infant behaviour	Feeding method	N	Median	Z	*p*
Mean duration of sleeping per day	breast	22	683.75	–4.04	.000
	bottle	49	825.00		
Mean number of sleeping episodes per day	breast	22	8.25	–2.93	.003
	bottle	49	7.00		
Mean duration of feeding per day	breast	22	216.25	–4.32	.000
	bottle	49	135.00		
Mean number of feeding episodes per day	breast	22	9.50	–5.92	.000
	bottle	49	5.50		
Mean duration of fussing per day	breast	22	61.25	–.07	.940
	bottle	49	60.00		
Mean number of fussing episodes per day	breast	22	4.00	–1.05	.295
	bottle	49	3.50		
Mean duration of crying per day	breast	22	23.75	–.55	.583
	bottle	49	30.00		
Mean number of crying episodes per day	breast	22	2.00	–.39	.698
	bottle	49	1.50		

The relationship between the frequencies and durations can be seen in a scatterplot relating the two. To illustrate the difference between breast and bottlefed infants the infants were identified according to their feeding method within the plot. Figure 7.4 outlines the relationship between *the mean duration of sleeping per day* and the *mean number of episodes of sleeping per day*, which clearly illustrates that breastfeeding infants spent less time sleeping but had more episodes of sleeping.

Figure 7.4 Scatterplot showing the relationship between the *mean duration of sleeping per day* and *mean number of episodes of sleeping per day*, with infants identified by *feeding method*

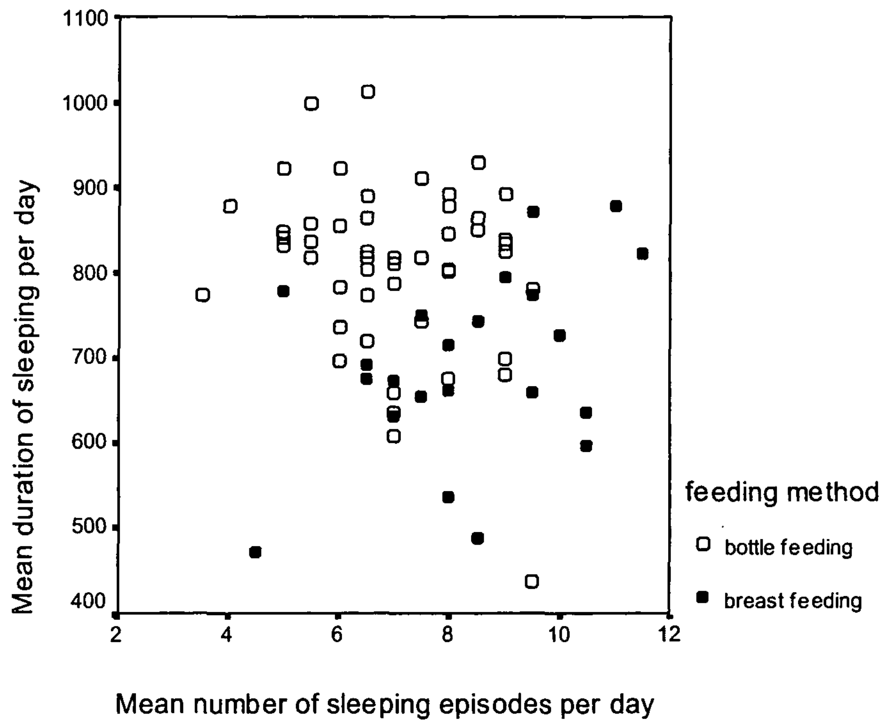


Figure 7.5 illustrates the relationship between the *mean duration of feeding per day* and *mean number of episodes of feeding per day* for infants with a different feeding method. The figure very clearly illustrates the difference between breast and bottlefeeding. Breastfeeding infants tended to feed more frequently and spent more time a day feeding. There is an outlier in the top right hand corner (X ~ 15, Y ~ 750), a breastfeeding infant who spent over ten hours a day feeding. This is in fact the same infant who in Figure 7.3 showed extreme sleeping behaviour, sleeping less than nine hours a day (infant 59). In summary, this infant spent a large amount of time a day feeding, and spent relatively little time sleeping.

Figure 7.5 Scatterplot showing the relationship between the *mean duration of feeding per day* and the *mean number of episodes of feeding per day*, with infants identified on *feeding method*

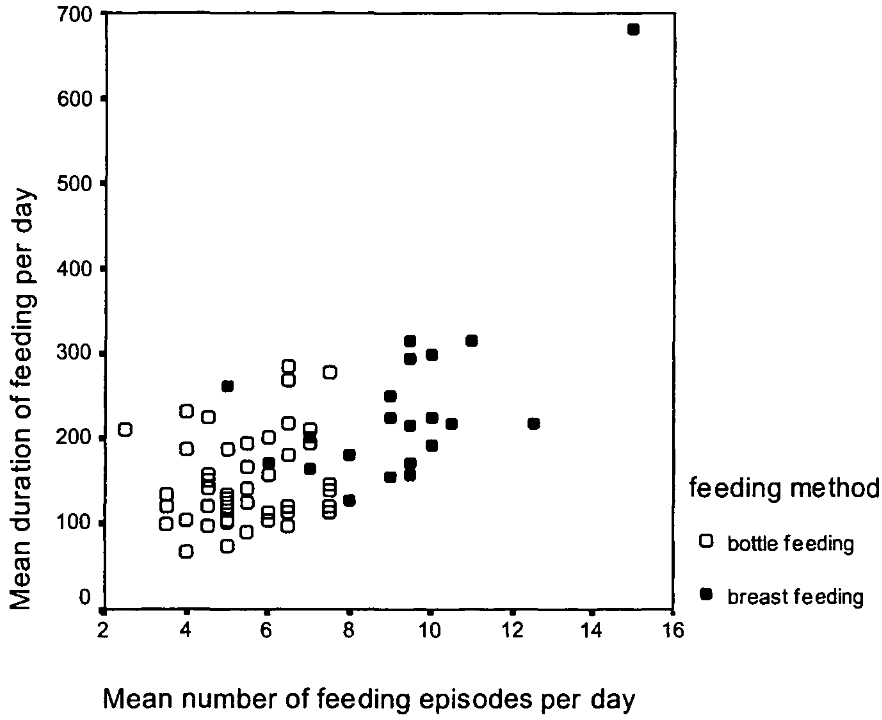


Figure 7.6 and 7.7 illustrate the relationship between the mean duration and mean number of episodes of fussing and crying respectively. The figures show that breast and bottlefeeding infants do not obviously differ for these behaviours. The figures do, however, show the strong relationship between the mean duration and the mean number of episodes for these behaviours.

Figure 7.6 Scatterplot showing the relationship between the *mean duration of fussing per day* and the *mean number of episodes of fussing per day*, with infants identified by *feeding method*

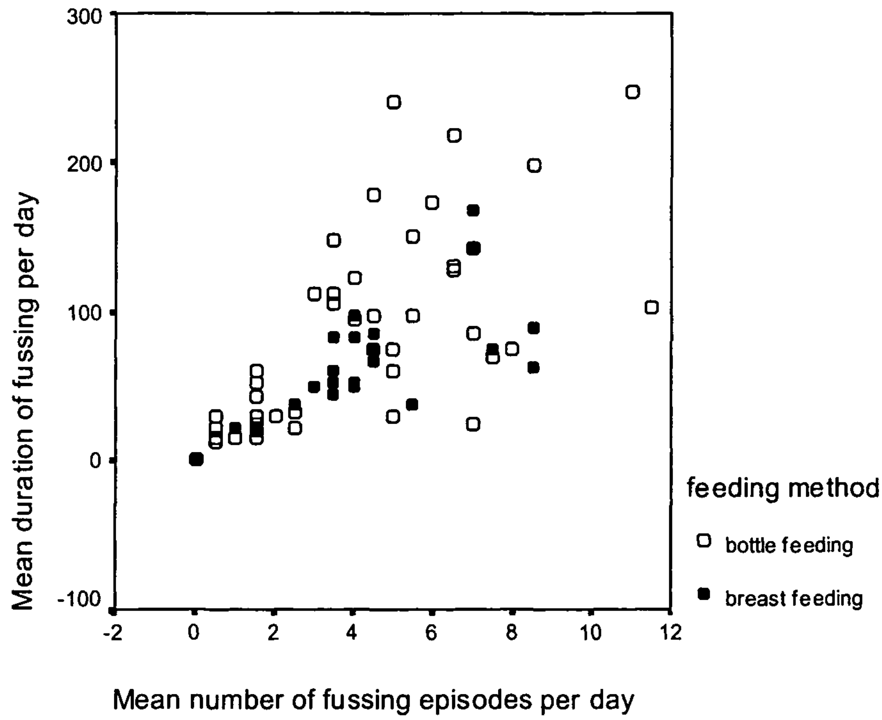
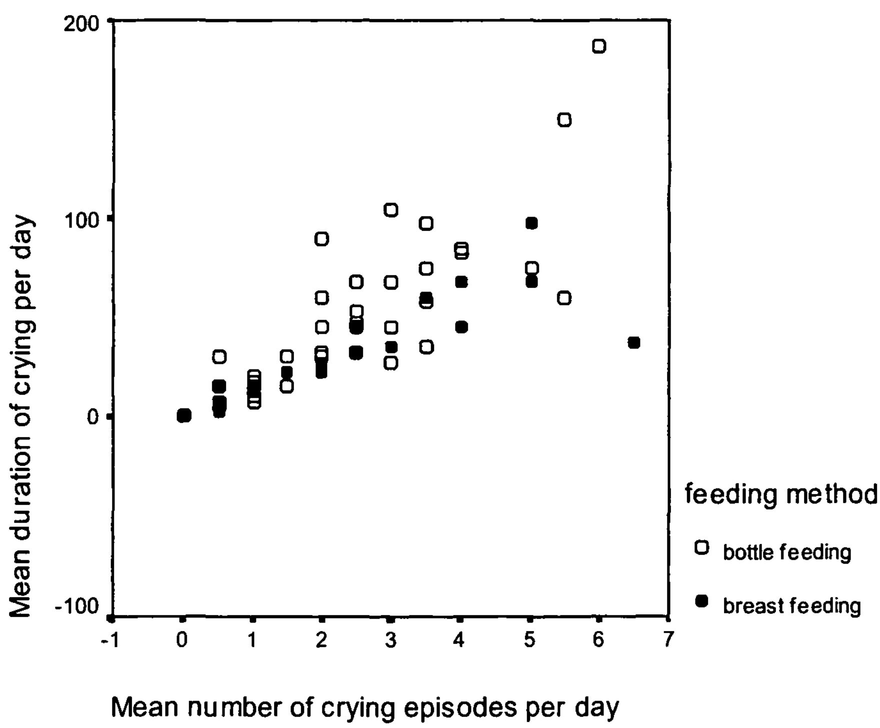


Figure 7.7 Scatterplot showing the relationship between the *mean duration of crying per day* and the *mean number of episodes of crying per day*, with infants identified by *feeding method*



As these scatterplots show the *mean duration* and the *mean number of episodes* for each behaviour variable were highly correlated (feeding: r = 0.64, p = 0.000; fussing: r = 0.69, p = 0.000; crying: r = 0.82, p = 0.000) with the exception of sleeping (r = -0.18, p = 0.14).

Since the duration and number of episodes of the behaviour variables were highly correlated the *mean duration per episode* for each variable was calculated, by dividing the mean duration per day by the mean number of episodes per day for each. A *t*-test was carried out, comparing infants on *feeding method* on these new variables. Table 7.9 outlines the findings.

Table 7.9 Results of a *t*-test of the *mean duration per episode* (mean duration per day divided by mean number of episodes per day) for each behaviour according to the *feeding method*

Behaviour variable	Feeding method	N	df	Mean	*t*	*p*
Mean duration of sleeping per episode	breast	22	69	86.41	–4.35	.000
	bottle	49		122.22		
Mean duration of feeding per episode	breast	22	69	25.97	–1.00	.317
	bottle	49		28.98		
Mean duration of fussing per episode	breast	22	69	15.36	–1.89	.063
	bottle	49		21.25		
Mean duration of crying per episode	breast	22	69	12.06	–1.65	.103
	bottle	49		16.53		

Table 7.9 shows that breast and bottlefeeding infants differed on sleeping behaviour. Sleeping episodes for breastfeeding infants were significantly shorter than those of bottlefeeding infants. The average sleeping episode is 86 min for a breastfeeding infant, and 122 min for a bottlefeeding infant, which

constitutes a significant difference (t = 4.35, p = 0.000). The infants did not differ on any of the other variables in Table 7.9.

Since the *mean duration per episode* was unrelated to the *mean number of episodes* for each behaviour, the mean duration per episode was added to a regression analysis, together with the mean number of episodes per day for each behaviour. These eight variables were examined in relation to weight gain over the first eight weeks and over the first six months.

First of all, a regression was carried out for weight at eight weeks on *birthweight* (g), *sex* (0 female, 1 male), and *age* (days) as the first step. Next *feeding method* (0 breast, 1 bottle) was added as the second step, and the behaviour variables as the third step. The change statistics for this regression (Table 7.10) show that the behaviour variables did not have a significant relationship with weight at eight weeks ($F_{8,58}$ = 0.861, p = 0.554).

Table 7.10 Change statistics of regression of weight at eight weeks on *birthweight*, *sex*, *age* and *feeding method* and the mean duration per episode and mean number of episodes for the behaviour variables

Step	Change Statistics ΔR^2	ΔF	Δdf regression	df residual	p
1 *Birthweight* *Sex* *Age*	.455	18.629	3	67	.000
2 *Feeding method*	.012	1.478	1	66	.228
3 *Mean duration of sleeping per episode* *Mean duration of feeding per episode* *Mean duration of fussing per episode* *Mean duration of crying per episode* *Mean number of episodes of sleeping per day* *Mean number of episodes of feeding per day* *Mean number of episodes of fussing per day* *Mean number of episodes of crying per day*	.057	.861	8	58	.554

The same analysis was carried for weight gain from birth to six months on *birthweight* (g), *sex* (0 female, 1 male), *age-6* (days), *feeding method* (0 breast, 1 bottle) and the mean duration per episode and the mean number of episodes for the behaviour variables. The change statistics (Table 7.11) show that at six months these variables did not have a significant overall effect ($F_{8,58} = 0.775$, $p = 0.626$).

Table 7.11 Change statistics of regression of weight at six months on *birthweight*, *sex*, *age* and *feeding method* and the mean duration per episode and the mean number of episodes per day for the behaviour variables

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age-6*	.363	12.727	3	67	.000
2 *Feeding method*	.000	.019	1	66	.891
3 *Mean duration of sleeping per episode* *Mean duration of feeding per episode* *Mean duration of fussing per episode* *Mean duration of crying per episode* *Mean number of episodes of sleeping per day* *Mean number of episodes of feeding per day* *Mean number of episodes of fussing per day* *Mean number of episodes of crying per day*	.061	.775	8	58	.626

In summary, the mean duration of an episode of behaviours such as sleeping, feeding, fussing, and crying did not have any significant relationship with weight gain from birth to eight weeks, or weight gain from birth to six months.

Infant temperament and behaviour

Next the variables measuring infant characteristics discussed in the previous two sections were investigated in relation to each other. The correlations between the scores on the temperament variables and the behaviour variables from the diary were examined. Table 7.12 shows the Pearson correlations between the variables.

Table 7.12 Pearson correlations between the temperament variables and the *mean duration* and *mean number of episodes* for each of the behaviour variables from the diary (*ns* indicates a non-significant results)

		Activity	*Distress to limitations*	*Fear*	*Duration of orientation*	*Smiling and laughter*	*Soothability*
Mean duration of sleeping per day	*r*	–.343	–.315	–.179	.113	.072	–.071
	p	.003	.007	*ns*	*ns*	*ns*	*ns*
Mean number of episodes of sleeping per day	*r*	.054	.117	.201	.107	–.145	–.100
	p	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Mean duration of feeding per day	*r*	.161	.120	.109	–.187	.026	–.035
	p	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Mean number of episodes of feeding per day	*r*	.092	.221	.174	–.298	–.166	–.130
	p	*ns*	*ns*	*ns*	.012	*ns*	*ns*
Mean duration of fussing per day	*r*	.006	.413	.098	–.128	–.242	.102
	p	*ns*	.000	*ns*	*ns*	.042	*ns*
Mean number of episodes of fussing per day	*r*	.181	.424	.135	–.016	–.290	.050
	p	*ns*	.000	*ns*	*ns*	.014	*ns*
Mean duration of crying per day	*r*	.307	.468	.359	–.091	–.243	.180
	p	.010	.000	.002	*ns*	.042	*ns*
Mean number of episodes of crying per day	*r*	.334	.515	.425	–.207	–.348	.050
	p	.005	.000	.000	*ns*	.003	*ns*

From Table 7.12 it is clear that there are certain correlations between the temperament variables and the behaviour variables as assessed by the two-day diary. First of all, *activity* was significantly correlated with the *mean duration of sleeping per day*, so that an infant with high levels of activity tended to spend less time sleeping each day. In addition, *activity* was positively related to the *mean number of episodes of crying per day. Distress to limitations*, which refers to the infant's irritability, was highly significantly correlated with the *mean duration of fussing and crying per d*ay and the *mean number of episodes of fussing and crying per day*, in so much that an irritable infant spent more time fussing and crying, as would be expected. A negative correlation between *distress to limitations* and the *mean number of minutes of sleeping per day* was found as well. Another finding was that infants who scored high on *fear* spent more time crying. These findings provide additional information, recorded in behavioural diaries, on behaviour of infants with certain temperament characteristics, as rated by the mother. High levels of *fear* were associated with slow weight gain, as reported earlier in the chapter, and these findings show that these infants are likely to spend more time crying. It must be taken into account that although the mentioned correlations were highly significant, the correlation coefficients were not very high.

Conclusions

The findings in this chapter show that weight at eight weeks was significantly related to the infant's level of *fear* and *activity*. High levels of fear and activity were associated with slow weight gain from birth to eight weeks. Infants that showed distress and rejection when presented with novel objects or persons (high levels of *fear*) were more likely to have slow weight gain. Infants who were active were more likely to have slow weight gain. With inclusion of the feeding method (breast or bottle) the relationship of *fear* with weight at eight weeks became stronger. However, the relationship of *activity* with weight at eight weeks diminished and became non-significant. A test of the relationship between temperament variables and the infant's feeding method did not indicate a significant difference for the infant's activity level. The only significant difference according to the infant's feeding method was *duration of orientation*. Infants who were breastfed had lower levels of attention as measured by the variable *duration of orientation*, than infants who were bottlefed.

There is an indication in the results that increased *distress to limitations* is associated with fast weight gain, which corresponds to previous findings (Wells et al., 1996, 1997; Carey, 1985). The relationship found in the current study, however, was not statistically significant.

Infant temperament did not present a significant relationship with weight at six months. Infants behaviour variables as assessed by the two-day diary did not show a relationship with weight gain over the first eight weeks or the first six months. However, sex differences and differences according to feeding method were found in relation to the behaviour variables. Females tended to sleep more than males. Breastfeeding infants slept significantly less every day, but had more sleeping episodes per day. Breastfeeding infants also fed more frequently, and on average for more minutes per day.

In the last section in this chapter the temperament variables were related to the behaviour variables. Infants with high levels of *activity* spent less time sleeping and more time crying. Infants with high levels of *distress to limitation* spent more time fussing and crying, and less time sleeping. Finally, infants with high levels of *fear*, spend more time crying. This indicates that infants with higher levels of *fear* are more likely to have slow weight gain, as shown before, and spend more time crying.

Chapter Eight

Maternal and interaction characteristics and weight gain

Maternal and interactional characteristics and weight gain

In this chapter certain maternal characteristics were investigated as well as characteristics of the interaction between the mother and the infant. First of all, the mother's eating behaviour was assessed, and related to weight gain in the first eight weeks and six months. Secondly, the mother's adaptation to motherhood was assessed. The relationship with the husband, satisfaction with motherhood and support from family and friends were among the adaptation variables that were investigated in relation to weight gain from birth to eight weeks and six months. Finally, in this chapter mother-infant interaction and its relationship to weight gain from birth to eight weeks, and birth to six months was investigated. In addition, differences between characteristics of the mothers of male and female infants and breast and bottlefed infants were examined.

Maternal eating behaviour

The mother's eating behaviour was assessed using the Dutch Eating Behaviour Questionnaire (DEBQ; van Strien et al., 1986). It provides information on three behaviours: *restrained eating*, *emotional eating* and *external eating*. *Restrained eating* refers to restricting food intake, i.e. dieting, in order to control weight. *Emotional eating* refers to using eating as a response to certain emotional states, such as anger and anxiety, and the variable *external eating* assesses a person's tendency to eat in response to food-related stimuli. Information on all the subscales was missing for one mother, and for another mother information was not available for the *external eating* behaviour subscale.

Figures 8.1 to 8.3 show the distribution of the three eating behaviour variables.

