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Research report

Development and factor structure of the Baby Eating Behaviour Questionnaire in the Gemini birth cohort☆

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ABSTRACT

The objective of this study was to develop a parent-report psychometric measure of infant appetite during the period of exclusive milk-feeding. Constructs and items for the Baby Eating Behaviour Questionnaire (BEBQ) were derived from an existing psychometric measure validated for older ages, the Children's Eating Behaviour Questionnaire, supplemented by a review of the literature on milk-feeding behaviours. Cognitive interviewing with a sample of mothers ($n = 10$) was used to refine the questions. The factor structure of the 18-item BEBQ was assessed in infants (one per family) from the Gemini twin birth cohort ($n = 2402$ families). Principal Component Analysis identified four distinct appetitive constructs, all of which had good internal reliability: 'enjoyment of food' (Cronbach's $\alpha = 0.81$), 'food responsiveness' ($\alpha = 0.79$), 'slowness in eating' ($\alpha = 0.76$), and 'satiety responsiveness' ($\alpha = 0.73$). A single item assessing 'general appetite' correlated with all of the constructs. The BEBQ is the first standardised measure of infant appetite designed to characterise appetitive traits that might confer susceptibility to excess weight gain.

Introduction

Rapid weight gain in infancy is associated with obesity in childhood and adulthood (Baird et al., 2005). Faster growing infants have higher energy intakes than those growing more slowly (Ong, Emmett, Noble, Ness, & Dunger, 2006); as do infants at higher risk of obesity by virtue of familial obesity (Stunkard, Berkowitz, Schoeller, Maislin, & Stallings, 2004). Infant appetite is not well understood and research is needed to identify the feeding behaviours that characterize a larger appetite.

In both children and adults, several appetitive behaviours have been associated with higher weight. Greater consumption after exposure to food cues or in the presence of palatable food (Fisher et al., 2007; Jansen et al., 2003) is seen in obese children compared with their normal-weight counterparts. Faster eating speed has been observed in obese or overweight children compared with leaner peers (Barkeling, Ekman, & Rossner, 1992; Drabman, Cordua, Hammer, Jarvie, & Horton, 1979; Llewellyn, van Jaarsveld, Boniface, Carnell, & Wardle, 2008), and obese children are prepared to 'work' harder for a food reward under conditions of reinforcement (Hill, Saxton, Webber, Blundell, & Wardle, 2009; Temple, Legierski, Giacomelli, Salvy, & Epstein, 2008). Obese children also show lower sensitivity to internal satiety signals characterized by non-decelerated eating over the course of a meal (Barkeling et al., 1992; Lindgren et al., 2000), and poorer compensation following a calorie 'preload' (Johnson & Birch, 1994).

There has been relatively little research into appetite in infancy and outside of the context of failure to thrive (e.g. Wright & Birks, 2000). However, there is some evidence that conceptually similar feeding behaviours are present in infancy. Two studies have shown that infants at higher risk of obesity (indexed with parental weight status) have a more avid sucking style (Millstein, 1980; Stunkard et al., 2004). A vigorous milk-feeding style at 2–4 weeks of age (characterised by long bursts of rapid, high pressure sucking with shorter resting periods) was found to be associated with higher adiposity 2 years later (Agras, Kraemer, Berkowitz, & Hammer,

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1990), and another study showed that infant-initiated bottle-emptying in the first six months of life predicted excess weight during the second six months (Li, Fein, & Grummer-Strawn, 2008). Variation in appetitive traits associated with susceptibility to obesity may therefore be present in the first few weeks of life.

While behavioural studies provide objectivity and detail, the effort and expense associated with direct observations of feeding behaviour makes it difficult to carry out the large-scale studies that are needed to detect small effects. Psychometric measures which can be completed by parents make it possible to collect appetite data in large samples, and have the additional advantage that parental evaluations aggregate the infant's behaviours over many situations rather than being limited to the single feed usually observed in behavioural studies.