Figure 8.1 Distribution of the scores on *restrained eating*

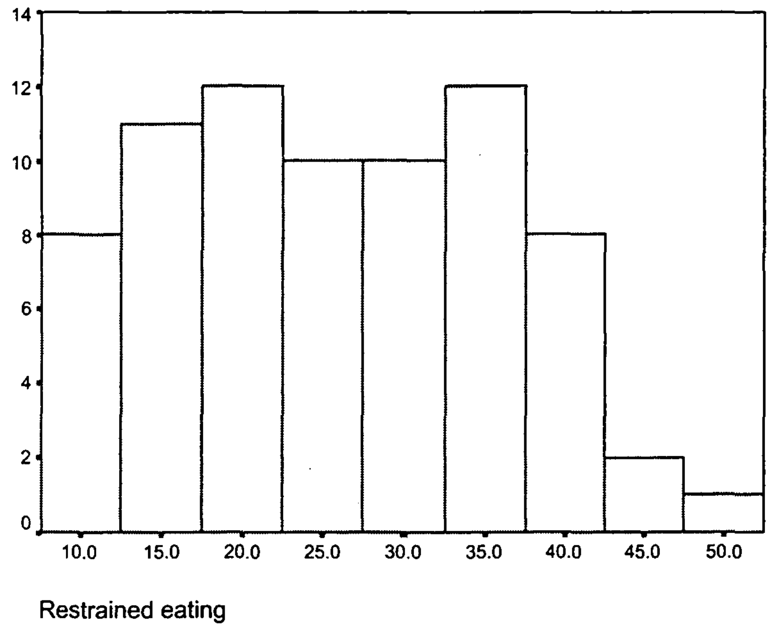


Figure 8.2 Distribution of scores on *emotional eating*

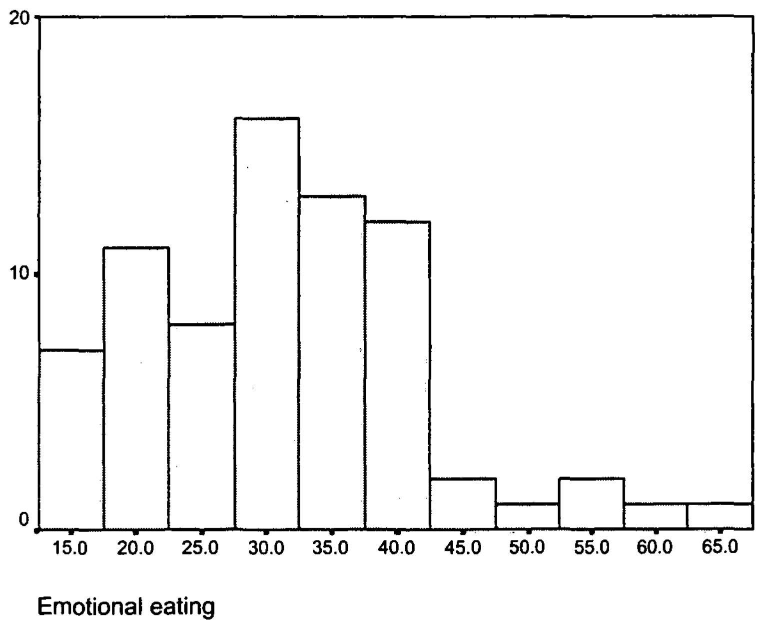
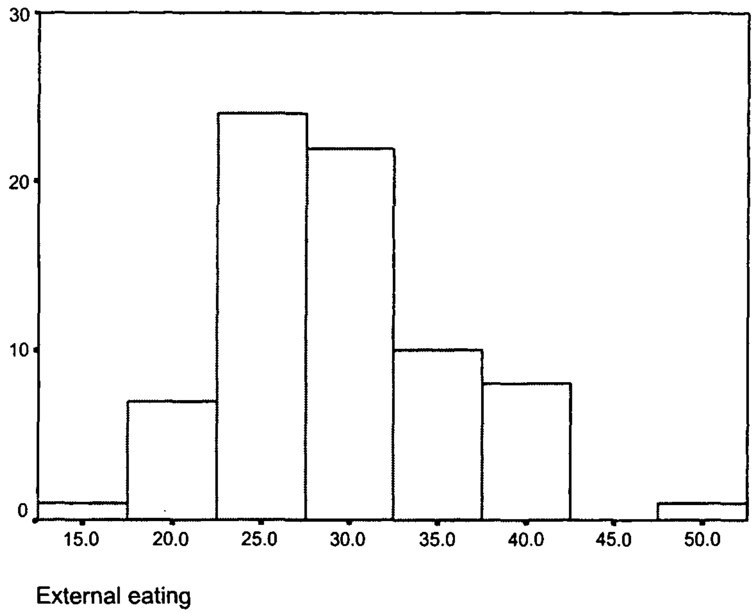


Figure 8.3 Distribution of scores on *external eating*



Eating behaviour might differ for mothers who are breastfeeding from mothers who are bottlefeeding. A breastfeeding mother needs to consider her own nutritional intake in relation to her infant's nutritional needs (Akre, 1989), and might have a different attitude to her own eating behaviour. The mean scores for both groups showed that breastfeeding mothers have a lower average score than bottlefeeding mothers on *restrained eating* behaviour (23.8 vs. 26.6) whereas breastfeeding mothers have a higher mean score on *emotional eating* behaviour (33.2 vs. 30.1). For external eating the scores were very similar (29.1 for breastfeeding mothers, 29.6 for bottlefeeding mothers). The distributions of the eating behaviour variables were roughly normally distributed and therefore a *t*-test was performed to assess possible differences for mothers who breastfeed and mothers who bottlefeed. As shown in Table 8.1 there were no significant differences on *restrained eating*, *emotional eating* or *external eating*.

The distributions for mothers with males and females was examined as well, and the results show that mothers of females tend to score higher on all three dimensions of eating behaviour. A *t*-test was carried out to assess whether these differences were statistically significantly different. There were no significant differences on either *restrained eating*, *emotional eating*, or *external eating* according to whether mothers had male or female infants (Table 8.1).

Table 8.1 *T*-tests of the maternal eating behaviour variables according to sex and feeding method

		N	Mean	*t*	*p*
Restrained eating					
	female	32	27.5	1.35	.181
	male	42	24.3		
	breast	23	23.8	−1.08	.285
	bottle	51	26.6		
Emotional eating	female	32	32.3	.80	.427
	male	42	30.3		
	breast	23	33.2	1.10	.276
	bottle	51	30.2		
External eating	female	31	30.7	1.47	.146
	male	42	28.5		
	breast	23	29.1	−.30	.765
	bottle	50	29.6		

An analysis of the relationship among the eating behaviour variables showed significant relationships between all the variables (Table 8.2). Therefore in the following regression analyses all the variables were added.

Table 8.2 Correlations between the maternal eating behaviour variables, i.e. *restrained eating*, *emotional eating* and *external eating*

		Restrained eating	*Emotional eating*
Emotional eating	*r*	.347	
	p	.002	
	n	74	
External eating	*r*	.233	.318
	p	.048	.006
	n	73	73

The relationship with weight at eight weeks (g) was assessed using a regression analysis with three steps, first of all *birthweight* (g), *sex* (0 female, 1 male), *age* (days), secondly the infant's *feeding method* (0 breast, 1 bottle), and finally the eating behaviour variables.

The change statistics in Table 8.3 show that the three maternal eating behaviour variables did not contribute significantly to the prediction of the infant's weight at eight weeks ($F_{3, 65} = 0.448, p = 0.719$). Table 8.4 shows the change statistics for a similar analysis using weight at six months as the outcome variable.

Table 8.5 shows that the variable *restrained eating* behaviour is nearing significance as a predictor of weight at six months. With every unit increase in the score on *restrained eating* weight at six months was on average 21 g higher. The indication is that higher levels of *restrained eating* in the mother is associated with faster weight gain from birth to six months. However, the relationship is not statistically significant, and the change statistics show that the addition of eating behaviour variables does not predict weight at six months weeks ($F_{3, 65} = 1.298, p = 0.283$).

Table 8.3 Change statistics of regression of weight at eight weeks on *birthweight*, *sex*, *age*, *feeding method* and maternal eating behaviour variables

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age*	.442	18.220	3	69	.000
2 *Feeding method*	.011	1.366	1	68	.247
3 *Restrained eating* *Emotional eating* *External eating*	.011	.448	3	65	.719

Table 8.4 Change statistics of regression of weight at six months on *birthweight*, *sex*, *age-6*, *feeding method* and maternal eating behaviour variables

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Birthweight* *Sex* *Age-6*	.350	12.387	3	69	.000
2 *Feeding method*	.001	.111	1	68	.740
3 *Restrained eating* *Emotional eating* *External eating*	.037	1.298	3	65	.283

Table 8.5 Regression of weight at six months (g) on *birthweight* (g), *sex* (0 female, 1 male), and *age-6* (days), *feeding method* (0 breast, 1 bottle) and maternal eating behaviour variables

	B	SE B	*t*	*p*
Constant	4931.40	1080.36	4.56	.000
Birthweight	.62	.26	2.37	.021
Sex (male)	1115.68	233.44	4.78	.000
Age-6	10.12	10.11	1.00	.321
Feeding method	35.57	241.53	.15	.883
Restrained eating	21.29	11.77	1.81	.075
Emotional eating	1.75	11.71	.15	.881
External eating	-12.44	18.46	-.67	.503

Analysis of Variance	Df	Sum of squares	Mean square	*F*	*p*
Regression	7	35386881	5055268.7	5.88	.000
Residual	65	55872941	859583.7		
Total	72	91259822			

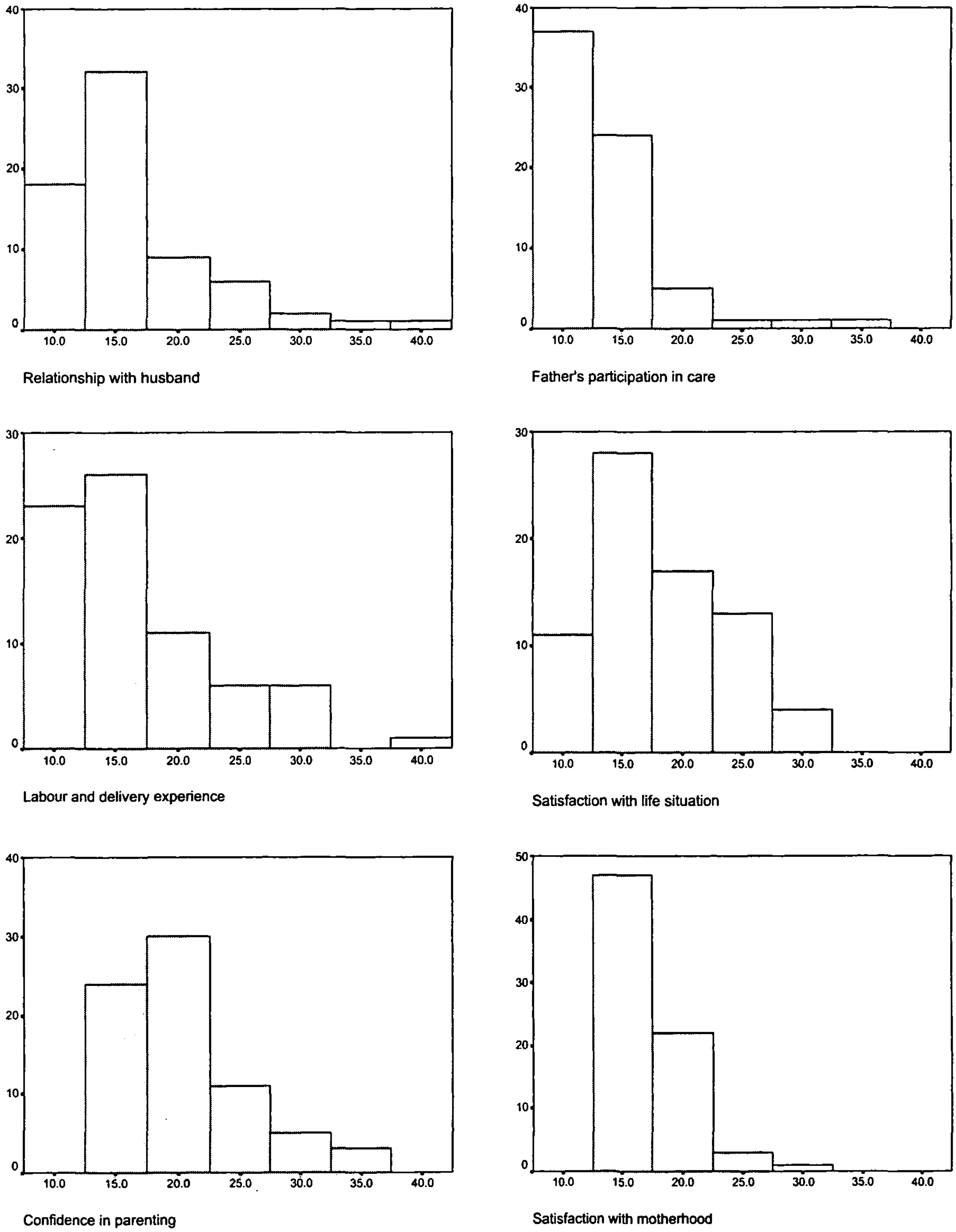
Multiple R	.62
R square	.39
Adjusted R square	.32
Standard error	927.14

In summary, the results have shown that the mother's eating behaviour as assessed by the DEBQ is not related to weight gain from birth to eight weeks, or birth to six months, although the relationship of restrained eating and weight at six months was nearing significance.

Adaptation to motherhood

Mothers completed a questionnaire on their adaptation to motherhood, the Postpartum Self-evaluation Questionnaire (PSQ; Lederman et al., 1981). The questionnaire consisted of seven subscales: quality of the relationship with the husband, mother's perception of the father's participation in child care, mother's gratification from her labour and delivery experience, mother's satisfaction with her life situation, mother's confidence in her ability to cope with the tasks of motherhood, mother's satisfaction with motherhood and infant care, and support for the maternal role from parents and from friends and family members. High scores on these variables indicates decreased satisfaction. Information was missing for two mothers on all subscales, since the questionnaires failed to reach the researcher in the post. In addition, information on the two subscales relating to the husband was unavailable for four mothers. The mothers were unable to provide the information because they were no longer in a relationship with the father of the infant. One mother had visibly changed the answers relating to her husband, to more favourable answers. Since the change was so obvious these items were assumed to be untrustworthy and therefore excluded from the analysis. Figure 8.4 shows the distributions of the scores on the variables on the mother's adaptation to motherhood.

Figure 8.4 Distribution of scores on maternal adaptation variables



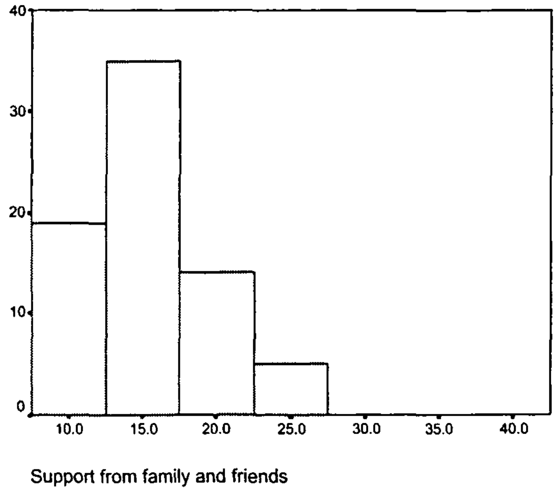


Figure 8.4 shows that the scores on the variables were mostly positively skewed, which means the scores were on the lower end of the distribution. A Mann-Whitney test was carried to assess differences on these variables between male and female and breast and bottlefed infants.

The results in Table 8.6 show that there were no differences in scores between breast and bottlefeeding infants, however one variable showed a difference according to the infant's sex ($Z = -2.49$, $p = 0.013$). Mothers with females (median = 16) scored higher than mothers with males (median = 13) on the variable *relationship with the husband*, and since lower scores on these variables indicate more positive feelings, this means that mothers of males tended to rate the relationship with their husband more positively.

Next the maternal adaptation variables were investigated in relation to weight gain from birth to eight weeks and six months. Table 8.7 outlines the change statistics for the multiple regression in three steps of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), *age* (days), *feeding method* (0 breast, 1 bottle) and the maternal adaptation variables. The table also contains the change statistics of the regression with weight at six months as the dependent variable.

Table 8.6 Mann-Whitney test for differences on maternal adaptation variables according to *sex* and *feeding method*

		N	Median	Z	*p*
Relationship with husband					
	female	28	16	−2.49	.013
	male	41	13		
	breast	23	13	−1.21	ns
	bottle	46	14.5		
Father's particpation in care	female	28	12	−.23	ns
	male	41	13		
	breast	23	12	−.68	ns
	bottle	46	12		
Labour and delivery experience	female	28	14.5	−1.90	ns
	male	41	17		
	breast	23	17	−1.18	ns
	bottle	46	14.5		
Satisfaction with life situation	female	28	17	−.11	ns
	male	41	17		
	breast	23	18	−.23	ns
	bottle	46	17		
Confidence in parenting	female	28	19	−.46	ns
	male	41	19		
	breast	23	19	−.77	ns
	bottle	46	19		
Satisfaction with motherhood	female	28	17	−.94	ns
	male	41	16		
	breast	23	16	−.61	ns
	bottle	46	16.5		
Support from family and friends	female	28	15	−.20	ns
	male	41	14		
	breast	23	15	−1.04	ns
	bottle	46	14.5		

Table 8.7 Change statistics of the regression analyses of weight at eight weeks on *birthweight*, *sex*, *age*, *feeding method* and the maternal adaptation variables, and weight at six months on *birthweight*, *sex*, *age-6*, *feeding method* and the maternal adaptation variables

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
Outcome variable weight at eight weeks					
1					
Birthweight *Sex* *Age*	.490	20.812	3	65	.000
2					
Feeding method	.011	1.468	1	64	.230
3					
Relationship with husband *Father's participation in care* *Labour and delivery experience* *Satisfaction with life situation* *Confidence in parenting* *Satisfaction with motherhood* *Support from family and friends*	.031	5.38	7	57	.802
Outcome variable weight at six months					
1					
Birthweight *Sex* *Age-6*	.404	14.665	3	65	.000
2					
Feeding method	.001	.090	1	64	.765
3					
Relationship with husband *Father's participation in care* *Labour and delivery experience* *Satisfaction with life situation* *Confidence in parenting* *Satisfaction with motherhood* *Support from family and friends*	.040	.580	7	57	.769

Table 8.7 shows that weight gain in the early months was not related to the mother's adaptation to motherhood. There was no overall significant effect of the maternal adaptation variables on weight gain as shown by the change statistics ($F_{7,57} = 0.538$, $p = 0.802$; $F_{7,57} = 0.580$, $p = 0.769$). Neither weight at eight weeks or weight at six months were significantly related to any of the adaptation variables.

Maternal eating behaviour and adaptation to motherhood

Maternal adaptation was investigated in relation to the variables discussed in the previous section, the mother's eating behaviour. Correlations were assessed and are given in Table 8.8. The *n*'s for the correlations varied for each correlation ($68 < n < 73$). Some mothers were without a partner at the time of the home visit, and would therefore not complete the sections on the *relationship with the husband* and the *father's participation in care.* In addition, some questionnaires were lost in the post; mothers insisted they had posted the questionnaire, but they never arrived.

The correlations in Table 8.8 show that there are certain relationships between the maternal eating behaviour variables and the maternal adaptation variables. In reviewing the table it must be kept in mind that high scores on the maternal adaptation variables means a negative outcome, for instance a high score on *confidence in motherhood* indicates low confidence in the mother. First of all, *restrained eating* behaviour in the mother was positively related to the relationship with the husband, confidence in parenting, and satisfaction with motherhood. A mother with restrained eating behaviour was more likely to have an unsatisfactory relationship with the father of the infant, and feel less satisfied with motherhood, and feel less confident about her abilities as a mother. The relationship of restrained eating behaviour was most strongly related to the level of satisfaction with motherhood (r = 0.512, p = 0.000), which is illustrated in Figure 8.5.

Table 8.8 Pearson correlations of maternal eating behaviour variables and maternal adaptation variables (68 < n < 73, *ns* indicates a non-significant relationship)

		Restrained eating	*Emotional eating*	*External eating*
Relationship with husband	*r*	.282	.543	.063
	p	.019	.000	*ns*
Father's participation in care	*r*	.206	.507	.112
	p	*ns*	.000	*ns*
Labour and delivery experience	*r*	.099	.069	-.097
	p	*ns*	*ns*	*ns*
Satisfaction with life situation	*r*	.222	.131	.102
	p	*ns*	*ns*	*ns*
Confidence in parenting	*r*	.302	.149	-.086
	p	.009	*ns*	*ns*
Satisfaction with motherhood	*r*	.512	.334	.037
	p	.000	.004	*ns*
Support from family and friends	*r*	.107	.156	.089
	p	*ns*	*ns*	*ns*

Figure 8.5 The relationship between *satisfaction with motherhood* and *restrained eating*

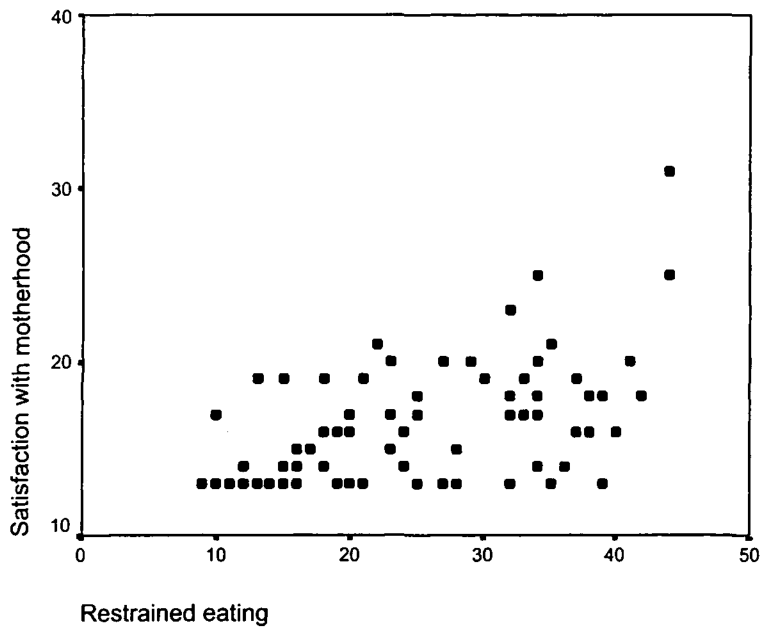


Figure 8.6 The relationship between *relationship with husband* and *emotional eating*