The Children's Eating Behaviour Questionnaire (CEBQ (Wardle, Guthrie, Sanderson, & Rapoport, 2001)) is a validated parent-report psychometric instrument for children aged 3–13 years that measures eight eating behaviours related to overweight and under-weight. Two of the eight sub-scales are indicative of a larger appetite or greater interest in food: 'food responsiveness' measures the child's drive to want to eat (e.g. 'If allowed to, my child would eat too much') and 'enjoyment of food' captures the level of subjective pleasure experienced from eating (e.g. 'My child enjoys eating'). Three scales describe traits related to better appetitive control or a lower interest in food: 'slowness in eating' evaluates the pace at which the child consumes their food (e.g. 'My child takes more than 30 min to finish a meal'), 'satiety responsiveness' measures a child's fullness threshold ('My child cannot eat a meal if s/he has had a snack just before'), and the 'fussiness' scale assesses pickiness with regard to the type of food the child is willing to eat (e.g. 'My child decides that s/he doesn't like a food even without tasting it'). Two scales measure eating in response to emotions: 'emotional overeating' and 'emotional under-eating' tap tendencies to either overeat or undereat in negative emotional states (e.g. 'My child eats more when worried', and 'My child eats less when upset'). Lastly, 'desire to drink' identifies behaviours that are indicative of a persistent desire to consume (e.g. 'My child is always asking for a drink').

Consistent associations between these appetitive traits and adiposity have been reported – e.g. higher 'food responsiveness' and 'enjoyment of food' have been associated with higher weight while greater 'satiety responsiveness' and 'slowness in eating' relate to lower weight (Carnell & Wardle, 2008; Sleddens, Kremers, & Thijs, 2008; Spence, Carson, Casey, & Boule, 2010; Webber, Hill, Saxton, van Jaarsveld, & Wardle, 2009).

In response to the need for a similar psychometric measure of infant appetite, we have developed an infant version of the CEBQ that characterizes important dimensions of feeding behaviour in the period that infants are still exclusively fed milk. The Baby Eating Behaviour Questionnaire (BEBQ) measures four appetitive traits that are thought to be important for weight. This paper describes the development and factor structure of the BEBQ.

Method

Development of the Baby Eating Behaviour Questionnaire

Generation of constructs and items. The appetitive constructs to be included in the BEBQ were based on: (i) existing scales in the CEBQ deemed appropriate for infants who are still exclusively milk-fed, (ii) a review of the literature on milk-feeding to identify distinctive appetitive behaviours during early postnatal life, and (iii) interviews with mothers of young infants.

Six of the eight CEBQ scales were considered potentially appropriate for infants: 'food responsiveness', 'enjoyment of food', 'satiety responsiveness', 'slowness in eating', 'emotional overeating' and 'emotional under-eating'. 'Food fussiness' by definition must involve the child being weaned so was not selected for the pilot work, and 'desire to drink' is inappropriate because infants have little fluid intake except milk before 3 months (the target age). The items from the six selected scales of the CEBQ were modified to ensure their suitability for milk-fed infants. All items were carefully worded to capture appetitive behaviours demonstrated by breast-fed or bottle-fed infants. Although the period of interest was 0–3 months, data were collected when the infants were a few months older therefore the past tense was used. Parents were instructed to respond to the milk-feeding period in retrospect as follows: 'These questions are about your twins' appetite over their first three months of life. We are specifically interested in the period when your twins were fed milk only, i.e. no solid foods or pre-prepared baby food yet.'

The literature review indicated that feeding speed and responsiveness to milk (sucking intensity) characterise appetite avidity in infants (Agras et al., 1990; Stunkard et al., 2004). Similar behaviours are assessed in the CEBQ, so these feeding styles identified in the literature review could be captured by modifying the items for the corresponding CEBQ scales to describe infant behaviours. However, another item was added to measure an aspect of food responsiveness that relates specifically to infant milk-feeding that is not assessed by the CEBQ: 'my baby frequently wants more milk than I provide'. The clinical literature on feeding problems and 'failure to thrive' highlights slow feeding (Reau, Senturia, Lebailly, & Christoffel, 1996), low enjoyment of food (Mathisen, Worrall, Masel, Wall, & Shepherd, 1999) and distress during feeding (Chatoor, Ganiban, Harrison, & Hirsch, 2001; Mathisen et al., 1999) as features of poor feeding or inadequate appetite. Slow feeding and low enjoyment of food are captured by scales in the CEBQ so could be assessed in infants using modified items, but infant distress level is not; two other items were therefore included to assess this: 'my baby seems contented while feeding' which fitted well with 'enjoyment of food', and 'my baby becomes distressed while feeding'. The same response options as the CEBQ were used: 'never', 'rarely', 'sometimes', 'often', 'always'.

Pilot work. Cognitive interviewing techniques (Willis, 1999) were used to assess the suitability of the scales and items. Two psychologists conducted in-depth qualitative interviews either face-to-face or over the telephone with a sample of 10 mothers with infants less than 6 months old. Interviews were structured with general questions at the beginning and at the end, while the separate scales and their items were discussed one-by-one in between.

Following the qualitative research, both emotional eating scales were excluded. Mothers felt that expressions of negative mood are often cues that a feed is due, making it difficult to distinguish emotions from hunger.

The shortened questionnaire with the four selected scales ('enjoyment of food', 'food responsiveness', 'slowness in eating', 'satiety responsiveness') was distributed to a pilot sample of mothers of twin children aged 2–24 months who were contacted via on-line twins clubs in June 2007. Questionnaires were either emailed by the Club organisers or given out at local meetings; 65 mothers agreed to take part, and 33 questionnaires were returned to the research team. Item means and frequencies were calculated from the pilot sample so that items where 90% or more of the mothers gave the same response could be discarded. Feedback from mothers or non-response to particular items also led to them being discarded. The final BEBQ contained 18 items designed to measure four traits: 'enjoyment of food' (4 items), 'food responsiveness' (5 items), 'slowness in eating' (4 items), and 'satiety responsiveness' (5 items). A table showing how the BEBQ items relate to the original CEBQ items may be viewed in Appendix A.

Assessing the factor structure of the Baby Eating Behaviour Questionnaire

Sample. The final BEBQ was completed by families taking part in the Gemini study (van Jaarsveld, Johnson, Llewellyn, & Wardle, 2010). Gemini is a birth cohort of families of twins from England and Wales that was set up in 2007 to assess influences on growth during the first 5 years of life. In January 2008 the Office for National Statistics (ONS) wrote to all families with twins born in England and Wales between March and December 2007 ($N = 6754$) to ask for consent to pass their contact details to the Gemini research team. 3435 families agreed to be contacted and were sent a baseline questionnaire containing the BEBQ in early 2008, of which 2402 (70%) families completed and returned it. The geographic distribution of Gemini families reflects the UK population density and the cohort is representative of national twin statistics on sex, zygosity, gestational age at birth, and birth weight (van Jaarsveld et al., 2010).

Measurement of sample characteristics. Parents were asked to report the sex of their children and the number of weeks the mother had been pregnant at the time of delivery, which was used as an estimate of gestational age. Parents reported their infants' birth weights and this information was used to calculate birth weight standard deviation scores (SDS) adjusted for sex and gestational age based on British 1990 growth reference data using the LMS growth macro for Microsoft Excel (Cole, 2009; Freeman et al., 1995); a birth weight SDS of 0 indicates average birth weight, a SDS > 0 indicates a higher birth weight and a SDS < 0 indicates a lower birth weight compared to the 1990 growth reference (Freeman et al., 1995). Infants were subsequently categorized into those who had a low birth weight (weight SDS ≤ -2.00) and those who did not have a low birth weight (weight SDS > -2.00).

Because the coordination of sucking, swallowing and breathing necessary for normal oral feeding is generally not established until 34 weeks post-conceptional age (Wolff, 1968) and infants born before this gestational milestone are likely to have been tube fed and may have experienced problems establishing normal oral feeding, infants were divided into those born before 34 weeks gestational age and those born at or after 34 weeks gestational age. Infant age at the time the questionnaire was completed was calculated in months by using the twins' date of birth and the date on which the questionnaire was completed. Infant feeding methods used during the first 3 months were assessed by asking mothers to report the proportion of breast-feeding versus bottle-feeding, using the question: 'Which feeding methods did you use in the first three months', with response options: 'entirely breast-feeding'; 'mostly breastfeeding with some bottle-feeding'; 'equally breastfeeding and bottle-feeding'; 'mostly bottle-feeding and some breastfeeding'; 'almost entirely bottle-feeding (only tried breastfeeding a few times)'; 'entirely bottle-feeding (never tried breastfeeding)'; and 'other'. There are many methods for categorizing infants into groups based upon their feeding method. Responses were categorized into three groups using the dominant feeding method given that mothers would be likely to be influenced by the main feeding method when responding to the questions. The three categories were 'breast-fed' (entirely or mostly breast-fed), 'bottle fed' (mostly, almost entirely or entirely bottle-fed), and 'mixed-fed' (equally breast-fed and bottle-fed).

Parents were asked two questions about feeding problems ('yes' or 'no'): 'Straight after birth, did either of your twins experience any complications which made it difficult to start feeding', and 'Were there any other times when feeding your twins was difficult, e.g. due to illness of the twins, health problems of the parent, changes on jobs or moving house.' Responses were used to group the infants into those with no reported feeding problems (parent answered 'no' to each question) and those with a reported feeding problem at any time (parents answered 'yes' to at least one of the questions).