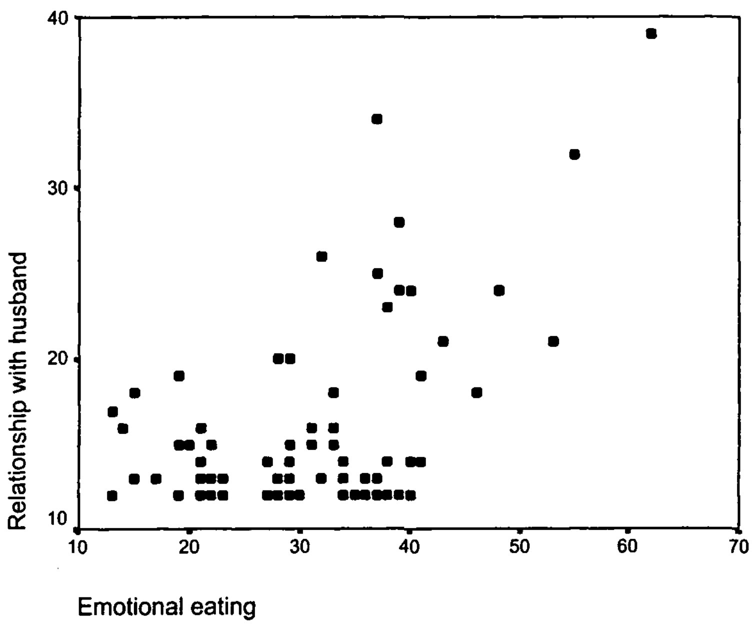


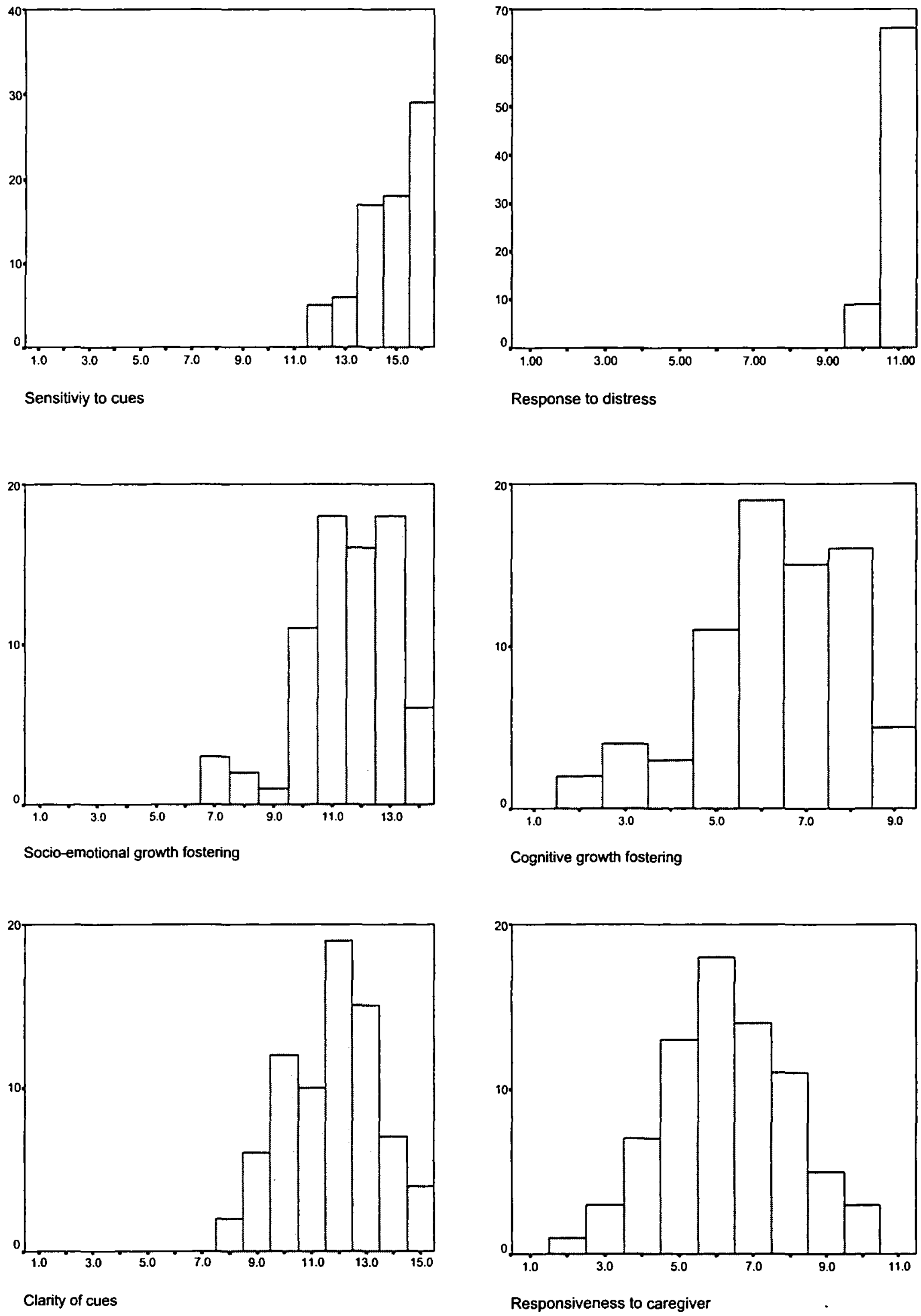
Table 8.8 also shows significant relationships between *emotional eating* behaviour and maternal adaption variables. Emotional eating was found to be positively related to the relationship with the husband, the father's participation in care and satisfaction with motherhood. This means that mothers who showed emotional eating behaviour were dissatisfied with their relationship with the infant's father, the father's participation with the care, and with motherhood. The strongest relationship was found between emotional eating and the relationship with the husband ($r = 0.543$, $p = 0.000$), as illustrated in Figure 8.6.

In summary, the mother's adaptation did not have a significant relationship with weight gain in the infant. Adaptation to motherhood was found to be related to the mother's eating behaviour as reported on the DEBQ.

Mother-infant interaction and weight gain

In this section mother-infant interaction was investigated. Differences according to the infant's feeding method and sex were examined, after which mother-infant interaction was investigated in relation to weight gain in the first eight weeks, and first six months. Mother-infant interaction was scored using the Nursing Child Assessment Feeding Scales (Barnard, 1979). The scales consisted of four variables relating to the mother's behaviour (*sensitivity to cues*, *response to distress*, *socio-emotional growth fostering* and *cognitive growth fostering*) and two variables that related to the infant's behaviour (*clarity of cues* and *responsiveness to caregiver*). The variables have been more extensively discussed in Chapter Two. Figure 8.7 shows the distribution of scores on the six mother-infant interaction variables.

Figure 8.7 Distribution of scores on mother-infant interaction variables, with the X-axis showing the range of possible scores



For each of the variables (subscales) there were items that related to reciprocity during mother-infant interaction, referred to as *contingency* items. An example of a contingency item within the *socio-emotional growth fostering* subscale is 'Caregiver smiles, verbalizes or touches child within five seconds of child smiling or vocalizing at caregiver'. Each subscale relating to the mother's behaviour contained contingency items, and the subscale on the infant's *responsiveness to caregiver* contained contingency items. These contingency items were included in analysis under the following variable names:

Contingency items	**Variable names**
Mother's behaviour	
Contingency items in the subscale on the mother's Sensitivity to cues	*Contingency: sensitivity*
Contingency items in the subscale on the mother's Response to distress	*Contingency: response*
Contingency items in the subscale on the mother's Socio-emotional growth fostering	*Contingency: socio-emotional*
Contingency items in the subscale on the mother's Cognitive growth fostering	*Contingency: cognitive*
Infant's behaviour	
Contingency items in the subscale on the infant's Responsiveness to caregiver	*Contingency: Infant*

First of all, differences between groups were investigated. In a comparison of interaction in mothers with their male infants and mothers with their female infants using a Mann-Whitney test there was no significant difference at $p < 0.05$, two tailed. Secondly, differences in mother-infant interaction were assessed for infants who were breastfed and infants who were bottlefed. A Mann-Whitney test showed a difference for one of the mother-infant interaction variables, as shown in Table 8.9.

Table 8.9 Mann-Whitney test for differences on mother-infant interaction variables according to *feeding method* (*ns* indicates a non-significant result

		N	Median	Z	*p*
Sensitivity to cues	breast	24	16	-3.35	.001
	bottle	51	15		
Response to distress	breast	24	11	-.85	*ns*
	bottle	51	11		
Socio-emotional growth fostering	breast	24	12	-.40	*ns*
	bottle	51	11		
Cognitive growth fostering	breast	24	7	-.82	*ns*
	bottle	51	6		
Clarity of cues	breast	24	12	-.56	*ns*
	bottle	51	12		
Responsiveness to caregiver	breast	24	7	-1.72	*ns*
	bottle	51	6		

Table 8.9 shows that the mother's *sensitivity to cues* differed for infants who were breastfed and infants who were bottlefed ($Z = -3.35, p = 0.001$). Mothers of breastfeeding infants were more sensitive to their infants' cues (median = 16.00) than mothers of bottlefeeding infants (median = 15.00).

Next the relationship between mother-infant interaction and weight gain was explored. A regression analysis of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), *age* (days), *feeding method* (0 breast, 1 bottle), and mother-infant interaction is shown in Table 8.11, with the change statistics shown in Table 8.10.

Table 8.10 Change statistics of regression of weight at eight weeks on *birthweight*, *sex*, *age*, *feeding method* and mother-infant interaction

	Change Statistics				
Step	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1					
Birthweight					
Sex					
Age	.450	19.368	3	71	.000
2					
Feeding method	.012	1.526	1	70	.221
3					
Sensitivity to cues					
Response to distress					
Socio-emotional growth fostering					
Cognitive growth fostering					
Clarity of cues					
Responsiveness to caregiver					
Contingency: sensitivity					
Contingency: response					
Contingency: socio-emotional					
Contingency: cognitive					
Contingency: infant					
	.104	1.291	11	59	.252

Table 8.11 Regression of weight at eight weeks (g) on *birthweight* (g), *sex* (0 female, 1 male), and *age* (days), *feeding method* (0 breast, 1 bottle) and mother-infant interaction variables

	B	SE B	*t*	*p*
Constant	−3756.72	4568.00	−.82	.414
Birthweight	.78	.17	4.62	.000
Sex (male)	648.55	149.35	4.34	.000
Age	41.43	12.57	3.30	.002
Feeding method	207.94	184.94	1.12	.265
Sensitivity to cues	54.61	109.68	.50	.620
Response to distress	764.61	699.03	1.09	.278
Socio-emotional growth fostering	27.82	61.71	.45	.654
Cognitive growth fostering	−76.68	66.48	−1.15	.253
Clarity of cues	-69.17	53.29	−1.30	.199
Responsiveness to caregiver	155.39	65.85	2.36	.022
Contingency: sensitivity	−118.01	192.58	−.61	.542
Contingency: response	−494.17	674.74	−.73	.467
Contingency: socio-emotional	−384.15	251.77	−1.53	.132
Contingency: cognitive	436.40	190.30	2.29	.025
Contingency: infant	−394.30	235.53	−1.67	.099

Analysis of Variance	df	Sum of squares	Mean square	*F*	*p*
Regression	15	26801831.0	1786788.73	5.13	.000
Residual	59	20534137.0	348036.22		
Total	74	47335968.0			

Multiple R	.75
R square	.57
Adjusted R square	.46
Standard error	589.94

From Table 8.11 it can be seen that two variables are significantly associated with weight at eight weeks. First of all, for every unit increase in the infant's *responsiveness to caregiver* the infant weighs on average 155 g more at eight weeks. For every unit increase in the scores on contingency on cognitive growth fostering (*Contingency: cognitive*) items, the infant weighs on average 436 g more. However, the scores on this last variable range from zero to two, so there is not a great amount of variance. Despite this finding the change statistics indicate that the overall influence of the mother-infant interaction variables on the infant's weight at eight weeks is not statistically significant (($F_{11,59} = 1.291$, $p = 0.252$).

The multiple regression analysis of weight at six months (g) on *birthweight* (g), *sex* (0 female, 1 male), *age-6* (days), *feeding method* (0 breast, 1 bottle), and mother-infant interaction is shown in Table 8.13, with the change statitistics in Table 8.12.

For the analysis of weight gain from birth to six months and mother-infant interaction (Table 8.13) the relationship with *Contingency: cognitive* is still significant, so that for every unit increase in score on this variable weight at six months was on average 695 g more. The change statistics (Table 8.12), however, show that the overall effect of mother-infant interaction is not statistically significant ($F_{11,59} = 0.738$, $p = 0.698$)

In summary, weight gain from birth to eight weeks, and birth to six months is not related to mother-infant interaction. One of the aspects of mother-infant interaction, the mother's *sensitivity to cues*, did differ according to the infant's feeding method.

Table 8.12 Change statistics of regression of weight at six months on *birthweight, sex, age-6, feeding method* and mother-infant interaction

Step	Change Statistics ΔR^2	ΔF	Δdf regression	df residual	p
1					
Birthweight					
Sex					
Age-6	.376	14.257	3	71	.000
2					
Feeding method	.000	.036	1	70	.850
3					
Sensitivity to cues					
Response to distress					
Socio-emotional growth fostering					
Cognitive growth fostering					
Clarity of cues					
Responsiveness to caregiver					
Contingency: sensitivity					
Contingency: response					
Contingency: socio-emotional					
Contingency: cognitive					
Contingency: infant					
	.075	.738	11	59	.698

Table 8.13 Regression of weight at six months (g) on *birthweight* (g), *sex* (0 female, 1 male), and *age-6* (days), *feeding method* (0 breast, 1 bottle) and mother-infant interaction variables

	B	SE B	*t*	*p*
Constant	1272.98	7336.86	.17	.863
Birthweight	.71	.28	2.56	.013
Sex (male)	1123.37	239.88	4.68	.000
Age-6	9.00	11.28	.80	.428
Feeding method	−89.69	302.69	−.30	.768
Sensitivity to cues	24.58	179.16	.14	.891
Response to distress	845.47	1128.84	.75	.457
Socio-emotional growth fostering	99.79	102.16	.98	.333
Cognitive growth fostering	−170.47	106.71	−1.60	.115
Clarity of cues	−32.90	86.92	−.38	.706
Responsiveness to caregiver	86.39	106.39	.81	.420
Contingency: sensitivity	−260.26	311.62	−.83	.407
Contingency: response	-852.24	1087.66	−.78	.436
Contingency: socio-emotional	-606.47	430.81	−1.41	.164
Contingency: cognitive	695.48	309.25	2.25	.028
Contingency: infant	−263.19	382.69	−.69	.494

Analysis of Variance	df	Sum of squares	Mean square	*F*	*p*
Regression	15	44339189.1	2955945.94	3.24	.001
Residual	59	53821058.9	912221.34		
Total	74	98160248.0			

Multiple R	.67
R square	.45
Adjusted R square	.31
Standard error	955.10

Mother-infant interaction and maternal adaptation to motherhood

In this section the relationship between the mother's adaptation to motherhood and mother-infant interaction was investigated. Spearman's correlations were carried out between the mother-infant interaction variables and the variables on maternal adaptation to motherhood, as shown in Table 8.13. In Figure 8.7 it can be seen that the mother-infant interaction variables are not all normally distributed, and therefore Spearman's correlations were chosen for the next analysis. The *n*'s for the correlations varied for each correlation ($69 < n < 73$). Four of the mothers were without partner at the time of the home visit, and could therefore not complete the sections on the *relationship with husband* and the *father's participation in care*. In addition, two questionnaires never reached the researcher through the post, even though the mothers insisted they had sent the questionnaires.

Table 8.14 shows that there are certain small correlations between mother-infant interaction and the mother's adaptation to motherhood. First of all, *sensitivity to cues* is negatively associated with *labour and delivery experience* ($r = -0.247$, $p = 0.035$) and *confidence in parenting* ($r = -0.362$, $p = 0.002$). This means that mother's who feel negatively about the birth experience and have low confidence in their ability as a parent are more likely to be less sensitive to their infant's cues during the feeding interaction. Secondly, the mother's *satisfaction with life situation* is negatively associated with *socio-emotional growth fostering* ($r = -0.281$, $p = 0.016$), so that for mothers who are less satisfied with their life situation score lower on socio-emotional growth fostering during the feeding interaction. Finally *labour and delivery experience* is negatively related to the infant's *clarity of cues* ($r = -0.249$, $p = 0.034$), so that mothers who have had a negative birth experience are more likely to have infants who score low on clarity of cues. Despite these findings it should be taken into account that the correlations are quite low, and therefore the relationships are not very strong.

Table 8.14 Spearman correlations between maternal adaptation variables and mother-infant interaction variables (69 <n < 73, *ns* indicates a non-significant relationship)

		Sensitivity to cues	*Response to distress*	*Socio-emotional growth fostering*	*Cognitive growth fostering*	*Clarity of cues*	*Responsiveness to caregiver*
Relationship with husband	*r*	–.011	.068	–.024	.075	.065	.076
	p	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Father's participation in care	*r*	–.025	.115	–.191	.060	.010	.091
	p	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Labour and delivery experience	*r*	–.247	–.023	–.206	.011	–.249	–.090
	p	.035	*ns*	*ns*	*ns*	.034	*ns*
Satisfaction with life situation	*r*	–.161	.090	–.281	–.197	–.093	–.130
	p	*ns*	*ns*	.016	*ns*	*ns*	*ns*
Confidence in parenting	*r*	–.362	.073	–.119	.123	–.063	–.030
	p	.002	*ns*	*ns*	*ns*	*ns*	*ns*
Satisfaction with motherhood	*r*	–.076	.052	–.149	–.112	.055	–.071
	p	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Support from family and friends	*r*	.013	–.032	–.003	–.111	.011	.026
	p	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

Conclusions

In this chapter maternal characteristics and mother-infant interaction were investigated. On the whole none of the variables were found to be related to weight gain.

First of all, maternal eating behaviour was investigated and analysis showed that there were no statistically significant differences in the mother's eating behaviour according to the infant's feeding method. In addition none of the variables, *restrained eating*, *emotional eating* and *external eating* were found to be related to weight gain over the first eight weeks and first six months. The variable *restrained eating* was nearing significance in the relationship with weight at six months.

Secondly, the mother's adaptation to motherhood was investigated and a Mann-Whitney test showed that mother's differed in the relationship with their husband according to the infant's sex. Mothers of female infants tended to be more dissatisfied with the relationship with their husband. No differences were found between breastfed and bottlefed infants, nor were there significant relationships between maternal adaptation variables and weight gain in the infants.

Mothers with *restrained eating* behaviour were more likely to be dissatisfied with the relationship with their husband, have less confidence in mothering, and be less satisfied with motherhood. Mothers who scored high on *emotional eating* behaviour were more dissatisfied with the relationship with their husband and his participation in the care of the infant, and more likely to be less satisfied with motherhood.

The data on mother-infant interaction showed that mothers of breastfeeding infants were more sensitive to their infant's cues, than mothers of bottlefeeding infants. A regression analysis showed that the infant's *responsiveness to cues* was positively related to weight at eight weeks. However, the change statistics showed that mother-infant interaction did not have an overall significant effect on weight gain from birth to eight weeks, so that the relationship between the infant's responsiveness to cues and weight at eight weeks should be considered with great caution. The change statistics for the relationship between mother-infant interaction and weight at six months did not show an overall significant relationship either.

In the last section of this chapter the mother-infant interaction variables were related to maternal adaptation variables. Several small correlations were found. Mothers with low confidence and a negative birth experience were more likely to be less sensitive to their infant's cues. Mothers who were less satisfied with their life situation scored lower on socio-emotional growth fostering. Finally, mothers who had a negative birth experience were more likely to have infants who displayed less clarity of cues. Although the relationships were statistically significant, the correlations were not very high. In addition, a high number of correlations were calculated increasing the probability that several were significant by chance.

Chapter Nine

Temperament and an overall model

Temperament and an overall model

In this chapter temperament was investigated in relation to the maternal and interactional characteristics. Belsky (1984) indicated that the infant's characteristics influence the process of parenting. Cutrona and Troutman (1986) found that difficult behaviour in the infant accounted for 30% of the variance in depressive symptoms in mothers. Therefore, in this chapter the infant's behaviour was investigated in relation to the mother's characteristics and mother-infant interaction. In addition in this chapter, an overall model is presented consisting of the variables that predict weight gain from birth to eight weeks.

First of all, temperament was examined in relation to the mother's adaptation to motherhood. The scores on maternal adaptation were mostly positively skewed and therefore Spearman's correlations were assessed between the temperament variables and the maternal adaptation variables. In reviewing the findings it must be taken into account that high scores on the maternal adaptation variables indicate negative feelings in the mother. The results are presented in Table 9.1.

Table 9.1 Spearman correlations of the relationship between maternal adaptation variables and temperament variables (68 < n < 72, *ns* indicates a non-significant results)

		Activity	*Distress to limitations*	*Fear*	*Duration of orientation*	*Smiling and laughter*	*Soothability*
Relationship with husband	*r*	.253	.239	.171	.001	–.017	.156
	p	.038	.050	*ns*	*ns*	*ns*	*ns*
Father's participation	*r*	.338	.215	.290	–.090	–.026	.122
	p	.005	*ns*	.016	*ns*	*ns*	*ns*
Labour and delivery experience	*r*	.058	.149	.100	–.075	–.198	.011
	p	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Satisfaction with life situation	*r*	–.071	.044	.239	–.049	.030	.190
	p	*ns*	*ns*	.043	*ns*	*ns*	*ns*
Confidence in parenting	*r*	.286	.185	.158	–.065	.025	.218
	p	.015	*ns*	*ns*	*ns*	*ns*	*ns*
Satisfaction with motherhood	*r*	.122	.320	.168	–.095	–.072	.197
	p	*ns*	.006	*ns*	*ns*	*ns*	*ns*
Support from family and friends	*r*	–.082	.173	.306	–.057	–.216	–.145
	p	*ns*	*ns*	.009	*ns*	*ns*	*ns*

From Table 9.1 it can be seen that several infant temperament characteristics are related to the mother's adaptation to motherhood. First of all, *activity* level is positively associated with *the mother's relationship with her husband, the father's participation in care* and *the mother's confidence in parenting.* In other words, mothers with infants who were very active were more likely to be dissatisfied with the relationship with the husband and his participation in the care. In addition, mothers with active infants were more likely to be less confident in their parenting abilities. Secondly, there was a positive relationship of *distress to limitations* with *the relationship with the husband* and *satisfaction with motherhood*. Mothers who had infants who scored high on distress to limitations, which is a measure of the infant's irritability, were more likely to be dissatisfied with the relationship with the husband and motherhood. Finally, high levels of *fear* were associated with high scores on the father's participation in care, the mother's satisfaction with motherhood, and support the mother receives from family and friends. Mothers with infants who scored high on the variable *fear*, were less satisfied with the father's participation in care of the infant and with motherhood, and with the support she received from family and friends. These relationships were all statistically significant, but the correlations were all very low. Considering the number of correlations calculated there a possibility that several of the significant correlations found are chance findings.

Infant temperament was also examined in relation to mother-infant interaction. Three weak correlations were found between one of the temperament variables and mother-infant interaction. *Activity* level was negatively related to *the mother's response to distress* ($r = -0.230, p = 0.50$, n = 73) *emotional growth fostering* ($r = -0.289$, $p = 0.013$, n = 73) and *the infant's responsiveness to caregiver* ($r = -0.295, p = 0.011$, n = 73). This indicates that infants with high levels of activity are more likely to elicit less responsive behaviour and less emotional growth fostering from their mothers. In addition, the infant's responsive behaviour to the mother was found to be reduced in more active infants. This indicates that the infant's temperament is of influence on both the mother's and infant's aspects of interaction. These findings give an overall picture of the active infant who shows low levels of responsiveness to the mother and the mother showing reduced socio-emotional growth fostering and response to the infant's distress. In addition, these mother's tended to be less confident in their role as a mother.

An overall model

Finally, in this chapter an overall model is presented of predictors of weight gain from birth to eight weeks. A regression model was presented in Chapter Five (Table 5.1, page 117) to estimate weight at eight weeks. The infant's *birthweight*, *sex*, *age* at time of weighing were found to be significant predictors of weight at eight weeks, and this model was used throughout the thesis to investigate behavioural predictors of weight gain. In Chapter Six (Table 6.10, page 149) significant relationship was found between weight at eight weeks and *length of feed*, which refers to the length of the feed from which the sucking parameter estimates were determined. Infants for whom the feed was long were more likely to have slow weight gain from birth to eight weeks. A relationship was also found between weight at eight weeks and the sucking parameter *pause length* at the end of the feed, although this relationship disappeared when one infant (infant 50) was excluded from the analysis because of the infant's extreme scores. In the determination of the overall model therefore, infant 50 is excluded from the analysis. In Chapter Seven a significant relationship was found between weight at eight weeks and the temperament variable measuring the infant's level of *fear*, with slow weight gain being associated with high levels of *fear* in the infant.