Assessment of the factor structure of the BEBQ. Principal Component Analysis (PCA) was used to identify the underlying structure of the BEBQ; analyses were performed in SPSS Version 15 for Windows. Oblique rotation (Field, 2005) was selected to allow for predicted inter-correlations among the factors (Wardle et al., 2001). This gives two matrices: the Pattern matrix which contains the factor loadings with the unique contribution of each variable to each factor, and the Structure matrix which takes account of correlations between factors when estimating the contribution of each variable to each factor. Because values in the Pattern matrix can be suppressed if factors are correlated (Graham, Guthrie, & Thompson, 2003) we present the Structure matrix.

We did not constrain the number of factors SPSS generated because we wanted to discover whether the same dimensions were found in the BEBQ as the CEBQ. Only items with factor loadings greater than 0.4 were considered (items for which the factor explained approximately 16% of the variance) (Stevens, 1996), but all items with loadings of 0.1 were generated to understand smaller relationships. Factors with eigenvalues greater than 1.0 were selected (Kaiser, 1960). We used Horn's parallel analysis (Horn, 1965) to test whether the eigenvalues obtained for the factors identified were significantly higher than the values that would be expected for factors generated through chance assuming no underlying factors are actually present in the dataset. This analysis was performed in Monte Carlo PCA for Parallel Analysis 2.3.

Pairwise deletion of missing cases was used to retain as much data as possible, which provides a reasonable solution with large datasets and few missing values (Tabachnick & Fidell, 2001). Missing values were also replaced with imputed scores using the Expectation–Maximisation method and the analysis was rerun on the dataset including imputed scores; the results were the same so the analysis without imputed data is presented here. Missing data varied by item.Internal reliabilities of the scales derived from the PCA were tested using Cronbach's alpha (α). Scores were calculated for the four scales by summing the individual item scores and dividing the total by the number of items in the scale. Means and standard deviations and medians and inter-quartile ranges were calculated for the scales. Pearson's Product Moment correlation coefficients were used to assess bivariate relationships between the normally distributed scales ('food responsiveness', 'slowness in eating', 'satiety responsiveness' and 'general appetite'), and Spearman's ρ to assess the correlations between 'enjoyment of food' and the other scales.

Data from one infant selected at random from each family were used for all the analyses to adjust for clustering of the twins in families. Sub-group PCAs and Cronbach's alphas were also run to ensure that the BEBQ could be used with confidence across infants with different characteristics. Differences by zygosity and sex were explored as well as across factors that potentially influence the infants' appetite or feeding behaviour including those born before or after 34 weeks gestational age, those with a very low birth weight (birth weight SDS ≤ -2.00) and those who did not have a very low birth weight (birth weight SDS > -2.00), those with and without reported feeding problems, and mainly breast-fed, mixed-fed and mainly bottle-fed infants (the PCA was also rerun for infants who were exclusively breast-fed and exclusively bottle-fed to check the extremes but the results were virtually the same so these results are not reported).

T-tests and analyses of variance (ANOVAs) were used to assess two-level and three-level (feeding method) group differences across all of the scales (we checked for differences in 'enjoyment of food' using non-parametric equivalents because this scale was skewed but results were the same so we report results of the *t*-test and ANOVA). For feeding method pairwise post hoc comparisons were carried out to explore which groups were significantly different from one another using the Bonferroni correction for multiple comparisons. Cohen's d was calculated for significant differences to indicate the size of the effect across groups ('small', 0.2–0.3; 'medium', ~0.5; 'large', 0.8 to ∞ (Cohen, 1988)). Correlations with gestational age and age at questionnaire completion were assessed using Spearman's ρ because age was positively skewed and gestational age was negatively skewed, Pearson's correlation coefficient was used to explore associations between birth weight SDS and the normally distributed BEBQ scales, Spearman's ρ was used for 'enjoyment of food' and birth weight SDS. An alpha level of 0.01 was selected for significance to reduce the risk of Type 1 errors.

Results

Sample characteristics

The characteristics of the full Gemini cohort and the analysis sample (one infant from each family) are shown in Table 1. There were equal numbers of male and female infants. The mean age of the infants when the BEBQ was completed was 8 months (range 4–20 months); approximately half of the infants were between 4 and 8 months old when the BEBQ was completed.

Table 1
Characteristics of the Gemini cohort and the analysis sample.

Characteristic	Full Gemini cohort[a] (n = 2402 families; n = 4804 infants)	Analysis sample[b] (n = 2402 infants)
	n (%) or Mean (sd)	n (%) or Mean (sd)
Twin pairs[c]		
MZ	729 (30.3%)	729 (30.3%)
DZ	1605 (66.8%)	1605 (66.8%)
Unknown	68 (2.9%)	68 (2.8%)
Sex		
Males	2386 (49.7%)	1194 (49.7%)
Females	2418 (50.3%)	1208 (50.3%)
Feeding mode		
Breast-fed	1571 (32.7%)	789 (32.8%)
Bottle-fed	2559 (53.3%)	1275 (53.1%)
Mixed/unknown	674 (14.0%)	338 (14.1%)
Feeding problems		
No	2971 (61.8%)	1465 (61.0%)
Yes	1831 (38.1%)	936 (39.0%)
Unknown	2 (0%)	1 (0%)
Age[d] (months)	8.2 (2.18)	8.2 (2.18)
Weight at birth (kg)	2.5 (0.54)	2.5 (0.55)
Gestational age (weeks)	36.2 (2.48)	36.2 (2.48)

[a] Includes both infants from all families who returned the baseline questionnaire.
[b] Includes one infant selected at random from each family that returned the baseline questionnaire; this sample is used for the analyses described in this paper.
[c] MZ, monozygotic; DZ, dizygotic; 'unknown' includes twins whose zygosity could not be classified using the questionnaire and twins with missing data.
[d] Age of the infants when the parents completed the Baby Eating Behaviour Questionnaire.

Factor structure of the BEBQ

PCA produced four factors with eigenvalues of 3.6, 3.5, 3.3 and 2.7. The same factors emerged in the Pattern and Structure matrices, confirming that the BEBQ contains four scales after taking into account inter-correlations between factors. Parallel analysis confirmed that the eigenvalues were above the values that would be expected for factors generated through chance. The four factors explained 59.7% of the variance in the 18 items.

Inspection of the factors indicated four appetitive traits which matched closely the CEBQ structure (Table 2). Factor 1 included the four items developed to measure 'enjoyment of food'. Factor 2 contained all the items originally developed to measure 'food responsiveness' and one that originally loaded on 'satiety responsiveness' ('My baby could easily take a feed within

Table 2
Factor loadings for all items of the Baby Eating Behaviour Questionnaire from the Structure matrix.

Item[a]	n[b]	Original scale[c]	Factors determined through PCA[d]			
			1 'Enjoyment of food'	2 'Food responsiveness'	3 'Slowness in eating'	4 'Satiety responsiveness'
My baby seemed contented while feeding	2350	EF	**0.84**	–	−0.28	−0.16
My baby enjoyed feeding time	2370	EF	**0.82**	0.17	−0.30	−0.25
My baby loved milk	2345	EF	**0.76**	0.22	−0.32	−0.39
My baby became distressed while feeding (R)	2368	EF	**0.75**	−0.11	−0.26	−0.22
If given the chance my baby would always be feeding	2360	FR	–	**0.80**	–	–
Even when my baby had just eaten well s/he was happy to feed again if offered	2348	FR	0.11	**0.78**	–	−0.16
My baby could easily take a feed within 30 minutes of the last one	2342	SR	0.11	**0.73**	–	–
My baby was always demanding a feed	2360	FR	–	**0.64**	–	0.13
If allowed to my baby would take too much milk	2358	FR	–	**0.62**	−0.25	−0.19
My baby frequently wanted more milk than I provided	2322	FR	–	**0.57**	−0.21	−0.24
My baby fed slowly	2370	SE	**−0.41**	−0.14	**0.86**	0.37
My baby finished feeding quickly (R)	2375	SE	−0.27	−0.30	**0.82**	0.18
My baby took more than 30 minutes to finish feeding	2372	SE	−0.31	–	**0.79**	0.20
My baby sucked more and more slowly during the course of a feed	2354	SE/SR	−0.16	0.14	**0.50**	**0.42**
My baby got full up easily	2363	SR	−0.16	–	0.13	**0.79**
My baby got full before taking all the milk I thought s/he should have	2364	SR	**−0.42**	−0.20	0.39	**0.77**
My baby found it difficult to manage a complete feed	2358	SR	**−0.58**	−0.25	**0.47**	**0.70**
My baby had a big appetite	2373	SR	**0.41**	**0.55**	**−0.43**	**−0.43**

[a] Items marked with (R) have been reversed for scoring purposes.
[b] n includes one child from each family selected at random with data on each item. The total n for half of the Gemini cohort selected at random = 2402.
[c] Appetite scale the item was originally intended to measure: EF, 'enjoyment of food'; FR, 'food responsiveness'; SE, 'slowness in eating'; SR, 'satiety responsiveness'.
[d] Factor loadings over 0.1 are presented. Factors loadings over 0.4 are bolded.

Table 3
Cronbach's alphas for the whole analysis sample and sub-groups.