In the following analysis all the relevant variables, from the prediction of weight gain from the infant's temperament, sucking behaviour and *length of feed*, were added to a forward stepwise regression. Table 9.2 shows the change statistics for the forward regression. The variables were the following:

Birthweight
Sex
Age
Feeding method
Activity
Distress to limitations
Fear
Duration of orientation
Smiling and laughter
Soothability
Sucks per burst, start
Sucks per burst, end
Suck duration, start
Suck duration, end
SD suck duration, start
SD suck duration, end
Pause length, start
Pause length, end
Length of feed

Table 9.2 Change statistics of the forward regression of weight gain from birth to eight weeks on temperament variables, sucking parameters and *length of feed*

	Change Statistics				
Model	**ΔR^2**	**ΔF**	**Δdf regression**	**df residual**	**p**
1 *Sex*	.276	26.630	1	70	.000
2 *Birthweight*	.156	18.944	1	69	.000
3 *Age*	.088	12.460	1	68	.001
4 *Fear*	.057	9.044	1	67	.004
5 *Length of feed*	.052	9.163	1	66	.004

Table 9.3 Forward stepwise regression of weight gain from birth to eight weeks on temperament variables, sucking parameters and *length of feed*

	B	SE B	*t*	*p*
Constant	2989.16	565.05	5.29	.000
Sex (male)	794.00	128.95	6.16	.000
Birthweight	.71	.14	4.96	.000
Age (days)	42.49	10.45	4.07	.000
Fear	−269.60	79.02	−3.41	.001
Length of feed (min)	−19.25	6.37	−3.02	.004

Analysis of Variance

	df	Sum of squares	Mean square	*F*	*p*
Regression	5	27416855.9	5483371.18	21.16	.000
Residual	64	16581321.2	259083.14		
Total	690	43998177.1			

Multiple R	.79
R square	.62
Adjusted R square	.59
Standard error	509.00

Table 9.3 shows the predictors of weight at eight weeks. The table shows the variables which were significant predictors of weight at eight weeks, at $p < 0.05$, adjusted for eachother. The control variables in the prediction of weight at eight weeks are *birthweight*, *sex*, and *age*. Male infants are on average 794 g heavier at eight weeks, than female infants. For each g increase in birthweight weight at eight weeks was 0.71 g higher, or more clearly, for every 100 g increase in *birthweight* weight at eight weeks was 71 g higher. For every day after eight weeks increase in age weight at eight weeks was on average 42 g more. The two predictor variables in previous analyses were still present in the overall model. For every unit increase in the infant's level of *fear* weight at

eight weeks was on average 269 g less, and with every increase in minutes of feeding weight at eight weeks was on average 19 g less.

In previous analyses the temperament variables and the sucking behaviour variables (including *length of feed*) were investigated in relation to weight at eight weeks separately, without adjusting for each other. Therefore, the regression coefficients of the analysis of weight at eight weeks on the sucking parameter estimates in Table 6.10 (page 149) are compared with the coefficients in Table 9.3. *Length of feed* shows a coefficient of –22.60 without adjusting for the temperament variables (Table 6.10), and –19.25 in Table 9.3 adjusting for the temperament variables. This means that adjusting for the temperament variables, *length of feed* is less influential. Looking at the coefficients for *fear* shows the opposite effect. With the inclusion of *length of feed* in the analysis the coefficient for *fear* changes from –240.06 (Table 7.6, page 161) to –269.60 (Table 9.3). This shows that with the inclusion of *length of feed* the influence of *fear* on weight at eight weeks increases in strength.

Conclusions

In this chapter several small relationships were found between infant temperament characteristics and the mother's adaptation to motherhood and mother-infant interaction. First of all, mothers of infants with high levels of *activity* were more likely to be unsatisfied with the relationship with the husband and his participation in the care of the infant, and feel less confident in parenting. Mothers of irritable infants (high scores on *distress to limitations*) were also less satisfied with the relationship with the husband and with motherhood. Infants with high levels of *fear* were more likely to have mothers who were less satisfied with the husband's participation in the care of the infant, and with the life situation, and with the support they were receiving from family and friends. Secondly, mothers of infants with high levels of *activity* were less responsive to the infant's distress and scored lower on socio-emotional growth fostering. Infants with high levels of *activity* displayed less responsiveness to the caregiver during interaction. It appears that infants with high levels of activity were less responsive and had mothers who were less responsive to them when in distress, and showed less socio-emotional growth fostering. These mothers were also less likely to be confident in their mothering skills.

Finally, in this chapter an overall model for the predication of weight at eight weeks was presented. Taking into account the control variables, *birthweight*, *sex*, and infant's *age* at weighing, two variables showed a significant relationship with weight at eight weeks. Infants with high levels of *fear* were more likely to have slow weight gain from birth to eight weeks, as were infants who spent a long time feeding. In addition, a comparison with previous analyses in which these two variables, *fear* and *length of feed*, were not adjusted for each other shows a difference in the relative individual influence that the variables have. The difference in weight at eight weeks which can be accounted for by *length of feed* decreased with the inclusion of *fear*. On the other hand the difference in weight at eight weeks that can be accounted for by *fear* increased with the inclusion of *length of feed*.

Chapter Ten

Discussion

Discussion

In this chapter the results are discussed, in relation to the initial aims of the study. These were outlined in Chapter One as the following:

1) Investigate the reliability of assessing sucking behaviour in infants using a mixture model.
2) Investigate early weight gain by selecting infants with different weight gain patterns from birth to eight weeks, and assessing whether any of the selected infants continue to fail to thrive over the first six months.
3) Investigate the relationship between weight gain from birth to eight weeks, and birth to six months and the following variables:
    - sucking behaviour
    - infant temperament and behaviour
    - maternal eating behaviour
    - maternal adaptation to motherhood
    - mother-infant interaction

4) Interrelate the maternal and infant characteristics

Sucking and reliability

Sucking behaviour in the present study was measured by observation of a feed. Previously sucking behaviour has been assessed using a pressure tranducer (Kron et al., 1963, 1968; Pollitt et al., 1978b) or with the use of a strain gauge attached to the infant's chin (Ramsay et al., 1996). In the present study sucking behaviour was assessed by direct observation, a method which has been found to be a valid means of measuring sucking behaviour (Woolridge and Drewett, 1986). One purpose of the study was to assess the reliability of the measurement of sucking behaviour through direct observation, which was possible since the observation has been videorecorded. Infant feeds are characterised by a burst-pause pattern and in previous research the differentiation of suck to suck intervals as sucks or pauses was established by defining a cut-off point (Drewett and Woolridge, 1979; Pollitt et al., 1978a; Ramsay et al., 1996). In the current study a different method of identifying sucks and pauses was used. Since suck and pause durations overlap (Bowen-Jones et al., 1982) a mixture model was used, which estimates the summary statistics for the two distributions (the distribution of suck durations and the distribution of pause durations) simultaneously (Chetwynd et al., 1998). Eight parameter estimates were available from the feed, namely *sucks per burst* (*start, end*), *suck duration* (*start, end*) *SD suck duration* (*start, end*) and *pause length* (*start, end*). The key question is the reliability of these parameter estimates, which summarise the whole meal. Sucking behaviour was coded for a random sample of 20 feeds by two researchers. The reliability of measuring sucking behaviour from observation and subsequent analysis of sucking behaviour using the mixture model was assessed. Four sucking parameters were found to be highly reliable; the *suck duration* and the *pause length* at the start and end of the feed (Table 4.2 page 106). The *SD of suck duration* at the start and end of the feed and the *sucks per burst* at the end of the feed were found to be adequately reliable. These findings are encouraging as it means that the measurement of sucking behaviour from observation, with the analysis using the mixture model is satisfactory. Measuring sucking behaviour through observation enables researchers to visit mothers and infants at home, where they can be assessed in their most natural environment. The analysis of the sucking behaviour using the mixture model facilitated a more thorough assessment of the changes that occur as the feed progresses. However, correlations of the estimates of the two researchers of *sucks per burst* at the start of the feed were found to be low.

A comparison of the mean of the parameter estimate sucks per burst for each researcher shows a huge difference, 38.23 vs 8.54 (Table 4.1, page 105). The question remains why the difference was so substantial. One possible explanation for the low correlation between the two researchers' parameter estimates of *sucks per burst* at the start of the feed is that the assessment procedure is not adequate for the measurement of sucking behaviour at the start of the feed. At the start of the feed when the milk flow is high, in the case of breastfeeding infants, and an infant is hungry, the *suck durations* are likely to be longer and become shorter over the course of the feed. The *pause length* is relatively shorter at the start of the feed, and likely to become longer over the course of the feed (Drewett and Woolridge, 1979). If the *suck durations* are relatively long and the *pause lengths* are relatively short at the start of the feed, there will be a smaller difference between the *suck duration* and the *pause length*. This in turn makes it harder to identify which intervals are sucks and which are pauses. It is possible that small differences in the sucking record have led to the mixture model analysing the sequence of sucks and pauses for the one researcher as one long burst and for the other as a sequence of very short bursts. Indeed imposing a burst-pause structure as in the mixture model, may be inappropriate. Kaye (1977) indicated that when the flow of milk is very rapid the pauses between bursts can disappear, so that a sucking burst can last as long as one or two minutes.

These explanations in themselves do not explain the differences found between the measurements by the two researchers. It may be the case that the lack of great difference between *suck durations* and *pause lengths* demands special accuracy when coding sucks from the observations. When Woolridge and Drewett (1986) investigated the validity of measuring sucking behaviour from observation, they compared the results from two ways of measuring sucking from feeds. They found a tendency for the observational measurement to record more sucks per burst than the measurement of sucking using a pressure transducer. Although this difference was not statistically significant, it showed that human error may be a factor in the assessment of sucking behaviour, and given the more general problem described above, this might explain the low reliability of the sucking parameter *sucks per burst* at the start of the feed.

Whatever the explanation, this parameter estimate cannot at the moment be reliably estimated.

The infant's sucking behaviour was examined in relation to the feeding method (breast or bottlefeeding). Both breast and bottlefeeding infants are likely to change their sucking behaviour as the feed progresses, due to satiation and tiredness. Breastfeeding infants experience differences in milk flow and milk composition during a feed (Akre, 1989), which are not experienced by bottlefeeding infants, so that it would be expected that changes in sucking behaviour would differ with feeding method. A Mann Whitney test of the differences in the sucking parameter estimates in breast and bottlefeeding infants (Table 4.4, page 109) showed that the two *end* parameters differed significantly, namely, *suck duration* and *pause length* at the end of the feed. The *suck duration* at the end of the feed is longer for bottlefeeding, and *pause length* at the end of the feed is longer for breastfeeding infants. Since the significant differences were only found in *end* estimates this provided evidence that changes occur over the course of the feed, and therefore new variables were created referring to the difference between the start and end variables. The start estimate was subtracted from the end estimate, creating four new variables; *sucks per burst difference*, *suck duration difference*, *SD suck duration difference*, and *pause length difference*. These variables measured the relative increase or decrease as the feed progresses and differences between breast and bottlefeeding infants were assessed using these new variables. Significant differences were found on all but one of the parameter estimates (Table 4.5, page 111). For both bottlefeeding and breastfeeding infants the *suck duration* decreased and the *pause length* increased over the course of the feed. The changes were significantly greater for breastfeeding infants. *Sucks per burst* increased for breastfeeding infants whereas it decreased for bottlefeeding infants, though it should be noted that this parameter is not reliably estimated at the start of the feed.

The results in the current study correspond to Drewett and Woolridge's (1979) findings that *pause lengths* tend to increase over the course of the feed. Certain factors of feeding change over the course of the feed to coincide with changes in the infants sucking behaviour. First of all, milk flow and composition change over the course of the feed (Akre, 1989) for breastfeeding infants. The mother's milk-ejection and milk production reflexes respond to stimulation from the infant's sucking behaviour, so that successful breastfeeding depends on sucking behaviour of the infant. Milk volume is governed by the infants efficiency in sucking and milk removal (Akre, 1989). Milk flow and composition only change for breastfeeding infants. Bowen-Jones et al. (1982) showed that in breastfeeding infants, when the milk flow is low the sucking rate (i.e. *sucks per burst*) is high, and when milk flow is high sucking rate is low. Milk flow decreases towards the end of the feed (Drewett and Woolridge, 1979), so that *sucks per burst* increase toward the end of the feed. This corresponds with the current findings, which showed that *sucks per burst* increase for breastfeeding infants and decreased for bottlefeeding infants. The changes that occur in the parameter estimates *pause length* and *suck duration* are similar for bottle and breastfeeding infants only bigger in breastfeeding infants. This may be due to the fact that there are more factors that change over the course of a feed for a breastfeeding infant than for a bottlefeeding infant. All infants are likely to get increasingly tired and satiated towards the end of a feed, which explains the changes for bottlefeeding infants. The breastfeeding infants also experience the changes in milk flow and milk composition which potentially increase the changes that occur. Bowen-Jones et al. (1982) showed that when controlling for changes in satiation in breastfeeding infants, the rate of milk flow still significantly influenced sucking behaviour.

Weight gain and failure to thrive

Infants were recruited for the study according to their weight gain from birth to six to ten weeks. A conditional eight-week weight standard was developed for the study and used to select infants with different weight gain patterns. The objective was to select infants with different relative weight gains rather than infants with different weights at a specific time. Relative weight gain from birth can not be analysed simply as the increase in weight from birth to a certain age, as this does not take into account the influence of birthweight on subsequent growth velocity. Ferguson et al. (1980) evaluated weight gain from birth to three months in a cohort of infants in New Zealand. The results showed a negative correlation between birthweight and weight gain to three months, which shows the tendency for infants who are relatively light at birth to gain more weight afterwards (Ferguson et al., 1980). A simple measure of relative weight gain ignores the influence of birthweight on subsequent weight gain. Over time infants' weights move closer to the mean, with the extent of regression to the mean being dependent on the time between the two weights (Cole, 1995). The conditional weight standards in the present study were devised to be able to identify relative weight gain allowing for birthweight, sex and exact age at weighing, so taking into account this 'regression to the mean'. The estimated (average) weight at about eight weeks was derived from the regression of weight at eight weeks on birthweight, with a correction for exact age at weighing. These estimated weights were defined using weight data from over 2000 infants from Newcastle-upon-Tyne (Wright et al., 1994). The weight data were transformed into z-scores. The z-scores were used in a regression analysis to derive the parameter estimates necessary to establish the cut-off points for the slowest and fastest growing 20% at different ages. These z-scores were then transformed back into weights in g, and tabulated for use in clinics. Infants were classified as either having slow, average or fast weight gain. Tables displaying weight cut-off points for males and females at different ages, are shown in Appendix One.

When examining weight gain in the clinics in the current study, it was found that not all clinics adhere to the correct procedure for weighing infants in the first year. One of the clinics visited, clinic Y, received so many visitors that the Health Visitors were obliged to weigh the infants in the clinic's waiting room, so all infants were weighed with their clothes on. A regression analysis of this clinic weight on weight at eight weeks (as measured at home in this project) with the clinic Y and the other clinics added as a dummy variable showed that the clothes accounted for on average ~250 g of the infant's weight at the clinic. In clinic Y infants' weights were noted in the Child Health Record (Yellow Book), but owing to a lack of time the Health Visitors often did not plot the weights on the growth chart in the health record. So infants' weights were not only inaccurate, they were also less likely to be plotted in a form that was useful. Davies and Williams (1983) warned against practices such as these, and asked whether weighing infants in the clinics is worthwhile. They argue that one of the greatest benefits of weighing infants on a regular basis may be the provision of the opportunity for mothers to discuss anxieties and problems with health professionals. However, other researchers advocate more effective monitoring of weight gain. Batchelor and Kerslake (1990) examined 6-8000 clinic cards and 2000 Health Visitor records to identify infants with weights below the third centile on a growth chart, which the authors used as a criterion for failure to thrive. They found that approximately a third of infants failing to thrive by this criterion went unrecognised by Health Visitors. In addition, infants with failure to thrive that were followed up were more likely to be infants with a greater degree of deprivation. They found that infants without some degree of deprivation were less likely to be identified as having failure to thrive, and more likely to be referred to as 'small infants'. This evidence led Batchelor and Kerslake to emphasise the need for consistent monitoring of weight gain in infants, to be able to administer timely intervention for those infants that need it. Hall (1995) acknowledged that weight monitoring is easy, but difficult to do well, and advocates that primary care staff should be well trained in order to be able to properly assess growth in infancy. Furthermore, primary care staff should also be able to refer infants that are in need of intervention, and be able to give these infants the appropriate care (Hall, 1995). Monitoring weight gain may need more attention from health authorities, so that variations in weighing procedures come to light and can be dealt with.

All infants in the current study were weighed at home by the researcher at around eight weeks and six months, using digital scales. These weights were used in a regression model initially to examine weight at eight weeks and six months in relation to three control variables. The measure of weight gain used was the residual from the regression of weight at eight weeks on birthweight, taking into account *sex* and exact *age*. Table 5.1 (page 117) illustrates the assessment of weight gain. A constant of 2079.73 and a coefficient for birthweight of 0.72 means that if a girl is weighed at exactly eight weeks her weight at that time is on average 2079.73 plus an extra 72 g for every added 100 g of her birthweight. In the regression the infant's sex was taken account since males gain in weight faster than females. Infants were weighed between eight and twelve weeks, and the number of days after eight weeks (56 days) the infant was weighed was added to the regression analysis, as the third control variable (*age*).

In Table 5.1 (page 117) it can be seen that for every 100 g increase in birthweight weight at eight weeks was 72 g more. For male infants the weight at eight weeks was on average 650 g higher, and for every day after eight weeks the weight was on average 40 g more. A similar analysis was carried out for weight at six months on the control variables birthweight, sex and the infant's age. Infants were weighed around six months, and the exact age in days before or after six months was added to the analysis. Table 5.2 (page 119) shows that for every added 100 g in birthweight weight at six months was 70 g more, for males weight at six months was 1095 g more, and for every day another 14 g was added. The regression model of assessing weight gain was used in all analyses in the thesis. Here the effect of exact age is not statistically significant, as weight gain is much slower. Behaviour variables were added as second blocks into the analyses.

Feeding method was added to the regression analysis for both weight at eight weeks and weight at six months, but the feeding method did not have a significant relationship with weight gain, over either time period. Previous research on weight gain comparing bottle and breastfed infants has reported certain differences. Dewey et al. (1992) investigated weight gain in breastfeeding and bottlefeeding infants and found that there was no significant difference in weight gain over the first three months according to feeding method. However, from three months onwards breastfeeding infants showed significantly slower weight gain than bottlefeeding infants.

Agostoni et al. (1999) reported differences in weight gain between breast and bottlefeeding infants as well. Seventy-three breastfeeding infants, breastfed until four months, and 65 bottlefed infants were measured on a regular basis over the first year. The authors found weight for age (in z-scores) differences in the first six months. Breastfeeding infants had higher weight for age z-scores in the first and second month, whereas bottlefeeding infants had higher weight for age *change* between birth and one month, one and two months, two and three months, and three and four months. In these first few months breastfeeding infants had higher weight for age z-scores, and bottlefeeding infants experienced more change in z-scores. The authors concluded that breastfeeding infants show a progressive decline in growth rate in the first year, whereas bottlefeeding infants show a progressive rise in weight gain in the first year. However, this study had several flaws. Breastfeeding infants had a significantly higher birthweight, and regression to the mean was not taken into account. The authors suggested that better intrauterine circumstances may underly the higher birthweight. However, they then failed to take this into account in further analysis.

In the current study no differences in weight gain (conditional on birthweight) were found between breast and bottlefeeding infants. This may be due to the fact that infants were selected for their weight gain pattern, and the interest was with extreme weight gain. Therefore, the current sample was not a reflection of an average population of infants.

Infants with different relative weight gain patterns from birth to eight weeks were investigated. Weights were also measured at six months partly to examine if any infants could be classified as having failure to thrive using a conventional clinical criterion. Failure to thrive was assessed from the weight gain patterns from birth to six months. Rather than using falling below the third or fifth centile for attained weight at a certain timepoint as the criterion, failure to thrive was assessed using the 'thrive index' (Wright et al., 1994), which is also a conditional weight gain criterion. Six infants met the criterion of failing to thrive at six months. All six infants were classified as having slow weight gain in the first eight weeks. A Fisher Exact test showed that the proportion of infants who were failing to thrive in the slow weight gain group differed significantly from that in the other groups. Over 25% (27.3%) of infants who had slow weight gain from birth to eight weeks met a conventional clinical criterion of failure to thrive by six months. Provisionally these findings indicate that the conditional weight standards used are effective in selecting infants who have an increased risk of developing failure to thrive in the first six months. This finding corresponds to findings by Drewett et al. (1999) and Skuse et al. (1994) who plotted weight gain from birth for infants who were classified as having failure to thrive later in the first year. These studies showed that infants who fail to thrive have slow weight gain from birth, showing a significant drop in weight gain early on (Drewett et al., 1999; Skuse et al., 1994). However, showing that most infants who fail to thrive have slow weight gain from birth is not the same as showing that weight gain from birth effectively predicts failure to thrive, which is shown in this study.

The findings do not, however, mean that infants who have slow weight gain in the first eight weeks will necessarily be classified as having failure to thrive at six months. For instance, in the current study one of the infants presented slow weight gain in the first eight weeks and the follow-up visit provided a reason for the slow weight gain. This particular infant had been found to be allergic to formula milk, and it was recommended she be fed soya-milk. The infant's weight gain increased after the introduction of soya-milk, and this infant was not classified as having failure to thrive at six months. In other instances infants tend to have increased weight gain once they are fed solids.

The conditional weight standards were intended for the detection of infants with slow weight gain in the early months, who may be at increased risk of developing failure to thrive. Further research should be conducted to assess whether screening a similar, or larger sample, still shows the same proportion of infants with slow weight gain in the first two months, classified as having failure to thrive at six months.

It would be interesting to assess whether the infants who are identified as having failure to thrive at six months are among the ones who belong to the slowest growing 5% at eight weeks, or whether 20% is an adequately safe cut-off point to make sure the right infants are picked up. It is more likely that not all infants who develop failure to thrive belong to the slowest growing 5% of weight gain in the first months. It may also be important to investigate which infants with slow weight gain in the early months are not identified as failing to thrive at six months and for what reasons. Their feeding history should be investigated to determine the turning point in weight gain. As mentioned previously this could be for example, the introduction of solids, or a change in formula, or the change from breast to bottle.