Sample	Cronbach's alpha (n^a)			
	'Enjoyment of food'	'Food responsiveness'	'Slowness in eating'	'Satiety responsiveness'
Whole sample	**0.81** (2319)	**0.79** (2263)	**0.76** (2346)	**0.73** (2342)
Monozygotic twins	**0.84** (702)	**0.80** (687)	**0.75** (711)	**0.70** (714)
Dizygotic twins	**0.80** (1553)	**0.79** (1517)	**0.76** (1571)	**0.73** (1564)
Males	**0.82** (1150)	**0.80** (1129)	**0.75** (1164)	**0.71** (1165)
Females	**0.81** (1169)	**0.78** (1134)	**0.76** (1182)	**0.73** (1177)
No feeding problems	**0.76** (1412)	**0.79** (1381)	**0.73** (1430)	**0.70** (1422)
Feeding problems	**0.85** (906)	**0.80** (881)	**0.78** (915)	**0.74** (919)
Born $\geq$ 34 weeks	**0.81** (2004)	**0.79** (1954)	**0.74** (2025)	**0.72** (2022)
Born < 34 weeks	**0.84** (305)	**0.79** (299)	**0.81** (311)	**0.72** (310)
Bottle-fed	**0.82** (1237)	**0.80** (1206)	**0.78** (1254)	**0.74** (1258)
Mixed-fed	**0.84** (220)	**0.79** (217)	**0.78** (221)	**0.83** (219)
Breast-fed	**0.79** (771)	**0.78** (751)	**0.72** (776)	**0.67** (770)
Birth weight SDS ≤ -2.00	**0.84** (148)	**0.74** (147)	**0.70** (152)	**0.73** (152)
Birth weight SDS > -2.00	**0.81** (2106)	**0.80** (2053)	**0.76** (2130)	**0.72** (2126)

[a] Includes number of infants with data on all items entered into the Cronbach's alpha analysis for each scale, when only one child is selected from each family at random.

30 min of the last one'). In infants, this item may be more indicative of responsiveness to cues of feeding; it did not load on to the 'satiety responsiveness' factor at all. Factor 3 contained all the items designed to measure 'slowness in eating', and Factor 4 consisted of three of the five items that were designed to measure 'satiety responsiveness'. One item ('My baby had a big appetite') loaded on to all four of the factors, and although it loaded onto the 'satiety responsiveness' scale in the CEBQ, at face-value it measures overall appetite. Because this item did not sit clearly on any one factor, we decided to use it as an individual item to measure general appetite. Running the PCA without this item resulted in the same factor structure.

The same factor structure was identified for all sub-groups, despite not instructing SPSS to generate 4 factors in any case. Moreover, for every group the stand alone item 'my baby had a big appetite' loaded on to the four scales with factor loadings of 0.3 or higher, including smaller sub-groups for which factor loadings would be less reliable. The PCA was then repeated for the subgroups on the 17 items, excluding 'My baby has a big appetite' and the same factor structure was again reproduced for each group, confirming that four factors underlie infant appetite, after taking into account different characteristics.

Internal reliability of the BEBQ and summary statistics

Cronbach's alphas were calculated for the four subscales identified in the PCA, excluding 'My baby has a big appetite'. All scales were internally reliable: 'enjoyment of food': $\alpha = 0.81$, 'food responsiveness': $\alpha = 0.79$, 'slowness in eating': $\alpha = 0.76$, and 'satiety responsiveness': $\alpha = 0.73$. The Cronbach's alphas for each subgroup were similar to the values for the whole sample, indicating that the scales had good internal reliability for all the groups (Table 3).

Table 4
Descriptive statistics for the Baby Eating Behaviour Questionnaire.

Baby Eating Behaviour Questionnaire Scale	Mean	sd	Median	IQR	*n*
'Enjoyment of food'	4.28	0.70	4.50	0.75	2355
'Food responsiveness'	1.95	0.68	1.83	0.83	2360
'Slowness in eating'	2.72	0.86	2.75	1.25	2372
'Satiety responsiveness'	2.44	0.81	2.33	1.00	2367
'General appetite'	3.29	1.06	3.0	1.00	2373

The summary statistics for the final scales are shown in Table 4 – 'enjoyment of food' was negatively skewed indicating that the majority of infants enjoyed milk and feeding times. The four factors were inter-correlated (Table 5). 'Enjoyment of food' was modestly and negatively correlated with 'slowness in eating' (−0.36) and 'satiety responsiveness' (−0.45) indicating that babies who enjoy their food also tend to feed more rapidly and be less sensitive to internal cues of satiety. Likewise 'food responsiveness' was negatively correlated with 'slowness in eating' (−0.10) and 'satiety responsiveness' (−0.21), although the size of the correlations were smaller, suggesting that babies who are more responsive to cues of feeding also tend to feed slightly more rapidly and are a little less satiety responsive. 'Slowness in eating' and 'satiety responsiveness' were modestly interrelated (0.45). The single item 'my baby had a big appetite' was positively correlated with both 'enjoyment of food' (0.34) and 'food responsiveness' (0.46) and negatively correlated with 'slowness in eating' (−0.37) and 'satiety responsiveness' (−0.48) indicating that this item is a good indicator of overall appetite avidity.

The means and standard deviations for the subgroups are shown in Table 6. There was a small but significant effect of gestational age on BEBQ scores, such that infants born before 34 weeks post-conceptional age were rated as enjoying feeding to a lesser extent [$t(385.783) = -2.795$, $p = 0.005$], being less responsive to external cues to feed [$t(2348) = -4.969$, $p < 0.001$], being more sensitive to internal cues of satiety [$t(2355) = 4.542$, $p < 0.001$], feeding more slowly [$t(385.406) = 5.300$, $p < 0.001$], and having a lower overall appetite [$t(2361) = -6.841$, $p < 0.001$] compared with infants born at or after 34 weeks gestation. The effect of gestational age was medium for 'slowness in eating' ($d = 0.54$) and small for the other traits ($d = 0.19$–0.29). The findings were the same treating gestational age as a continuous measure, although the effect appeared to be small in each case (Table 5).

The same differences were found between infants with reported feeding problems and infants with no reported feeding problems. 'Problem-feeders' were rated as enjoying food less [$t(1574.024) = 8.927$, $p < 0.001$], being less responsive to feeding cues [$t(2357) = 2.661$, $p = 0.008$], being more satiety sensitive [$t(1830.658) = -8.324$, $p < 0.001$], feeding more slowly [$t(1840.982) = -7.885$, $p < 0.001$], and having a lower overall appetite compared with infants with no feeding problems at all [$t(2370) = 5.577$, $p < 0.001$]. The size of the effect on each scale was

Table 5
Pairwise correlation matrix showing the inter-relationships between the appetitive constructs of the Baby Eating Behaviour Questionnaire, and relationships between the constructs, age, gestational age and birth weight.

Baby Eating Behaviour Questionnaire Scale	Correlation coefficient[a] (*n*)						
	Age[b] (months)	Gestational age (weeks)	Birth weight (kg)	'Enjoyment of food'	'Food responsiveness'	'Slowness in eating'	'Satiety responsiveness'
'Enjoyment of food'	0.03 (2355)	**0.06**[c] (2345)	**0.11**[d] (2289)	–	–	–	–
'Food responsiveness'	0.01 (2360)	**0.13**[d] (2350)	0.05 (2294)	0.04 (2340)	–	–	–
'Slowness in eating'	−0.01 (2372)	−**0.11**[d] (2362)	−**0.12**[d] (2306)	−**0.36**[d] (2351)	−**0.10**[d] (2358)	–	–
'Satiety responsiveness'	−0.04 (2367)	−**0.12**[d] (2357)	−**0.16**[d] (2302)	−**0.45**[d] (2346)	−**0.21**[d] (2354)	**0.45**[d] (2366)	–
'General appetite'	−0.04 (2373)	**0.15**[d] (2363)	**0.16**[d] (2308)	**0.34**[d] (2349)	**0.46**[d] (2353)	−**0.37**[d] (2366)	−**0.48**[d] (2362)

[a] Spearman's rho was used for correlations including non-normally distributed variables (age, gestational age, 'enjoyment of food'); Pearson's product moment correlation coefficient was used for correlations between normally distributed variables (birth weight, 'food responsiveness', 'slowness in eating', 'satiety responsiveness', 'general appetite').
[b] Age of the infants when the parents completed the Baby Eating Behaviour Questionnaire.
[c] Correlation significant at an alpha level of 0.005 (bolded).
[d] Correlations significant at an alpha level of <0.001 (bolded).

Table 6
Means (and standard deviations) for each scale of the BEBQ by zygosity, sex, gestational age, feeding problems, feeding method and birth weight SDS.