Next are the practical issues to consider. First of all, there is concern over the accuracy of the weights collected at the baby-clinics. The weights collected by the Health Visitor after birth at home and at the clinic are subject to the variability caused by the different scales that are used. Health Visitors use portable scales to weigh infants at home, and mostly use different scales in the clinic. Batchelor and Kerslake (1990) asked Health Visitors about their access to scales, and reported that some Health Visitors were not satisfied with their scales. Sometimes they would have to share them, and some scales 'weigh light' whereas others 'weigh heavy' (Batchelor and Kerslake, 1990). This can result in a small difference in weight, which may lead to wrong interpretation of the infant's weight gain. In addition, sometimes errors are made in the documentation of weights. Infants' weights are often measured in pounds and ounces and then converted into kilograms using a conversion chart, which adds to the risk of errors. The Child Health Record (Yellow Book) is intended for the parents to keep. However, in most cases the Health Visitor is the one who attempts to keep the charts up to date.

Although the conditional weight standards used in the current study are relatively easy to use in the clinic, they would add to the work of the Health Visitor. Health Visitors have many administrative duties, they may well argue that they have too many administrative duties. Anecdotal evidence from the current study showed that weights that are obtained during baby-clinics often have to be recorded in the Yellow Book, in the doctors notes and also in an additional folder in which the Health Visitors keep a file on each infant. Batchelor and Kerslake (1990) confirmed this with their findings of Health Visitors reporting high levels of duplication of the child's weights. They added that the use of both metric and imperial scales adds to the risk of mistakes being made (Batchelor and Kerslake, 1990). These administrative duties are often fulfilled during baby clinics which leaves little time for added monitoring. One might suggest that the Health Visitors use the weight standards for infants they are worried about. They would be able to evaluate the infant's weight gain after the baby clinic, if it proves too time consuming during the clinic. There would be, however, an element of subjectivity in this that would be undesirable in a screening programme.

Apart from the possibility that Health Visitors would not appreciate the addition to their workload, they may consider the current weight charts adequate in picking up infants who fail to thrive. Increased monitoring of weight gain may be something that Health Visitors feel is not worth their time, especially if the new conditional weight standards identify infants who have a relatively small chance (25%) of being classified as failing to thrive at six months. These possibilities need to be investigated in research on the monitoring of weight gain by the Health Visitors.

Weight gain and other variables

Sucking behaviour

A regression analysis was carried out to assess whether sucking problems predict weight gain from birth to eight weeks, and from birth to six months. The sucking parameter estimates were added to the basic regression model of weight at eight weeks on *birthweight*, *sex* and *age*. A significant relationship was found between weight at eight weeks and the *pause length* at the end of the feed. Infants who had long pauses at the end of the feed were more likely to have slow weight gain from birth to eight weeks. However, additional diagnostic statistics, showed one infant (infant 50) with relatively high values for Cook's D. The regression was therefore rerun without infant 50 to ascertain the relative influence of one infant. The results showed that the significant relationship had disappeared. This means that the significant relationship of *pause length* at the end of the feed and weight at eight weeks was attributable to the extreme scores of one infant. In the current study the infant's sucking behaviour did not influence weight gain from birth to eight weeks, or birth to six months.

Since infant 50 had such a great influence on the results in the regression analysis of sucking behaviour and weight gain, this infant's sucking parameter estimates were investigated more closely. Infant 50 was found to have an extreme sucking parameter estimate for *pause length* at the end of the feed. This infant had very long pauses at the end of the feed. Subsequently, weight gain was evaluated more closely by plotting the unstandardised residuals of the regression of weight gain in the first eight weeks, against birthweight. The scatterplot showed that infant 50 was an outlier on this plot (Figure 6.6, page 146). Infant 50 had very slow weight gain from birth to eight weeks, gaining only 310 g over that period. So in summary this was an infant with extreme sucking behaviour, having extremely long pauses at the end of the feed, and extremely slow weight gain. The interesting finding was that this was not an infant who met the criterion for failure to thrive at six months. At six months the infant's weight gain had significantly increased over the weeks after the eight-week visit, and the infant's weight pattern was on the original birth centile. The mother reported that the infant's weight gain had improved after the introduction of solids. This is an important finding because it shows that not all infants with slow weight gain in the first eight weeks are classified as having failure to thrive at six months.

Pollitt et al. (1978b) investigated sucking behaviour in the first days after birth in relation to weight at one month. A relationship was found between the mean amplitude of sucking, as measured with a pressure transducer, and weight at one month. However, weight gain was not assessed in this study, rather sucking behaviour was related to *attained weight* at one month. In addition, sucking behaviour was assessed using a pressure transducer and infants were not allowed to suck during an entire meal. Sucking was measured for test-trials, which lasted one minute each. This method fails to record the changes that occur over the course of a feed, so therefore these findings are not comparable to the findings in the current study.

Agras et al. (1987) assessed sucking behaviour, again with a pressure transducer, in 2 to 4-week old infants and found that shorter intervals between sucking bursts were associated with adiposity at one year of age. In other words the *pause length* at the end of the feed was related to adiposity at two years. Adiposity at 2 years was also related to higher sucking pressure and fewer feeds per day. The authors described a vigorous sucking style as exhibiting rapid sucking, higher sucking pressure, and shorter intervals between longer suck and burst duration (Agras et al., 1987). The difference between this study and the current one is that rather than assessing weight gain, adiposity was assessed in infants aged two years. Furthermore the relationship between sucking behaviour and adiposity disappeared by the age of six.

In the current study the length of the feed from which the sucking parameter estimates were taken was added to the regression analysis of sucking behaviour and weight gain (Table 6.6, page 138). The results showed that the length of the feed (*length of feed*) was a significant predictor of weight at eight weeks. Infants with long feeds were found to have slow weight gain and this relationship remained statistically significant when infant 50 was excluded from the analysis. In addition, the variable was independently related to weight at eight weeks, taking into account the infant's sucking behaviour. On the surface this finding seems counterintuitive since longer feeds would enable the infant to increase the milk intake.

Dubignon and Cooper (1980) reported that infants who spent less time sucking, also sucked less strongly, were more likely to be described as poor feeders, with a low milk intake, as opposed to good feeders with a higher milk intake. Poor feeders were also more likely to spend a long time feeding, i.e. longer than 45 minutes, which is in line with the findings of the current study. They also had shorter sucking bursts with fewer sucks, and had more sucking bursts and longer times between sucking bursts. However, in their study bottlefeeding infants were assessed on their sucking behaviour using a pressure transducer connected to a specialised nipple. Sucking was assessed during test trials, which only assessed a small part of the infant's feeding behaviour. In addition, these are not natural observations of sucking. Finally, the question is whether low intake in infants leads to slow weight gain in these infants, on which the Dubignon and Cooper's study did not provide any information.

Previous research has investigated feeding problems in infants with failure to thrive. However, data is mostly retrospective and without a clear description of what constitutes a feeding problem. Mothers have reported feeding problems in infants with failure to thrive (Mitchell et al., 1980; Kotelchuck and Newberger, 1983), for example with mothers describing problems such as less vigorous sucking and not finishing the bottle (Tolia, 1995). Obviously the data from the failure to thrive studies are not conclusive because the information was retrospective and the mother's memory may potentially be clouded by feeding problems at the time the infant is referred for failure to thrive.

One question is why infants with slow weight gain are more likely to have longer feeds. These may be infants who tend to fall asleep fairly soon into the feed, and need a lot of attention from their mother to be enticed to carry on feeding. On the other hand infants that spend a long time feeding may be the ones who have difficulties sucking, and need more time to reach satiation, and carry on feeding for a long time.

Infant temperament

In the present study certain findings emerged concerning the infant's temperament and its relationship with weight gain. First of all, infants differed according to their feeding method, on one of the temperament variables. Infants who were breastfed scored lower on the temperament dimension *duration of orientation*, which means that infants who were breastfed tended to have shorter attention spans than bottlefed infants. DiPietro et al. (1987) investigated behavioural and physiological differences between breast and bottlefed infants. Asssessments were made shortly after birth and the results showed that breastfeeding infants were significantly more irritable during the administration of the Neonatal Behavioural Assessment Scale (NBAS; Brazelton, 1973). Breastfeeding infants were also less likely to complete the orientation items because of fussy behaviour. However, the current study measured temperament through a questionnaire completed by the mother, whereas in DiPietro et al.'s study temperament was assessed through direct observation during the administration of the NBAS. Moreover, the infants in the present study were much older, compared to the newborns of a few days old. Crockenberg and Smith (1982) investigated infant irritability in the first three months of life and did not find a difference in irritability between breast and bottlefeeding infants. However, as in DiPietro et al.'s study the infant's behaviour was assessed using the NBAS, which is an observational measure rather than a mother completed questionnaire. Their study showed that irritable behaviour in the infant was more related to the mother's unresponsive behaviour, rather than the feeding method (Crockenberg and Smith, 1982). The differences in measures used to assess temperament may be the reason for conflicting results of temperament in relation to the feeding method.

Worobey (1993) put forward several suggestions for the behavioural differences between breastfeeding and bottlefeeding infants. The difference in the substances that breast and bottlefeeding infants ingest may be responsible for differences in behaviour, through the difference in composition of the milk. It is not clear what part of the composition might influence behaviour or in what way. This is potentially difficult to ascertain in new research since formula milk changes constantly in order to have it resemble breast milk as closely as possible.

Another suggestion is the difference in Socio-Economic Status (SES) between breastfeeding and bottlefeeding mothers. If differences in the levels of responsiveness in the mother are of influence on the infant's behaviour it is possible that SES plays a part. Breastfeeding mothers are more likely to be middleclass. Therefore another analysis was carried out with the data from the current study. An univariate analysis of covariance (ANCOVA), first of all with the activity level as the dependent variable, feeding method as the fixed factor and SES as the covariate, showed no significant difference due to SES. The remaining temperament variables were added to a similar ANCOVA, but none of the dimensions showed any significant differences due to SES. This means that the difference in temperament found between breast and bottlefeeding infants in the current sample was not related to their socio-economic status.

Infant temperament was examined in relation to weight gain, in a regression analysis with weight at eight weeks as the dependent variable. A negative relationship was found between *fear* and *activity* and weight at eight weeks. For every unit increase in the level of *fear*, weight at eight weeks was on average 232 g less, and for every unit increase in level of *activity* weight at eight weeks was on average 212 g less. So infants with high levels of *fear* and *activity* were more likely to have slow weight gain in the first eight weeks. This relationship changed when the infant's feeding method was added to the regression analysis, so that the relationship between *fear* and weight at eight weeks became stronger and the relationship between *activity* and weight at eight weeks disappeared. This indicated that the infant's level of *activity* is dependent on the feeding method. As stated above, a t-test showed that the temperament dimension *activity* did not differ significantly between breast and bottlefeeding infants. Worobey (1993) investigated differences between three and half month old breast and bottlefeeding infants using the Infant Behavior Questionnaire (IBQ; Rothbart, 1981), just as in the current study. No statistically significant differences were found on any of the temperament dimensions, although the mean for *activity* level as measured by the IBQ in Worobey's study was higher for breastfeeding infants than for bottlefeeding infants. However, significant differences were found on *activity* levels when measured using an Actometer. Breastfeeding infants showed significantly more movements of their arms and legs, than bottlefeeding infants. These findings indicate that the dimension activity level in the questionnaire measures something different than straightforward activity. The questionnaire measures activity over the last week assessed by the mother. Items such as the following are examples of how activity is assessed. 'During feeding how often did your baby lie and sit quietly?', ' When placed in an infant seat or car seat, how often did your baby wave arms and kick'. The actometer on the other hand measures physical activity during a certain amount of time.

Coming back to the significant relationship in the current study between weight at eight weeks and temperament, specifically the dimension *fear*. Two other studies investigated the relationship between weight and temperament, which found evidence for a relationship between irritable behaviour and fast weight gain. Wells et al. (1997) found a positive relationship between *distress to limitations*, which is a measure of the infant's irritability, and percentage fat in childhood (2 to 3.5 years). The relationship found in Well et al.'s study was not significant after adjusting for baseline fat. Carey (1985) studied increased and decreased weight gain in infants under a year old, and found that infants with increased weight gain were more likely to be more irritable. Only an indication of a similar relationship was found in the current study. *Distress to limitations* was positively related to weight at eight weeks, although this relationship was not statistically significant.

One other study that investigated weight gain and infant behaviour was by Kestermann (1981) who studied differences among infants in the early days of life using the NBAS (Brazelton, 1973) to assess behaviour. In addition, weight gain (relative to birthweight) was assessed in relation to the infant's behaviour. Infants who were described as less alert had lower weight gain from day one to day eight. The findings from this study are by no means conclusive since the assessment of weight gain over seven days is hardly a reliable measure of weight gain, and the relationship between weight gain and behaviour therefore not very valuable. In addition, the measure of behaviour differs from the measure used in the current study. In the current study the infant's behaviour was rated by the mother, whereas in Kestermann's study behaviour was rated by the researcher through observation.

Infants with failure to thrive have been compared on their behaviour to infants with average growth, and they were found to be more likely to resort to crying as a way of communication (Mathisen et al., 1989), to be less happy and have more negative affect (Polan et al., 1991), and to be more fussy and unhappy, less adaptable and more demanding and difficult (Wolke et al., 1990). The infants in the current study were not selected for having failure to thrive, but on their weight gain pattern from birth to eight weeks, which explains the discrepancy between the findings. In addition, the infants in the previously mentioned studies were also older, and the interaction between the infant and the mother will have evolved more and potentially deteriorated more since very early infancy.

Infant behaviours, such as sleeping, feeding, fussing and crying were also assessed in the current study. A significant difference was found for males and females on sleeping behaviour, with female infants spending significantly more hours sleeping per day. In addition, breast and bottlefeeding infants were found to differ significantly on some of these behaviours. A Mann Whitney test showed that breastfeeding infants differed on sleeping and feeding behaviour.

These relationships were illustrated in the scatterplots of the mean duration and mean number of episodes of the behaviour variables. The relationship between the *mean duration of sleeping per day* and the *mean number of episodes of sleeping per day* (Figure 7.4, page 168), showed that breastfeeding infants had a higher number of sleeping episodes and a lower number of minutes of sleeping a day, as compared to bottlefeeding infants. The relationship between the *mean duration of feeding per day* and the *mean number of episodes of feeding per day* (Figure 7.5, page 169) showed that breastfeeding infants had a higher number of episodes feeding and they also fed for more minutes each day, which corresponds with findings of Wells and Davies (1995) that breastfeeding infants feed significantly more over a 24-hour period than bottlefeeding infants. Breast and bottlefeeding infants did not differ on the mean duration and mean number of episodes per day of fussing and crying. Since the mean duration and mean number of episodes for each behaviour were highly correlated (with the exception of sleeping behaviour) the mean duration of an episode was calculated, by dividing the mean duration of a behaviour by the mean number of episodes of a behaviour. A regression analyses was carried out to ascertain whether the behaviour variables were significant predictors of weight at eight weeks, or weight at six months. The *mean duration per episode* and the *mean number of episodes* for each behaviour were added to the regression analyses, but no significant relationship was found with either weight at eight weeks or weight at six months.

Interrelating the temparement variables and the infant behaviour variables showed several correlations. *Distress to limitations* was positively related to the *mean duration of fussing and crying*, whereas *smiling and laughter* showed a negative relationship with these variables. This corresponds to the idea that *distress to limitations* measures the infant's level of irritability, and *smiling and laughter* measures positive emotionality. High levels of *fear* and *activity* were also positively related to a high mean duration and number of episodes of crying. These last findings add to the profile of infants who had slow weight gain from birth to eight weeks. Infants with high levels of *fear* had slow weight gain from birth to eight weeks, and these analyses showed that these infants are also more likely to have more minutes and episodes of crying. A shortcoming of the data obtained from the diary on infant behaviour completed by the mother was that some mothers were more thorough in completing the diary than other mothers. The diary measures behaviour over two days, which means that mothers need to remember to write down behaviour soon after it happens, which will inevitably be more difficult for behaviours such as fussing and crying. These behaviours elicit soothing behaviour from the mother and were likely to be shorter than sleeping and feeding behaviour. Feeding and sleeping were also more likely to be more regular, as mothers were attempting to regulate the infant's diurnal rhythm. Considering the shortcomings in the assessment of crying and fussing behaviour the results may be different for data of mothers who take an equal amount of care in completing the diary.

Nevertheless, these analyses add to the understanding of the contribution of the infant's behaviour to weight gain. The infant's behaviour is of influence on development from birth and needs to be taken into account in the feeding situation, especially in relation to the relationship with the mother.

Maternal eating behaviour and adaptation to motherhood, and mother-infant interaction

The mother's eating behaviour was assessed using the Dutch Eating Behaviour Questionnaire (van Strien et al., 1986). This generated scores on the mother's *restrained*, *emotional* and *external* eating behaviour. An analysis of the mothers' eating behaviour according to the infant's feeding method showed that breastfeeding mothers scored lower on *restrained eating* behaviour and higher on *emotional eating* behaviour compared to bottlefeeding mothers. The findings of lower scores on restrained eating behaviour fits with the fact that mothers who breastfeed have to take their own intake into account in relation to their infants nutritional requirements (Akre, 1989), and are therefore probably less likely to restrict their own intake. However, the differences between bottle and breastfeeding mothers in the current study were not found to be statistically significant. Barnes et al. (1997) investigated intentions of women to breastfeed in relation to the women's body shape and weight concerns. A group of 12.000 women were asked to take part in the Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC), which followed women from the prenatal period to four months postnatal. In the prenatal period women were asked what their feeding intentions were, either breastfeeding, bottlefeeding, or a combination of the two. The women were also asked to complete a questionnaire about eating, body shape, and weight concerns that they might have had in the previous month. Concerns about body shape were found to be highly significantly predictive of breastfeeding intentions in the first week, as well as intentions of breastfeeding up to four months. Weight concerns were predictive only of breastfeeding intentions up to four months. Mothers who intended to breastfeed up to four months were less concerned with their body shape and weight (Barnes et al., 1997). This ties in with the findings in the current study of lower restrained eating behaviour in breastfeeding mothers. However, the study by Barnes et al. (1997) did not provide any information about actual feeding practices after birth and whether this was affected by the mother's body shape and weight. Their study was mainly concerned with *intentions* in relation to weight and shape concern prenatally.

Another possibility for the difference between breast and bottlefeeding mothers lies in the timing of assessment of the mother's eating behaviour. On the one hand, it may be so that women who intend to breastfeed have fewer weight and shape concerns during pregnancy as reported by Barnes et al. (1997). On the other hand, after pregnancy mothers who are breastfeeding are more aware that they need to take their infant's nutritional needs into account in relation to their own. This may result in the inability of women to show restrained eating behaviour. They may want to restrict their intake but are aware that it would influence the infant's nutrition.

In the present study the mother's eating behaviour was also investigated in relation to weight gain from birth to eight weeks and birth to six months, but no significant relationships were found. McCann et al. (1994) found increased restrained eating behaviour in mothers of four-year old children with failure to thrive as compared to mothers with children without failure to thrive. The mothers of failure to thrive children were more likely to restrict fattening and sweet foods. However, these findings are not really comparable to findings in the current study for several reasons. The children in McCann et al.'s study were older children, ranging from one year to nine years, who had been diagnosed with failure to thrive. In the present study eating behaviour was related to weight gain, in infants who had not been diagnosed with failure to thrive. In addition, all children in McCann et al.'s study had been referred to a consultant paediatrician for having a weight below the third centile on a population growth chart, and were therefore not representative of infants with failure to thrive. It is likely that there was no significant relationship between weight gain and the mother's eating behaviour in the current study because the sample was based on eight-week old infants with different weight gain patterns, rather than infants diagnosed as failing to thrive.

It is unlikely that the mother's own eating behaviour would have such a strong effect on the infant's feeding behaviour as to significantly slow down their weight gain. The mother's restrained eating behaviour would have to be fairly extreme to have such a powerful influence. A possibility is that the mother's eating behaviour influences the child's feeding behaviour indirectly through mother-infant interaction. However, an analysis to assess correlations between mother-infant interaction and the mother's eating behaviour showed no significant associations.

Next the mother's adaptation to motherhood was assessed, which included among other variables a measure of social support, the mother's relationship with the infant's father, and the mother's confidence in her role as a parent. A Mann Whitney test showed a difference according to the infant's sex. Mothers of female infants were more likely to have an unsatisfactory relationship with the husband. No differences were found according to the infant's feeding method.

An investigation of the relationship between the different maternal adaptation variables showed certain correlations. In particular the mother's confidence in her abilities as a parent was found to be related to certain adaptation variables. The mother's confidence was influenced by the relationship with the husband ($r = 0.4$), the father's participation in care ($r = 0.3$) and the mother's satisfaction with motherhood ($r = 0.3$). Cutrona and Troutman (1989) investigated social support in relation to the mother's feelings of self-efficacy as a parent and found a positive correlation between these two variables. This indicates that high levels of support influence the mother's feeling of competence in the role as a mother. Those findings tie in with the findings in the current study; the mother's sense of confidence was influenced by the quality of the relationship with the father of the infant. A mother who feels the father of the infant is not contributing sufficiently to the care of the infant, and therefore feels unsupported, is less likely to feel confident as a mother.

Maternal adaptation was not associated with weight gain from birth to eight weeks or six months. A relationship was not expected, rather maternal adaptation was expected to be related to mother-infant interaction. In the current study several small correlations were found between maternal adaptation variables and mother-infant interaction. The mother's *sensitivity to the infant's cues* during interaction was related to mother's confidence in her parenting abilities, so that less confident mothers were less sensitive in interaction. Williams et al. (1987) found that the mother's feelings of confidence influenced mother-infant interaction. The authors identified confidence as the driving force in mother-infant interaction, although the correlations in their study were low, as they were in the current study. In assessing the relationship between the adaptation variables and the mother-infant interaction variables 42 correlations were computed. Computing a large number of correlations will yield a number of significant correlations which can be attributed to chance and should therefore be interpreted with some caution. Nevertheless, it was interesting to find that confidence was related to the mother's behaviour during interaction. Previous research has often investigated depressive symptoms in mothers as an influence on the relationship between the mother and infant (Lundy et al., 1996; Cohn et al., 1990). However, mothers may not suffer from depression but still feel less confident in their abilities as a mother, which in turn may influence the interactions with the infant.

Social support, which was also measured in the questionnaire on maternal adaptation, did not have a significant relationship with weight gain. Benoit et al. (1989) investigated levels of social support in mothers of infants with failure to thrive and found a difference in comparison with mothers of average growing infants. They found that mothers of infants with failure to thrive were more likely to receive support from nonfamilial sources, such as friends or the church, than mothers with average growing infants. However, the findings in this study can not be conclusive because of the sample that was used. The sample in this study consisted of hospitalised infants, either with failure to thrive, or hospitalised for another reason, which are not made clear in the report. In addition, the occurance of substance abuse was investigated in all mothers and it was found that 36% of mothers of infants with failure to thrive had substance abuse as opposed to 12% of the infants with average growth, which indicates that the mothers were not a representative sample (Benoit et al., 1989). This adds to the view that this sample was not representative of infants with growth faltering.

Maternal adaptation variables were also found to be related to the mother's eating behaviour. The mother's confidence in parenting was negatively related to *restrained eating*, so that mothers with low confidence in their parenting abilities were more likely to have restrained eating behaviour. A stronger relationship was found between *restrained eating* behaviour and the mother's satisfaction with motherhood, so that mothers who were less satisfied with motherhood were more likely to have *restrained eating* behaviour. *Emotional eating* behaviour in mothers was most strongly related to variables concerning the husband. *Emotional eating* behaviour was associated with less satisfaction with the relationship with the husband and his participation in care of the infant. These findings are in concordance with the notion that these mothers eat in response to certain emotional states (van Strien et al., 1986), in this case influenced by the relationship with the father of the infant.

Mother-infant interaction was investigated and a difference was found between mothers who breastfeed their infants and those who bottlefeed their infants. Scores on the subscale *sensitivity to cues* were found to be higher for breastfeeding mothers than for bottlefeeding mothers, which indicates relatively more sensitivity in breastfeeding mothers. Worobey (1993) investigated play, touch, vocalisation and positive affect in mothers of breastfeeding and bottlefeeding infants. Breastfeeding mothers touched their infants significantly more than bottlefeeding mothers. These results are difficult to compare with the results in the current study since the infants in Worobey's study were eight months old, the sample was smaller (27 infants) and the interaction behaviours were reduced to the previously mentioned categories for the analysis. Dunn and Richards (1977) observed the feeding situation in the early weeks in both bottlefeeding and breastfeeding infants. They found that breastfeeding mothers have a tendency to kiss, rock and touch their infant more, and also talk more during feeding. These findings coincide with the current finding of more sensitive behaviour on the mother's part during the feeding situation.

Mother-infant interaction was also examined in relation to weight gain, and the only significant relationship that was found was between the infant's *responsiveness to caregiver* and weight at eight weeks. For every unit increase in the score of the infant's responsiveness, weight at eight weeks was on average 155 g higher. The overall relationship, as indicated by the change statistics, between mother-infant interaction variables and weight gain from birth to eight weeks was non-significant. The only other study to have related mother-infant interaction and the infant's weight gain in the early months is the study by Pollitt et al. (1978a) who investigated mother-infant interaction shortly after birth and found a relationship with weight gain in the first month. The number of times the infant opened its eyes was positively related to weight gain. This ties in with the finding of the relationship between the infant's responsive behaviour toward the mother and weight gain in the current study. In Pollit et al.'s study the *frequency* and *duration* of behaviours in the mother and infant were assessed, whereas in the current study the *occurrence* of behaviour and interaction was assessed, and the frequency of the behaviours was mostly ignored. Although the two studies differ in design and the measures used to assess mother-infant interaction, they both imply an actively engaging infant influencing physical development.

Research on failure to thrive has found more negative interactions between mothers and infants with failure to thrive than in mothers and their average growing infants (e.g. Mathisen et al., 1989; Polan et al., 1991). Once again this comes back to the issue of sampling. The infants in those studies had been referred for their weight faltering and are therefore unrepresentative of all infants with failure to thrive in the community. The infants in the current study were infants with different weight gain patterns, ranging from one extreme to the other. The relationship between the infant's responsiveness to the caregiver and weight gain was found to be statistically significant, but not when taking into account the number of variables that were added to the regression analysis.

This together with the finding of a relationship between weight gain and temperament shows that the infant has an important role to play in feeding and interaction. Previous research on weight gain has looked at motherhood as the cause of inadequate weight gain in the infant (e.g. Benoit et al., 1989; Polan and Ward, 1994). But the findings in the current study underline the role of the infant's behaviour in physical development.

In the final results chapter the temperament variables were examined in relation to the maternal adaptation variables and mother-infant interaction. Irritable behaviour, as measured by the temperament dimension *distress to limitations*, was positively related to the mother's relationship with the husband and the mother's satisfaction with motherhood, so that mothers with infants who had high scores on *distress to limitations* were more likely be dissatisfied with their relationships with the husband and with motherhood. High levels of *fear* in infants was related to less satisfaction with the father's participation in care, with the life situation and with support from family and friends. Mothers with active infants were less satisfied with the relationship with the husband, and with his participation in care. Finally the mother's confidence in parenting was less for mothers with very active infants.

When reviewing the results for mother-infant interaction it is striking to find that activity in infants is related to certain aspects of mother-infant interaction. Active behaviour in infants is associated with lower scores on the mother's *response to distress*, the mother's *emotional growth fostering* and the infant's *responsiveness to caregiver*. These findings correspond with Belsky's (1984) emphasis on the influence of the infant's behaviour on the mother's well-being. Cutrona and Troutman (1986) found that the mother's sense of competence and overall well-being was related to infant's characteristics. These findings and the relationship found between mother-infant interaction and the mother's adaptation variables confirm Belsky's model of parenting (1984) and Cutrona and Troutman's mediational model (1986). The mother's well-being was influenced by the infant's behaviour, which in turn influenced mother-infant interaction.

Dissatisfaction with the relationship with the husband and the role as a mother is associated with a certain pattern of behaviour in the infant. Mothers of irritable, active or fearful infants were found to be more likely to be dissatisfied with the relationship with the father of the infant and their role as a mother. On the one hand it is possible that dissatisfaction with certain aspects of life influences the way the mother perceives her infant's behaviour. Alternatively, the infant's behaviour may be influencing the way she feels towards her husband and her role as a mother. Research into postnatal depression has investigated the infant's behaviour in relation to the mother's mood. Cutrona and Troutman (1989) found a positive significant correlation between depressive symptoms and the infant's difficult behaviour. This provides evidence for the importance of the infant's behaviour when it comes to the mother's feelings.

In the final results section of the thesis an overall model was presented for the prediction of weight gain from birth to eight weeks. A forward stepwise regression was carried out including the behaviour variables which in previous chapters were found to be related to weight gain, i.e. the infant's temperament, sucking behaviour and the duration of the feed. The outcome of the regression analysis showed that apart from the control variables *birthweight*, *sex*, and *age*, two variables were independently significant predictors of weight gain. The infant's level of *fear* and *length of feed* predicted weight at eight weeks. Infants with high levels of *fear* and longer feeding times were more likely to have slow weight gain from birth to eight weeks. A comparison with previous analyses in which the two variables were not adjusted for each other showed that the relative influence of *length of feed* decreased with the inclusion of *fear*. On the other hand, the relative influence of *fear* increases with the inclusion of the variable *length of feed*.

Conclusions

The study was carried out to investigate behavioural predictors of weight gain in the early months. The aim was to examine behaviour during the feeding situation in order to find characteristics associated with poor weight gain. Research on failure to thrive has highlighted the need for the investigation of mother-infant interaction in relation to weight gain, as well as specific problems of feeding behaviour. Methodological flaws in the majority of studies on failure to thrive emphasised the need for a prospective study, which was able to avoid the problems such as unrepresentative sampling, and retrospective data collection.

In the current study infants were recruited around eight weeks, which allows the investigation of behaviour during feeding in the early weeks. The first purpose was to evaluate the reliability of the assessment of observing sucking behaviour and analysing it using a mixture model. The sucking parameters were estimated with good or reasonable reliability, with the exception of *sucks per burst* at the start of the feed. Assessing sucking behaviour through observation is a relatively easy and non-intrusive method, and can be used both for bottle and for breastfed infants. The mixture model enabled the identification of changes that occur over the course of the feed, which were found to be more pronounced in breastfeeding infants. This is in line with the fact that breastfeeding infants experience more changes as the feed progresses, such as changes in the composition and flow of milk, than bottlefeeding infants. It also shows that in investigating sucking behaviour it is essential that the feeding method is taken into account.

The most important aim of the study was to investigate behavioural predictors of weight gain. New conditional weight standards were used to classify infants as having either slow, average or fast weight gain at eight weeks. Infants were also weighed at six months, which allowed the evaluation of weight gain over the first six months, and the identification of infants with failure to thrive at that time. Using the thrive index (Wright et al., 1994) six infants were identified as having failure to thrive at six months. Striking in these findings was that all six infants had slow weight gain from birth to eight weeks. This showed that infants with slow weight gain in the first eight weeks have an approximate 25% chance of failing to thrive by six months. This shows that close monitoring of infants with slow weight gain in the early months is practical.

Since the conditional weight standards proved to be effective in selecting infants with different weight gain patterns in this study, it would be valuable to investigate the use of the standards in a larger population of infants. In our sample six of the 22 slow weight gaining infants were found to be failing to thrive at six months and it is important to investigate whether this would replicate in a different sample. In addition, it should be investigated whether it is feasible to use the conditional weight standard in GP practices and whether Health Visitors would find them useful for early monitoring of weight gain.

Weight gain from birth to eight weeks was examined in relation to different dimensions of the infant's and mother's behaviour. In recruiting infants with different weight gain patterns it was hoped that behaviour associated with slow weight gain would become clearer. First of all, a regression analysis showed that one of the sucking parameter estimates was a significant predictor of weight at eight weeks. Infants with longer *pause lengths* at the *end* of feed were more likely to have slow weight gain. However, additional analyses showed that this relationship was attributable to one infant's extreme scores. This infant had extremely long *pause lengths* at the *end* of the feed. In addition, this infant had extreme weight gain as well, only gaining approximately 350 g in eight weeks. This infant's feeding behaviour was sufficiently extreme to strongly influence the results of the regression analysis. Although no overall significant relationship was found between weight gain and the infant's sucking behaviour, this infant's scores give an indication that in some cases unusual sucking behaviour may be related to poor weight gain. With regards to the investigation of sucking behaviour in future research it would be useful to examine sucking behaviour in infants with very slow weight gain. In the present study slow weight gain comprised a group of infants who were the slowest growing 20%. It is possible that the slowest growing infants are the ones who have most problems feeding, and this could be studied by selecting the slowest 10% of 5% of a population of healthy infants.

Another aspect of feeding did prove to be a significant overall predictor of weight gain, namely the length of the feed from which the sucking behaviour was assessed. Infants with longer feeds were more likely to have slow weight gain in the first eight weeks. This seems counterintuitive in the sense that longer feeds would enable the infant to ingest more milk. However, longer feeds may be a result of poorer appetite. Long feeds could be an indicator for Health Visitors to focus on when monitoring infants with slow weight gain. More research should carried out on feeding behaviour in order to establish what constitutes a long feeding time, and what length of time should warrant concern.

Another predictor established in the study was the infant's temperament, in particular the infant's level of *fear*. Infants with high levels of *fear* were more likely to have slow weight gain from birth to eight weeks. This shows that the infant's behaviour plays a part in weight gain. Previous research has focused on the mother's behaviour quite strongly in trying to find answers for infant's slow weight gain. This inadvertently assumes that the infant is simply a receiver of care in the first few months, rather than actively demanding care. When considering the relationship between temperament and weight gain it may the case that temperament characteristics in the infant make it more difficult for the mother to adequately interpret her infants' behaviour, which may result in decreased sensitivity to the infant's needs. More research is needed into examining the more specific influence the infant's temperament has on interactions from a very early age.

The results that were found only pertained to weight gain from birth to eight weeks; none of the variables were related to weight gain from birth to six months. One possibility for this finding is that the behaviours measured were examined at eight weeks and therefore were more relevant at that age. Another is that slow weight gain in the first eight weeks does not necessarily result in slow weight gain thereafter. Changes such as changing from breast to bottle, or being weaned onto solids, often change the weight gain pattern. This was very obvious in the infant (50) who had extreme slow weight gain and extreme sucking behaviour. After having been introduced to solids the infant's weight gain increased significantly so that at six months the infant had regained the original birthweight centile on the growth chart. One way forward would be to investigate behavioural characteristics at six months and relate them to weight at six months. Another would be close monitoring of changes in feeding behaviour which may coincide with changes in weight gain. This could increase our understanding of weight gain in young infants.

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Appendix One

Conditional eight week weight standards

		BOYS			GIRLS		
birthweight	age in weeks	slow <	mean	fast >	slow <	mean	fast >
2000	6	3300	3620	3960	3180	3470	3760
2000	7	3500	3830	4180	3360	3660	3970
2000	8	3710	4060	4410	3550	3860	4170
2000	9	3920	4280	4640	3740	4050	4370
2000	10	4120	4480	4860	3920	4240	4560
2100	6	3370	3750	4040	3260	3540	3850
2100	7	3580	3910	4270	3440	3740	4050
2100	8	3790	4140	4490	3630	3930	4250
2100	9	3990	4350	4720	3820	4130	4450
2100	10	4190	4560	4930	3990	4310	4640
2200	6	3450	3780	4130	3300	3630	3930
2200	7	3660	4000	4350	3510	3820	4130
2200	8	3870	4210	4580	3700	4010	4340
2200	9	4070	4430	4800	3890	4200	4530
2200	10	4270	4630	5020	4060	4390	4720
2300	6	3540	3870	4210	3410	3710	4010
2300	7	3740	4080	4430	3590	3890	4210
2300	8	3950	4300	4660	3780	4090	4410
2300	9	4150	4510	4880	3960	4280	4610
2300	10	4340	4710	5090	4130	4460	4800
2400	6	3610	3950	4290	3490	3780	4100
2400	7	3820	4160	4520	3670	3970	4300
2400	8	4020	4380	4740	3850	4160	4500
2400	9	4230	4590	4970	4030	4350	4690
2400	10	4420	4790	5180	4200	4530	4880
2500	6	3690	4030	4380	3560	3860	4180
2500	7	3900	4240	4600	3740	4060	4380
2500	8	4100	4460	4830	3930	4240	4580
2500	9	4300	4670	5050	4110	4430	4770
2500	10	4490	4870	5260	4280	4610	4960
2600	6	3770	4110	4460	3640	3950	4260
2600	7	3970	4320	4680	3820	4140	4460
2600	8	4180	4540	4910	4000	4320	4660
2600	9	4380	4740	5130	4180	4510	4850
2600	10	4560	4940	5330	4350	4680	5040
2700	6	3850	4200	4550	3710	4020	4340
2700	7	4050	4400	4770	3890	4210	4540
2700	8	4260	4620	5000	4070	4400	4740
2700	9	4450	4830	5210	4250	4580	4930
2700	10	4640	5020	5410	4410	4760	5110

birthweight	age in weeks	BOYS slow <	BOYS mean	BOYS fast >	GIRLS slow <	GIRLS mean	GIRLS fast >
2800	6	3930	4280	4630	3790	4100	4430
2800	7	4130	4490	4850	3970	4290	4620
2800	8	4330	4700	5080	4150	4480	4820
2800	9	4530	4900	5290	4320	4660	5010
2800	10	4710	5100	5490	4490	4830	5190
2900	6	4010	4350	4710	3870	4180	4510
2900	7	4210	4560	4940	4050	4370	4710
2900	8	4400	4780	5150	4220	4550	4900
2900	9	4600	4980	5370	4400	4730	5090
2900	10	4790	5170	5580	4560	4900	5270
3000	6	4090	4440	4800	3940	4260	4590
3000	7	4280	4650	5020	4110	4440	4780
3000	8	4480	4860	5240	4290	4620	4970
3000	9	4680	5060	5450	4460	4810	5160
3000	10	4860	5250	5660	4630	4970	5340
3100	6	4170	4520	4880	4020	4340	4670
3100	7	4360	4720	5110	4190	4520	4870
3100	8	4560	4930	5320	4370	4700	5060
3100	9	4760	5140	5530	4540	4880	5240
3100	10	4930	5330	5730	4960	5050	5410
3200	6	4240	4600	4960	4090	4410	4750
3200	7	4440	5810	5180	4260	4600	4940
3200	8	4630	5010	5400	4440	4780	5130
3200	9	4830	5220	5610	4610	4960	5320
3200	10	5010	5400	5810	4760	5120	5490
3300	6	4320	4680	5050	4170	4500	4830
3300	7	4520	4890	5270	4340	4680	5020
3300	8	4710	5090	5490	4510	4850	5210
3300	9	4910	5290	5690	4680	5030	5400
3300	10	5080	5480	5890	4830	5190	5560
3400	6	4400	4760	5130	4240	4570	4910
3400	7	4590	4970	5350	4420	4750	5100
3400	8	4790	5170	5560	4580	4930	5290
3400	9	4980	5370	5770	4750	5110	5470
3400	10	5160	5560	5970	4910	5270	5640
3500	6	4480	4840	5210	4320	4650	5000
3500	7	4670	5040	5430	4490	4830	5180
3500	8	4860	5250	5640	4660	5010	5370
3500	9	5050	5440	5860	4820	5180	5550
3500	10	5220	5630	6040	4980	5340	5720

		BOYS			GIRLS		
birthweight	age in weeks	slow <	mean	fast >	slow <	mean	fast >
3600	6	4560	4920	5300	4390	4730	5070
3600	7	4750	5130	5520	4560	4910	5260
3600	8	4940	5330	5730	4730	5080	5450
3600	9	5130	5520	5940	4890	5250	5630
3600	10	5300	5700	6130	5040	5410	5790
3700	6	4640	5000	5380	4470	4810	5160
3700	7	4830	5210	5600	4640	4990	5340
3700	8	5020	5410	5810	4810	5160	5530
3700	9	5200	5600	6010	4960	5330	5700
3700	10	5370	5780	6210	5120	5480	5870
3800	6	4710	5080	5470	4550	4890	5240
3800	7	4910	5280	5680	4710	5060	5420
3800	8	5100	5490	5890	4880	5240	5600
3800	9	5280	5680	6100	5030	5400	5780
3800	10	5450	5860	6280	5180	5560	5940
3900	6	4790	5160	5550	4620	4960	5320
3900	7	4980	5370	5760	4790	5130	5500
3900	8	5170	5560	5980	4950	5310	5680
3900	9	5350	5760	6170	5110	5470	5860
3900	10	5520	5930	6360	5250	5630	6020
4000	6	4870	5240	5630	4700	5040	5400
4000	7	5090	5450	5850	4860	5210	5580
4000	8	5250	5640	6060	5020	5380	5760
4000	9	5430	5840	6260	5180	5550	5930
4000	10	5600	6010	6440	5320	5700	6100
4100	6	4950	5330	5720	4770	5120	5480
4100	7	5140	5530	5930	4930	5290	5660
4100	8	5330	5720	6140	5090	5460	5840
4100	9	5500	5920	6340	5250	5620	6010
4100	10	5670	6090	6520	5390	5770	6170
4200	6	5030	5410	5800	4840	5200	5560
4200	7	5220	5610	6010	5000	5370	5740
4200	8	5410	5810	6220	5160	5540	5920
4200	9	5580	5990	6420	5320	5700	6080
4200	10	5750	6160	6600	5460	5850	6240
4300	6	5110	5490	5880	4920	5270	5640
4300	7	5300	5690	6100	5080	5440	5810
4300	8	5480	5890	6290	5240	5610	5990
4300	9	5660	6070	6500	5390	5770	6160
4300	10	5810	6240	6680	5530	5920	6320

birthweight	age in weeks	BOYS slow <	BOYS mean	BOYS fast >	GIRLS slow <	GIRLS mean	GIRLS fast >
4400	6	5190	5570	5970	4990	5350	5720
4400	7	5370	5770	6180	5150	5510	5900
4400	8	5560	5960	6380	5310	5680	6070
4400	9	5730	6150	6580	5460	5840	6240
4400	10	5890	6310	6760	5600	5990	6390
4500	6	5270	5650	6050	5070	5430	5800
4500	7	5450	5850	6260	5220	5600	5970
4500	8	5640	6040	6470	5380	5760	6150
4500	9	5810	6230	6660	5530	5920	6310
4500	10	5970	6390	6840	5670	6060	6470
4600	6	5350	5730	6130	5150	5500	5880
4600	7	5530	5930	6340	5300	5670	6060
4600	8	5710	6120	6550	5460	5830	6230
4600	9	5880	6310	6740	5600	5990	6390
4600	10	6040	6470	6910	5740	6130	6540
4700	6	5420	5820	6210	5220	5580	5960
4700	7	5610	6010	6420	5370	5740	6130
4700	8	5790	6200	6630	5520	5910	6300
4700	9	5960	6380	6820	5670	6060	6470
4700	10	6110	6540	6990	5800	6200	6610
4800	6	5500	5900	6300	5290	5660	6040
4800	7	5690	6100	6510	5450	5830	6210
4800	8	5870	6290	6710	5600	5990	6380
4800	9	6040	6470	6900	5740	6140	6540
4800	10	6180	6620	7070	5870	6280	6690
4900	6	5580	5980	6380	5360	5740	6120
4900	7	5770	6170	6590	5520	5900	6290
4900	8	5950	6360	6800	5670	6060	6460
4900	9	6110	6540	6980	5810	6210	6620
4900	10	6260	6700	7160	5940	6340	6770
5000	6	5670	6060	6470	5440	5810	6200
5000	7	5850	6250	6680	5600	5970	6370
5000	8	6020	6440	6880	5740	6130	6540
5000	9	6190	6620	7070	5880	6280	6690
5000	10	6330	6780	7230	6010	6410	6840

Appendix Two

Letter to GP manager

Dear Sir/Madam,

Infant weight gain project

I am currently planning a research project with the above title, in collaboration with Dr Robert Drewett of this University and Dr Charlotte Wright, First Assistant in Community Child Health at the University of Newcastle upon Tyne. I am writing to ask if you would be kind enough to discuss the project with the doctors in your practice, and ask their permission for me to recruit families through your practice Health Visitors and well baby clinics.

Details of the project are given in the enclosed information sheets. Dr Nnenna Cookey, Consultant Paediatrician in Community Health, is the NHS Clinical Supervisor of the project, and it has the support of Anne Nichol, Clinical Leader for Health Visiting. It has been approved by the County Durham Health Authority Ethics Committee (Study 11/APR97).

If your practice doctors are willing to let me do so, I would like to ask the practice Health Visitors if I could attend a well-baby clinic weekly to recruit volunteers for the project at the 8 week check. The recruitment procedures are given in outline in the enclosed information sheet, and would be decided in detail in consultation with your Health Visitors.

I would be most grateful to know if your practice doctors could give their approval to this project. If they are willing to do so, perhaps you could let me know who I should contact to make arrangements to attend the baby clinic.

Yours sincerely,

Anne-Sophie Molkenboer

Appendix Three

Information sheet for General Practitioners

UNIVERSITY OF DURHAM
South Road
Durham DH1 3LE
tel: 0191 374 7780

Infant weight gain project- information for General Practitioners.

We are planning a research project on weight gain in early infancy. To be able to recruit the appropriate families we would need to regularly visit the baby clinics and therefore we would very much appreciate your cooperation and that of your practice Health Visitors.

We would like to select a group of infants with different weight gains, to examine how this relates to their feeding behaviour and other characteristics. Our interest lies particularly with poor weight gain since it may sometimes be an early sign of failure to thrive.

In order to select the infants we will need to see all mothers and their infants at the 8 week check at the baby clinic. We will ask the mothers some general questions and establish the infant's weight gain with the new growth charts. We will then select about half the infants to be representative of different patterns of weight gain, and ask the mothers if they are willing to take part in the study.

Shortly after we will visit the mother and her infant at home and videotape a feeding session. The mother will be given questionnaires, one on her experience of motherhood, and one which assesses the mother's own feeding attitudes. These will be collected at the second visit, at which time another videotape will be made. The infant will be weighed at the visit and at a follow-up at 6 months, and these weights will be available for the child's Personal Child Health Record.

Though most of the children will have normal growth there is a small possibility, as a result of the additional weighing, that we will detect an otherwise unnoticed case failure to thrive. In such a case, with consent of the parents, we will pass the information on to the Health Visitor. Further clinical handling will be by the Health Visitor and the GP.

We do appreciate that you have many responsibilities, and we will be careful not to inconvenience the normal working of the clinic. Please do not hesitate to ask if you would like any further information about our work.

Ms. Anne-Sophie Molkenboer, Research Worker
Dr. Robert F. Drewett, Senior Lecturer in Psychology
Dr. Charlotte Wright, First Assistant in Community Child Health, University of Newcastle-upon-Tyne
Dr. Nnenna Cookey, Consultant Paediatrician in Community Health

Appendix Four

Information sheet for Health Visitors

UNIVERSITY OF DURHAM
South Road
Durham DH1 3LE
tel: 0191 374 7780

Infant weight gain project- information for Health Visitors.

We are planning a research project on weight gain in early infancy. We wish to recruit families from the baby clinics and therefore we would very much appreciate your cooperation.

We would like to select a group of infants with different weight gains, to examine how this relates to their feeding behaviour and other characteristics. Our interest lies particularly with poor weight gain since it may sometimes be an early sign of failure to thrive.

In order to select the infants we will need to see all mothers and their infants at the 8 week check at the baby clinic. We will ask the mothers some general questions and establish the infant's weight gain with the new growth charts. We will then select about half the infants to be representative of different patterns of weight gain, and ask the mothers if they are willing to take part in the study.

Shortly after we will visit the mother and her infant at home and videotape a feeding session. The mother will be given questionnaires, one on her experience of motherhood, and one which assesses the mother's own feeding attitudes. These will be collected at the second visit, at which time another videotape will be made. The infant will be weighed at the visit and at a follow-up at 6 months, and these weights will be available for the child's Personal Child Health Record.

Though most of the children will have normal growth there is a small possibility, as a result of the additional weighing, that we will detect an otherwise unnoticed case of failure to thrive. In such a case, with consent of the parents, we will pass the information on to the Health Visitor. Further clinical handling will be by the Health Visitor and the GP.

We do appreciate that you have many responsibilities, and we will be careful not to inconvenience the normal working of the clinic. Please do not hesitate to ask if you would like any further information about our work.

Ms. Anne-Sophie Molkenboer, Research Worker
Dr. Robert F. Drewett, Senior Lecturer in Psychology
Dr. Charlotte Wright, First Assistant in Community Child Health, University of Newcastle-upon-Tyne
Dr. Nnenna Cookey, Consultant Paediatrician in Community Child Health

Appendix Five

Parental consent form

PARENTAL DECLARATION OF INFORMED CONSENT

I am willing to take part in the project on growth in infancy. I have been given a copy of the Information Sheet. I have been informed that all information collected will be kept confidential. I understand that I may withdraw from the study at any time.

Child's name

Parent's name
(please print)

Parent's signature

date

Appendix Six

Information sheet for mothers

Anne-Sophie Molkenboer
University of Durham
South Road
Durham DH1 3LE

Infant Growth Project

I would like to invite you and your child to take part in a study on growth in infancy. In this study we are interested in different growth patterns in healthy infants, in the early months of life. Through this study, we hope to gain a greater understanding of weight gain in healthy children which will enable us to help more with children who have feeding and growth problems.

Taking part in this study will involve me visiting you at home, on two consecutive days. I would like to arrange to come to your home to make video recordings of feeding sessions, when your baby is about 2 months old. I will also ask you to help me weigh your child using a portable scale.

In addition I will ask you to complete several questionnaires relating to your own eating behaviour, your experience of motherhood and your child's everyday behaviour. I would also like you to keep a diary of your child's sleeping behaviour.

If at any time you would like more information about this study please do not hesitate to contact either myself (Tel. 0191 374 2628) or my colleague Dr. Robert Drewett (Tel. 0191 374 2612) at Durham University.

If you wish to participate I will ask you to sign a consent form. Obtaining signed consent is routine for all studies; it does not oblige you to participate, and you will be free to withdraw from the study at any time.

I would like to reassure you that the aim of the study is solely to describe feeding behaviour and weight gain in healthy infants. I will not be asking you to change your child's feeds in any way. All information collected during this study will be kept confidential.

Many thanks,

Anne-Sophie Molkenboer

Appendix Seven

Questions on the mother's and father's education and occupation

Questions relating to the parents' education and occupation

1. How old were you when you finished full-time education?

16 or under	☐
17	☐
18	☐
19 or over	☐

2. What qualifications have you obtained at school or college?

no formal qualifications	☐
CSE (or equivalent)	☐
'O' level (or equivalent)	☐
GCSE	☐
'A' level	☐
degree	☐
other (specify)	☐

____

3. What was your current (or last) form of paid employment?

jobtitle ☐

full-time	☐
part-time	☐

job description ☐

organisation description ☐

manager	☐
supervisor	☐
neither	☐

4. Do you have a car?

yes ☐
no ☐

5. Do you have a telephone?

yes
no

6. Does your household own or rent this house or flat?

owns - with mortgage or loan or outright
rents local authority/new town
housing association
privately unfurnished
privately furnished
from employer
other with payment
tied house
rent free

7. Is the father present in the household?

yes
no

8. Do you smoke?

no
yes, 1-10 a day
11-20 a day
21-30 a day
more

Appendix Eight

Infant Behavior Questionnaire

Child's name_______________________ IDNR______________

Infant Behaviour Questionnaire

INSTRUCTIONS: Please read carefully before starting:

As you read each description of the baby's behaviour below, please indicate how often the baby did this during the LAST WEEK (the past seven days) by circling one of the numbers in the right column. These numbers indicate how often you observed the behaviour during the last week.

1	2	3	4	5	6	7	X
never	**very rarely**	**less than half of the time**	**about half the time**	**more than half the time**	**almost always**	**always**	**does not apply**

The "does not apply" (X) column is used when you did not see the baby in the situation described during the last week. For example, if the situation mentions the baby having to wait for food or liquids and there was no time during the last week when the baby had to wait, circle the "X" column. "Does not apply" is different from "Never" (1). "Never" is used when you saw the baby in the situation but the baby never engaged in the behaviour listed during the last week. For example, if the baby did have to wait for food or liquids at least once but never cried loudly while waiting, circle the "1" column.
Please be sure to circle a number for every item.

FEEDING

When having to wait for food or liquids during the last week, how often did the baby:

1. seem not bothered?	1	2	3	4	5	6	7	X
2. show mild fussing?	1	2	3	4	5	6	7	X
3. cry loudly?	1	2	3	4	5	6	7	X

During feeding, how often did the baby:

4. lie or sit quietly?	1	2	3	4	5	6	7	X
5. squirm or kick?	1	2	3	4	5	6	7	X
6. wave arms?	1	2	3	4	5	6	7	X
7. fuss or cry when s/he had enough to eat?	1	2	3	4	5	6	7	X
8. fuss or cry when given a disliked food?	1	2	3	4	5	6	7	X

1 never	2 very rarely	3 less than half the time	4 about half the time	5 more than half the time	6 almost always	7 always	X does not apply

When given a new food or liquid, how often did the baby:

9. accept it immediately?	1	2	3	4	5	6	7	X
10. reject it by spitting out, closing mouth, etc.?	1	2	3	4	5	6	7	X
11. not accept it no matter how many times offered?	1	2	3	4	5	6	7	X

SLEEPING

Before falling asleep at night during the last week, how often did the baby:

12. show no fussing or crying?	1	2	3	4	5	6	7	X

During sleep, how often did the baby:

13. toss about in the crib?	1	2	3	4	5	6	7	X
14. move from the middle to the end of the crib?	1	2	3	4	5	6	7	X
15. sleep in one position only?	1	2	3	4	5	6	7	X

After sleeping, how often did the baby:

16. fuss or cry immediately?	1	2	3	4	5	6	7	X
17. play quietly in crib?	1	2	3	4	5	6	7	X
18. coo and vocalize for periods of 5 minutes or longer?	1	2	3	4	5	6	7	X
19. cry if someone doesn't come within a few minutes?	1	2	3	4	5	6	7	X

How often did the baby:

20. seem angry (crying and fussing) when you left her/him in the crib?	1	2	3	4	5	6	7	X
21. seem contented when left in the crib?	1	2	3	4	5	6	7	X
22. cry or fuss before going to sleep for naps?	1	2	3	4	5	6	7	X

1 never	2 very rarely	3 less than half the time	4 about half the time	5 more than half the time	6 almost always	7 always	X does not apply

BATHING AND DRESSING

When being dressed or undressed during the last week, how often did the baby:

23. wave his/her arms and kick?	1	2	3	4	5	6	7	X
24. squirm and/or try to roll away?	1	2	3	4	5	6	7	X
25. smile or laugh?	1	2	3	4	5	6	7	X

When put into the bath water, how often did the baby:

26. smile?	1	2	3	4	5	6	7	X
27. laugh?	1	2	3	4	5	6	7	X
28. splash or kick?	1	2	3	4	5	6	7	X
29. turn body and/or squirm?	1	2	3	4	5	6	7	X

When face was washed, how often did the baby:

30. smile or laugh?	1	2	3	4	5	6	7	X
31. fuss or cry?	1	2	3	4	5	6	7	X

When hair was washed, how often did the baby:

32. smile or laugh?	1	2	3	4	5	6	7	X
33. fuss or cry?	1	2	3	4	5	6	7	X

1 never	2 very rarely	3 less than half the time	4 about half the time	5 more than half the time	6 almost always	7 always	X does not apply

PLAY

How often during the last week did the baby:

34. look at pictures in books and/or magazines for 2-5 minutes at a time?	1	2	3	4	5	6	7	X
35. look at pictures in books and/or magazines for 5 minutes or longer at a time?	1	2	3	4	5	6	7	X
36. stare at a mobile, crib bumper, or picture for 5 minutes or longer?	1	2	3	4	5	6	7	X
37. play with one toy or object for 5-10 minutes?	1	2	3	4	5	6	7	X
38. play with one toy or object for 10 minutes or longer?	1	2	3	4	5	6	7	X
39. spend time just looking at playthings?	1	2	3	4	5	6	7	X
40. repeat the same sounds over and over again?	1	2	3	4	5	6	7	X
41. laugh aloud in play?	1	2	3	4	5	6	7	X
42. smile or laugh when tickled?	1	2	3	4	5	6	7	X
43. cry or show distress when tickled?	1	2	3	4	5	6	7	X
44. repeat the same movement with an object for 2 minutes or longer (e.g. putting a block in a cup, kicking or hitting a mobile)?	1	2	3	4	5	6	7	X

When something the baby was playing with had to be removed, how often did s/he:

45. cry or show distress for a time?	1	2	3	4	5	6	7	X
46. cry or show distress for several minutes or longer?	1	2	3	4	5	6	7	X
47. seem not bothered?	1	2	3	4	5	6	7	X

1	2	3	4	5	6	7	X
never	**very rarely**	**less than half the time**	**about half the time**	**more than half the time**	**almost always**	**always**	**does not apply**

When tossed around playfully, how often did the baby:

48. smile?	1	2	3	4	5	6	7	X
49. laugh?	1	2	3	4	5	6	7	X

During a peekaboo game, how often did the baby:

50. smile?	1	2	3	4	5	6	7	X
51. laugh?	1	2	3	4	5	6	7	X

DAILY ACTIVITIES

How often during the last week did the baby:

52. cry or show distress at a loud sound (blender, vacuum cleaner, etc.)?	1	2	3	4	5	6	7	X
53. cry or show distress at a change in parents' appearance (glasses off, shower cap on, etc.)?	1	2	3	4	5	6	7	X
54. when in a position to see the television set, look at it for 2-5 minutes at a time?	1	2	3	4	5	6	7	X
55. when in a position to see the television set, look at it for 5 minutes or longer?	1	2	3	4	5	6	7	X
56. protest being put in a confining place (infant seat, play pen, car seat, etc.)?	1	2	3	4	5	6	7	X
57. cry after startling?	1	2	3	4	5	6	7	X

When being held, how often did the baby:

58. squirm, pull away or kick?	1	2	3	4	5	6	7	X

1	2	3	4	5	6	7	X
never	**very rarely**	**less than half the time**	**about half the time**	**more than half the time**	**almost always**	**always**	**does not apply**

When placed on his/her back, how often did the baby:

59. fuss or protest?	1	2	3	4	5	6	7	X
60. smile or laugh?	1	2	3	4	5	6	7	X
61. lie quietly?	1	2	3	4	5	6	7	X
62. wave arms and kick?	1	2	3	4	5	6	7	X
63. squirm and/or turn body?	1	2	3	4	5	6	7	X

When the baby wanted something, how often did s/he:

64. become upset when s/he could not get what s/he wanted?	1	2	3	4	5	6	7	X
65. have tantrums (crying, screaming, face red, etc.) when s/he did not get what s/he wanted?	1	2	3	4	5	6	7	X

When placed in an infant seat or car seat, how often did the baby:

66. wave arms and kick?	1	2	3	4	5	6	7	X
67. squirm and turn body?	1	2	3	4	5	6	7	X
68. lie or sit quietly?	1	2	3	4	5	6	7	X
69. show distress at first; then quiet down?	1	2	3	4	5	6	7	X

When you returned from having been away and the baby was awake, how often did s/he:

70. smile or laugh?	1	2	3	4	5	6	7	X

1	2	3	4	5	6	7	X
never	**very rarely**	**less than half the time**	**about half the time**	**more than half the time**	**almost always**	**always**	**does not apply**

When introduced to a strange person, how often did the baby:

71. cling to a parent?	1	2	3	4	5	6	7	X
72. refuse to go to the stranger?	1	2	3	4	5	6	7	X
73. hang back from the stranger?	1	2	3	4	5	6	7	X
74. never "warm up" to the stranger?	1	2	3	4	5	6	7	X
75. approach the stranger at once?	1	2	3	4	5	6	7	X
76. smile or laugh?	1	2	3	4	5	6	7	X

When introduced to a dog or cat, how often did the baby:

77. cry or show distress?	1	2	3	4	5	6	7	X
78. smile or laugh?	1	2	3	4	5	6	7	X
79. approach at once?	1	2	3	4	5	6	7	X

SOOTHING TECHNIQUES

Have you tried any of the following soothing techniques in the last **2 weeks**? If so, how often did the method soothe the baby? Circle (X) if you did not try the technique during the LAST TWO WEEKS.

80. rocking	1	2	3	4	5	6	7	X
81. holding	1	2	3	4	5	6	7	X
82. singing or talking	1	2	3	4	5	6	7	X
83. walking with the baby	1	2	3	4	5	6	7	X
84. giving the baby a toy	1	2	3	4	5	6	7	X
85. showing the baby something to look at	1	2	3	4	5	6	7	X

1 never	2 very rarely	3 less than half the time	4 about half the time	5 more than half the time	6 almost always	7 always	X does not apply

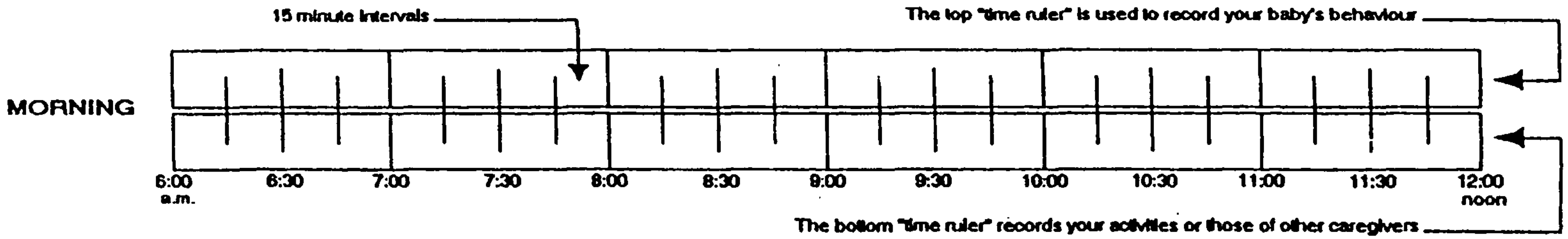
86. patting or gently rubbing some part of the baby's body	1	2	3	4	5	6	7	X
87. offering food or liquid	1	2	3	4	5	6	7	X
88. offering baby his/her security object	1	2	3	4	5	6	7	X
89. changing baby's position	1	2	3	4	5	6	7	X
90. other (please specify)____________________	1	2	3	4	5	6	7	X

Appendix Nine

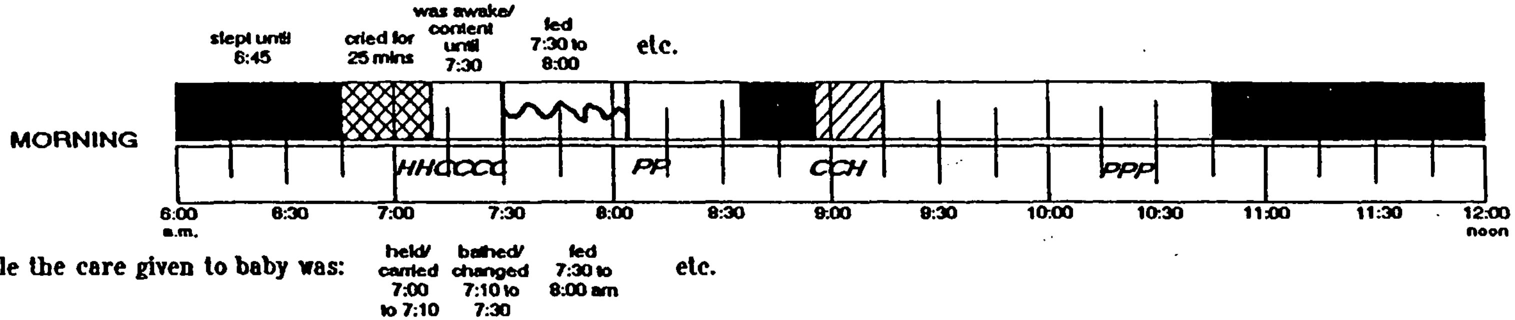
48 hour baby's day record

INSTRUCTIONS FOR COMPLETING THE "BABY'S DAY" RECORD

This record is designed to enable you to record your baby's behaviour and your activities with your baby over a continuous twenty-four hour period. As you can see, the day is divided into four blocks of six hours each. For example:



The record is filled in by shading on the "time rulers".
For instance, in the example below, baby:

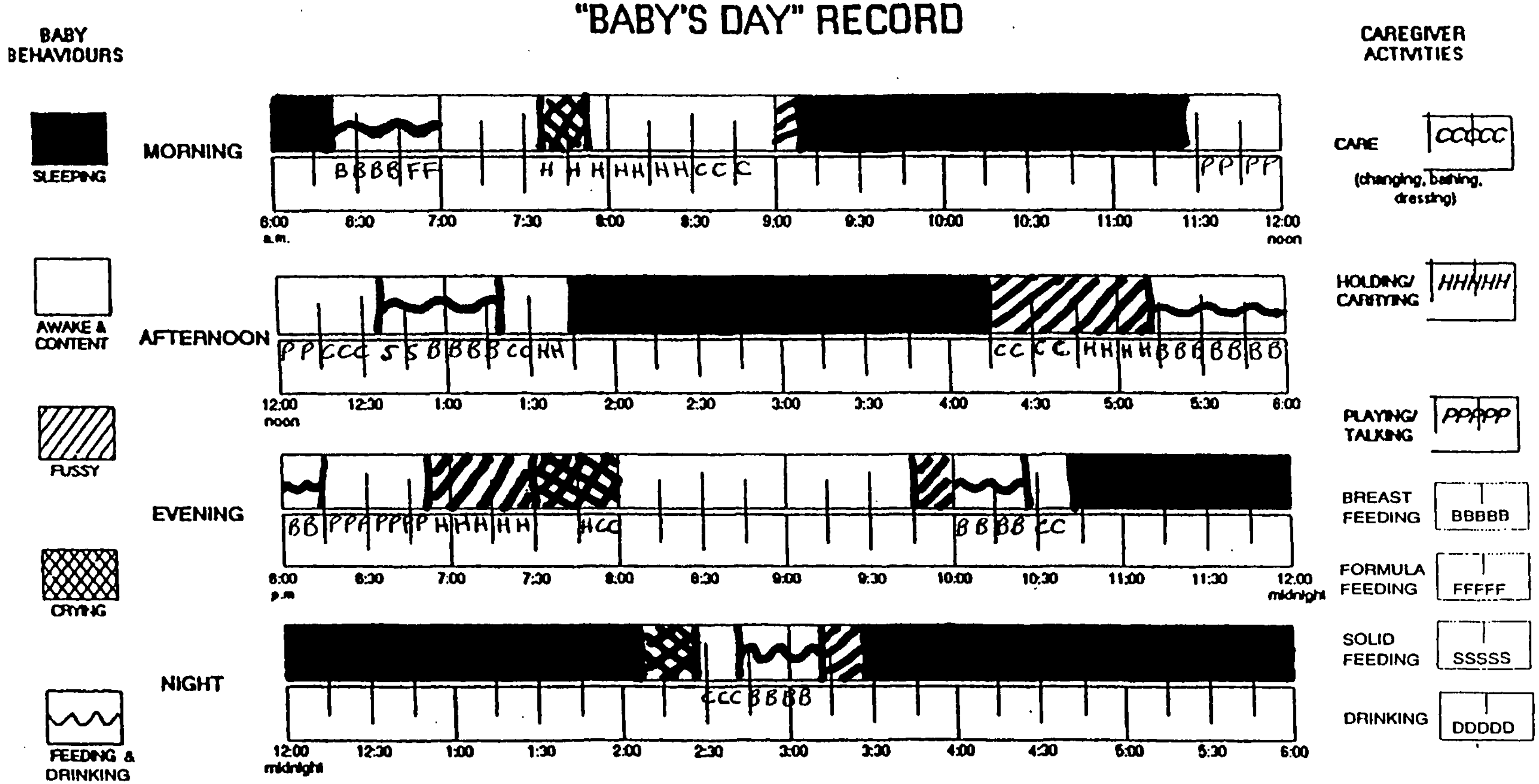


While the care given to baby was:

The attached example record shows a full 24 hours record filled in and explains the symbols. Note that activities or behaviours don't need to last 15 minutes in order to be filled in. The length of the shading-in tells us how long they lasted for. If you can be accurate to within about 5 minutes – and omit activities/behaviours which last less than 5 minutes – that will be accurate enough.

Baby's full name: EXAMPLE Baby's age: ______ weeks/months (please indicate weeks or months) Today's Date: __ : __ : __

"BABY'S DAY" RECORD



* FUSSY: your baby is unsettled, irritable, restless or fractious and may be vocalizing but not continuously crying

** CRYING: periods of prolonged distressed vocalization.

Appendix Nine: 48 hour baby's day record

Baby's full name: ______________________ Baby's age: ________ weeks/months (please indicate weeks or months) Today's Date: ___ : ___ : ___

"BABY'S DAY" RECORD

BABY BEHAVIOURS

- SLEEPING
- AWAKE & CONTENT
- FUSSY
- CRYING
- FEEDING & DRINKING

MORNING

6:00 a.m. | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | 11:30 | 12:00 noon

AFTERNOON

12:00 noon | 12:30 | 1:00 | 1:30 | 2:00 | 2:30 | 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00

EVENING

6:00 p.m | 6:30 | 7:00 | 7:30 | 8:00 | 8:30 | 9:00 | 9:30 | 10:00 | 10:30 | 11:00 | 11:30 | 12:00 midnight

NIGHT

12:00 midnight | 12:30 | 1:00 | 1:30 | 2:00 | 2:30 | 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00

CAREGIVER ACTIVITIES

- CARE (changing, bathing, dressing) — CCCCC
- HOLDING/ CARRYING — HHHHH
- PLAYING/ TALKING — PPPPP
- BREAST FEEDING — BBBBB
- FORMULA FEEDING — FFFFF
- SOLID FEEDING — SSSSS
- DRINKING — DDDDD

* FUSSY: your baby is unsettled, irritable, restless or fractious and may be vocalizing but not continuously crying

** CRYING: periods of prolonged distressed vocalization.

Appendix Nine: 48 hour baby's day record

Appendix Ten

Dutch Eating Behavior Questionnaire

Child's name:_______________________________ IDNR_______________

Eating Behaviour Questionnaire

directions: circle the appropriate response from the options

(1)never	(2)seldom	(3)sometimes	(4)often	(5)very often	(6)not relevant

1. If you have put on weight, do you eat less than you usually do?	1	2	3	4	5	6
2. Do you try to eat less at mealtimes than you would like to eat?	1	2	3	4	5	
3. How often do you refuse food or drink offered because you are concerned about your weight?	1	2	3	4	5	
4. Do you watch exactly what you eat?	1	2	3	4	5	
5. Do you deliberately eat foods that are slimming?	1	2	3	4	5	
6. When you have eaten too much, do you eat less than usual the following days?	1	2	3	4	5	6
7. Do you deliberately eat less in order not to become heavier?	1	2	3	4	5	
8. How often do you try not to eat between meals because you are watching your weight?	1	2	3	4	5	
9. How often in the evening do you try not to eat because you are watching your weight?	1	2	3	4	5	
10. Do you take into account your weight with what you eat?	1	2	3	4	5	
11. Do you have the desire to eat when you are irritated?	1	2	3	4	5	6
12. Do you have a desire to eat when you have nothing to do?	1	2	3	4	5	6
13. Do you have a desire to eat when you are depressed or discouraged?	1	2	3	4	5	6
14. Do you have a desire to eat when you are feeling lonely?	1	2	3	4	5	6

(1)never	(2)seldom	(3)sometimes	(4)often	(5)very often	(6)not relevant

15. Do you have a desire to eat when somebody lets you down?	1	2	3	4	5	6
16. Do you have a desire to eat when you are cross?	1	2	3	4	5	6
17. Do you have a desire to eat when you are approaching something unpleasant to happen?	1	2	3	4	5	
18. Do you get the desire to eat when you are anxious, worried or tense?	1	2	3	4	5	
19. Do you have a desire to eat when things are going against you or when things have gone wrong?	1	2	3	4	5	
20. Do you have a desire to eat when you are frightened?	1	2	3	4	5	6
21. Do you have a desire to eat when you are disappointed?	1	2	3	4	5	6
22. Do you have a desire to eat when you are emotionally upset?	1	2	3	4	5	6
23. Do you have a desire to eat when you are bored or restless?	1	2	3	4	5	6
24. If food tastes good to you, do you eat more than usual?	1	2	3	4	5	
25. If food smells and looks good, do you eat more than usual?	1	2	3	4	5	
26. If you see or smell something delicious, do you have a desire to eat it?	1	2	3	4	5	
27. If you have something delicious to eat, do you eat it straight away?	1	2	3	4	5	
28. If you walk past the baker do you have the desire to buy something delicious?	1	2	3	4	5	
29. If you walk past a snackbar or a cafe, do you have the desire to buy something delicious?	1	2	3	4	5	
30. If you see others eating, do you also have the desire to eat?	1	2	3	4	5	
31. Can you resist eating delicious foods?	1	2	3	4	5	
32. Do you eat more than usual, when you see others eating?	1	2	3	4	5	
33. When preparing a meal are you inclined to eat something?	1	2	3	4	5	

Appendix Eleven

Certificate of gratitude for participation in the study

5 May 1999

CERTIFICATE

We would like to thank

Anne Smith

for participating in our project, with great enthusiasm.

INFANT GROWTH PROJECT

Durham University

Anne-Sophie Molkenboer

Appendix Twelve

Sucking behaviour output file

Output file on infant's sucking behaviour (Filename 73LLE.obs)

=	=	=	10:	1:41:31	29:10:	97	13SST
2	*	q	10:	1:48:73	29:10:	97	
2	*	Y	10:	1:52:24	29:10:	97	
2	*	a	10:	2: 2: 8	29:10:	97	
2	*	m	10:	2: 4:22	29:10:	97	
2	*	v	10:	2:10:53	29:10:	97	
2	*	v	10:	2:11:14	29:10:	97	
2	*	v	10:	2:11:74	29:10:	97	
2	*	v	10:	2:12:40	29:10:	97	
2	*	v	10:	2:13: 6	29:10:	97	
2	*	v	10:	2:13:83	29:10:	97	
2	*	v	10:	2:14:60	29:10:	97	
2	*	v	10:	2:15:31	29:10:	97	
2	*	v	10:	2:15:97	29:10:	97	
2	*	v	10:	2:16:80	29:10:	97	
2	*	v	10:	2:17:62	29:10:	97	
2	*	v	10:	2:18:61	29:10:	97	
2	*	v	10:	2:19:60	29:10:	97	
2	*	v	10:	2:20:42	29:10:	97	
2	*	v	10:	2:21:24	29:10:	97	
2	*	v	10:	2:22:18	29:10:	97	
2	*	v	10:	2:22:89	29:10:	97	
2	*	v	10:	2:23:94	29:10:	97	
2	*	v	10:	2:24:65	29:10:	97	
2	*	v	10:	2:25:69	29:10:	97	
2	*	v	10:	2:26:74	29:10:	97	
2	*	v	10:	2:27:73	29:10:	97	
2	*	v	10:	2:28:82	29:10:	97	
2	*	v	10:	2:30: 3	29:10:	97	
2	*	v	10:	2:30:97	29:10:	97	
2	*	v	10:	2:32: 6	29:10:	97	
2	*	v	10:	2:32:61	29:10:	97	
2	*	v	10:	2:33:60	29:10:	97	
2	*	v	10:	2:34:65	29:10:	97	
2	*	v	10:	2:35:96	29:10:	97	
2	*	v	10:	2:37:56	29:10:	97	
2	*	v	10:	2:39:15	29:10:	97	
2	*	v	10:	2:40:63	29:10:	97	
2	*	v	10:	2:41:57	29:10:	97	
2	*	v	10:	2:42:39	29:10:	97	

2	*	v	10:	2:43:38	29:10:	97
2	*	v	10:	2:44:48	29:10:	97
2	*	v	10:	2:45:36	29:10:	97
2	*	v	10:	2:46:13	29:10:	97
2	*	v	10:	2:47: 0	29:10:	97
2	*	v	10:	2:47:77	29:10:	97
2	*	k	10:	2:51:12	29:10:	97
2	*	v	10:	2:54:42	29:10:	97
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2	*	v	10:	2:58:21	29:10:	97
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2	*	v	10:	3: 1:50	29:10:	97
2	*	v	10:	3: 2:44	29:10:	97
2	*	v	10:	3: 3:81	29:10:	97
2	*	v	10:	3: 4:58	29:10:	97
2	*	v	10:	3: 5:46	29:10:	97
2	*	v	10:	3: 6:17	29:10:	97
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2	*	v	10:	3: 7:93	29:10:	97
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2	*	v	10:	3:11:72	29:10:	97
2	*	v	10:	3:16:33	29:10:	97
2	*	v	10:	3:17:10	29:10:	97
2	*	v	10:	3:18:81	29:10:	97
2	*	v	10:	3:19:47	29:10:	97
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2	*	v	10:	3:24:96	29:10:	97
2	*	v	10:	3:25:84	29:10:	97
2	*	v	10:	3:26:66	29:10:	97
2	*	v	10:	3:27:48	29:10:	97
2	*	v	10:	3:28:36	29:10:	97
2	*	v	10:	3:31: 5	29:10:	97
2	*	v	10:	3:31:88	29:10:	97
2	*	v	10:	3:32:65	29:10:	97

```
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2  *  y  10: 3:37:26  29:10:  97
2  *  a  10: 3:53:46  29:10:  97
2  *  v  10: 3:54:78  29:10:  97
2  *  v  10: 3:55:44  29:10:  97
2  *  v  10: 3:56:27  29:10:  97
2  *  v  10: 3:57:14  29:10:  97
2  *  v  10: 3:58: 8  29:10:  97
2  *  v  10: 3:58:96  29:10:  97
2  *  v  10: 3:59:78  29:10:  97
2  *  v  10: 4: 0:77  29:10:  97
2  *  v  10: 4: 1:59  29:10:  97
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2  *  v  10: 4: 3:57  29:10:  97
2  *  v  10: 4: 4:61  29:10:  97
2  *  v  10: 4: 5:44  29:10:  97
2  *  v  10: 4: 6: 4  29:10:  97
2  *  v  10: 4: 6:92  29:10:  97
2  *  v  10: 4: 7:74  29:10:  97
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2  *  v  10: 4: 9:45  29:10:  97
2  *  v  10: 4:10:11  29:10:  97
2  *  v  10: 4:11:10  29:10:  97
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2  *  v  10: 4:18: 2  29:10:  97
2  *  v  10: 4:18:89  29:10:  97
2  *  v  10: 4:20:43  29:10:  97
2  *  k  10: 4:22:79  29:10:  97
2  *  y  10: 4:23:23  29:10:  97
2  *  a  10: 4:44:93  29:10:  97
2  *  v  10: 4:45:53  29:10:  97
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2  *  v  10: 4:53:39  29:10:  97
2  *  v  10: 4:54:32  29:10:  97
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2  *  v  10: 5: 3:44  29:10:  97
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2  *  v  10: 5: 4:70  29:10:  97
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2  *  v  10: 5: 8:88  29:10:  97
2  *  v  10: 5:10: 3  29:10:  97
2  *  v  10: 5:11:18  29:10:  97
2  *  v  10: 5:14: 9  29:10:  97
2  *  v  10: 5:15:14  29:10:  97
2  *  v  10: 5:16:40  29:10:  97
2  *  k  10: 5:18:98  29:10:  97
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2  *  v  10: 5:23:21  29:10:  97
2  *  k  10: 5:25:85  29:10:  97
2  *  y  10: 5:26:18  29:10:  97
2  *  a  10: 5:32:15  29:10:  97
2  *  v  10: 5:33:15  29:10:  97
2  *  v  10: 5:33:65  29:10:  97
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2  *  v  10: 5:36: 1  29:10:  97
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2  *  v  10: 5:37:71  29:10:  97
2  *  v  10: 5:39: 3  29:10:  97
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2  *  v  10: 5:40:79  29:10:  97
2  *  v  10: 5:41:78  29:10:  97
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2  *  v  10: 5:47:38  29:10:  97
2  *  v  10: 5:48: 9  29:10:  97
2  *  v  10: 5:48:86  29:10:  97
2  *  v  10: 5:49:58  29:10:  97
2  *  v  10: 5:50:46  29:10:  97
2  *  v  10: 5:51:88  29:10:  97
```

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2	*	m	10:	5:59:24	29:10:	97
2	*	v	10:	6: 0:23	29:10:	97
2	*	v	10:	6: 1:72	29:10:	97
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2	*	v	10:	6: 4:19	29:10:	97
2	*	v	10:	6: 5:61	29:10:	97
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2	*	v	10:	7: 5:10	29:10:	97
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2	*	v	10:	7: 6:97	29:10:	97
2	*	v	10:	7: 7:68	29:10:	97
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2	*	v	10:	7:10:98	29:10:	97
2	*	v	10:	7:11:91	29:10:	97

```
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2  *  v  10: 7:13:56  29:10:  97
2  *  v  10: 7:14:38  29:10:  97
2  *  v  10: 7:15:21  29:10:  97
2  *  v  10: 7:15:97  29:10:  97
2  *  v  10: 7:18:72  29:10:  97
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2  *  v  10: 7:25:86  29:10:  97
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2  *  v  10: 7:38:44  29:10:  97
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2  *  v  10: 7:39:92  29:10:  97
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2  *  v  10: 8: 1:51  29:10:  97
2  *  v  10: 8: 2:28  29:10:  97
2  *  v  10: 8: 6:73  29:10:  97
2  *  v  10: 8: 9:75  29:10:  97
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2  *  v  10: 8:13:92  29:10:  97
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2  *  v  10: 8:15:51  29:10:  97
2  *  v  10: 8:16:61  29:10:  97
2  *  v  10: 8:17:99  29:10:  97
2  *  v  10: 8:18:92  29:10:  97
2  *  v  10: 8:19:80  29:10:  97
2  *  v  10: 8:20:79  29:10:  97
```

```
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2   *   v   10: 8:23:75   29:10:   97
2   *   v   10: 8:24:69   29:10:   97
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2   *   v   10: 8:27:49   29:10:   97
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2   *   v   10: 8:29:19   29:10:   97
2   *   v   10: 8:33:25   29:10:   97
2   *   v   10: 8:33:80   29:10:   97
2   *   v   10: 8:34:63   29:10:   97
2   *   v   10: 8:35:29   29:10:   97
2   *   v   10: 8:36:50   29:10:   97
2   *   v   10: 8:37:37   29:10:   97
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2   *   v   10: 8:44:57   29:10:   97
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2   *   v   10: 9: 4: 1   29:10:   97
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2   *   v   10: 9: 5:99   29:10:   97
2   *   v   10: 9: 7: 9   29:10:   97
2   *   v   10: 9: 8:19   29:10:   97
2   *   v   10: 9: 9:12   29:10:   97
2   *   v   10: 9: 9:83   29:10:   97
2   *   v   10: 9:10:77   29:10:   97
2   *   v   10: 9:11:87   29:10:   97
2   *   v   10: 9:12:91   29:10:   97
2   *   v   10: 9:13:95   29:10:   97
2   *   v   10: 9:15:44   29:10:   97
2   *   v   10: 9:15:93   29:10:   97
2   *   v   10: 9:17:25   29:10:   97
2   *   k   10: 9:19:12   29:10:   97
2   *   v   10: 9:22:14   29:10:   97
2   *   v   10: 9:22:96   29:10:   97
2   *   v   10: 9:23:68   29:10:   97
2   *   v   10: 9:24:39   29:10:   97
2   *   v   10: 9:25:10   29:10:   97
2   *   v   10: 9:26:37   29:10:   97
2   *   v   10: 9:27:25   29:10:   97
2   *   v   10: 9:28:18   29:10:   97
```

```
2  *  v  10: 9:29:11  29:10:  97
2  *  v  10: 9:30:10  29:10:  97
2  *  v  10: 9:31:26  29:10:  97
2  *  v  10: 9:32:30  29:10:  97
2  *  k  10: 9:36:47  29:10:  97
2  *  y  10: 9:39:88  29:10:  97
.  .  .  10:10:36:16  29:10:  97
```

Appendix Thirteen

Sucking parameter estimates

Infant	Sucks per burst		Suck duration		SD suck duration		Pause length	
	start	end	start	end	start	end	start	end
1.00	4.183	3.142	.782	.728	.111	.144	.446	2.617
2.00	3.885	2.340	.830	.741	.135	.141	.649	2.761
3.00	7.875	5.701	.710	.641	.226	.168	3.074	5.646
4.00	2.327	4.552	.846	.616	.083	.175	.231	17.093
5.00	9.932	5.164	.720	.574	.098	.143	.441	3.079
6.00	2.858	7.181	.735	.832	.224	.199	.433	2.258
7.00	8.929	4.994	.822	.509	.169	.167	1.064	4.643
8.00	8.076	16.060	.644	.609	.104	.079	1.041	3.930
9.00	4.406	2.836	.802	.872	.151	.100	.270	2.718
10.00	8.263	5.314	.744	.739	.088	.124	.987	1.973
11.00	15.373	6.365	.683	.715	.132	.173	1.553	3.198
12.00	4.926	5.606	.956	.759	.267	.174	1.922	3.812
13.00	3.001	4.491	.780	.883	.117	.213	.293	2.872
14.00	5.761	4.655	.694	.684	.106	.085	1.693	.548
15.00	4.647	12.518	.854	.842	.161	.079	3.160	1.200
16.00	3.813	11.806	.752	.780	.099	.116	.134	1.655
17.00	2.315	5.931	.798	.729	.174	.178	.326	2.934
18.00	11.197	4.336	.670	.741	.087	.086	.548	.976
19.00	1.175	6.445	.611	.892	.092	.147	.058	2.097
20.00	4.324	4.965	.702	.513	.176	.157	5.914	10.159
21.00	4.000	3.552	.860	.604	.176	.112	1.122	4.496
22.00	5.039	2.669	1.008	.745	.213	.156	.377	2.172
23.00	1.001	152.329	.732	1.243	.167	.200	.201	6.479
24.00	5.755	2.177	.933	.754	.167	.090	3.789	5.464
25.00	4.772	4.936	.723	.612	.095	.100	1.753	6.836
26.00	578.716	8.186	.726	.736	.087	.093	.229	1.207
27.00	4.308	5.694	.637	.748	.067	.129	.559	2.911
28.00	20.978	4.810	.832	.718	.120	.154	2.405	4.126
29.00	9.178	18.329	.574	.569	.114	.063	.415	3.068
30.00	10.426	5.492	.778	.767	.114	.115	2.291	7.316
31.00	63.917	17.888	1.017	1.142	.114	.189	.428	4.454
32.00	31.740	4.772	.734	.657	.162	.102	4.399	6.703
33.00	4.726	3.516	.753	.768	.082	.088	.606	.305
34.00	7.353	8.729	.611	.685	.067	.118	.542	2.624
35.00	3.601	4.144	.705	.606	.102	.105	1.151	3.802
36.00	4.014	5.371	.894	.641	.213	.107	.253	3.750
37.00	15.087	5.761	.777	.659	.115	.119	.794	3.376
38.00	184.776	2.843	.956	.902	.147	.126	.112	2.178
39.00	5.647	6.226	.814	.700	.159	.089	1.373	1.655
40.00	10.997	3.346	.797	.643	.106	.093	.714	3.544
41.00	15.972	3.931	.816	.711	.121	.187	.521	5.515
42.00	50.366	1.380	.954	.627	.126	.096	10.304	.427
43.00	9.552	2.153	1.007	.671	.175	.167	3.899	10.033
44.00	5.785	9.805	.806	.603	.146	.125	.354	29.020
45.00	4.147	5.316	.821	.505	.175	.072	.941	7.225
46.00	35.984	4.471	.859	.629	.096	.103	1.848	2.964
47.00	5.952	7.137	.718	.787	.082	.142	.530	3.649
48.00	82.943	4.979	.964	.950	.097	.128	.812	.398
49.00	13.793	3.051	.759	.622	.102	.092	3.323	3.942
50.00	1.070	13.153	.515	.772	.061	.168	.003	215.257

Infant	Sucks per burst		Suck duration		SD suck duration		Pause length	
	start	end	start	end	start	end	start	end
51.00	7.535	3.000	.716	.705	.080	.088	.923	1.008
52.00	3.133	4.240	.615	.645	.077	.118	1.932	2.517
53.00	10.981	5.782	.789	.734	.145	.162	5.793	8.623
54.00	3.833	3.858	.679	.675	.103	.126	.239	5.327
55.00	4.393	2.064	1.014	1.018	.159	.167	.413	1.031
56.00	5.660	2.933	.695	.580	.082	.093	2.222	5.592
57.00	4.703	2.369	.757	.658	.100	.087	.694	3.608
58.00	1.835	3.775	.820	.819	.091	.141	.300	13.912
59.00	3.264	6.658	.494	.547	.135	.093	8.801	10.484
60.00	6.393	3.537	.806	.913	.068	.228	.091	4.276
61.00	7.726	3.889	.779	.725	.120	.126	1.696	3.732
62.00	7.512	13.367	.852	.883	.130	.107	2.769	3.051
63.00	5.417	5.215	.904	.700	.143	.094	1.049	2.981
64.00	2.005	3.347	.770	.995	.128	.175	.244	2.289
65.00	8.024	3.118	.824	.693	.137	.074	.858	1.869
66.00	6.826	6.042	.637	.752	.098	.096	3.491	4.574
67.00	4.894	2.671	.693	.705	.107	.084	.798	3.299
68.00	3.654	3.257	.472	.673	.105	.091	3.876	6.030
69.00	2.574	4.743	.803	.802	.069	.130	.135	1.018
70.00	5.032	6.026	.794	.701	.114	.107	.539	4.655
71.00	2.951	2.592	.725	.629	.158	.102	2.419	4.731
72.00	5.848	7.598	.666	.595	.109	.072	.717	3.624
73.00	1.776	6.558	.952	.484	.140	.067	.374	7.325
74.00	11.676	9.312	.751	.647	.095	.120	1.029	5.992
75.00	3.832	4.532	.584	.672	.110	.087	1.491	2.258