Characteristic	Mean (sd)				
	EF	FR	SE	SR	GA
Zygosity					
MZ	4.29 (0.71)	1.92 (0.67)	2.78 (0.84)	2.47 (0.77)	3.21 (1.04)
DZ	4.27 (0.69)	1.96 (0.68)	2.70 (0.86)	2.42 (0.82)	3.31 (1.06)
Sex					
Males	4.29 (0.70)	**2.00** (0.70)	2.70 (0.85)	**2.38** (0.79)	**3.41** (1.08)
Females	4.27 (0.69)	**1.90** (0.65)	2.74 (0.86)	**2.50** (0.81)	**3.17** (1.03)
Gestational age					
<34 weeks	**4.16** (0.79)	**1.77** (0.63)	**2.99** (0.97)	**2.63** (0.85)	**2.91** (1.08)
≥34 weeks	**4.29** (0.68)	**1.98** (0.68)	**2.68** (0.83)	**2.41** (0.80)	**3.34** (1.04)
Feeding problems					
No	**4.38** (0.60)	**1.98** (0.68)	**2.61** (0.81)	**2.61** (0.84)	**3.38** (1.03)
Yes	**4.11** (0.80)	**1.91** (0.67)	**2.89** (0.89)	**2.33** (0.76)	**3.14** (1.08)
Feeding method					
Breast-fed	4.35 (0.66)	**2.14** (0.70)	2.75 (0.82)	**2.27** (0.77)	**3.47**[a] (1.03)
Mixed-fed	4.26 (0.68)	**1.94**[a] (0.66)	2.67 (0.85)	**2.55**[a] (0.88)	**3.30**[ab] (1.03)
Bottle-fed	4.25 (0.71)	**1.85**[a] (0.65)	2.70 (0.87)	**2.50**[a] (0.80)	**3.20**[b] (1.06)
Birth weight SDS					
≤−2.00	**4.03** (0.81)	1.85 (0.58)	**3.11** (0.77)	**2.72** (0.85)	**2.87** (1.02)
>−2.00	**4.30** (0.68)	1.96 (0.68)	**2.69** (0.85)	**2.41** (0.80)	**3.32** (1.06)

Abbreviations: EF 'enjoyment of food'; FR 'food responsiveness'; SE 'slowness in eating'; SR 'satiety responsiveness'; GA 'general appetite'.
Sample sizes: Zygosity: MZs, *n* = 712–719; DZs, *n* = 1578–1589. Sex: males, *n* = 1172–1183; females, *n* = 1183–1192. Gestational age: <34 weeks, *n* = 311–315; ≥34 weeks, *n* = 2033–2048. Feeding problems: 'yes', *n* = 919–928; 'no', *n* = 1433–1445. Feeding method: breast-fed, *n* = 781–785; mixed-fed, *n* = 221–224; bottle-fed, *n* = 1257–1271. Birth weight: ≤−2.00, *n* = 152–153; >−2.00, *n* = 2137–2155. *Statistical information*: Groups whose means were significantly different are bolded. [ab]Means sharing the same subscript are not significantly different from one another following Bonferroni correction for multiple comparisons (at an alpha level of $p < 0.01$).

small to medium (d = 0.11–0.45), the largest effect being observed for 'enjoyment of food' (d = 0.45) and the smallest for 'food responsiveness' (d = 0.11).

There was a small but significant effect of birth weight SDS on some appetitive traits (Table 5). We found that infants who were heavier at birth enjoyed food more, fed faster, were less sensitive to internal satiety cues, and had a larger overall appetite. Birth weight was not significantly associated with 'food responsiveness'. In keeping with these findings, infants with a very low birth weight enjoyed food less [$t(166.483) = 3.969$, $p < 0.001$], fed more slowly [$t(2304) = -5.959$, $p < 0.001$], were more satiety sensitive [$t(2300) = -4.601$, $p < 0.001$] and had a smaller overall appetite than the rest [$t(2306) = 5.128$, $p < 0.001$]. The effect size for birth weight was medium for 'enjoyment of food' (d = 0.62) but small for the other traits (d = 0.19–0.25). 'Food responsiveness' did not differ significantly different between birth weight groups.

There were some differences in scores by feeding method for 'food responsiveness' [$F(2,2262) = 45.079$, $p < 0.001$], 'satiety responsiveness' [$F(2,2268) = 23.205$, $p < 0.001$], and 'appetite size' [$F(2,2274) = 16.659$, $p < 0.001$]. Breast-fed babies were rated as being more responsive to food than either mixed-fed ($p < 0.001$) or bottle-fed babies ($p < 0.001$), while mixed-fed and bottle-fed babies were not different from one another ($p = 0.210$). The same pattern was observed for 'satiety responsiveness' with breast-fed babies being scored lower on 'satiety sensitivity' than either mixed-fed ($p < 0.001$) or bottle-fed infants ($p < 0.001$), but no difference was found for this characteristic between mixed-fed and bottle-fed infants ($p = 1.00$). Breast-fed infants also had significantly higher scores for 'appetite size' than bottle-fed infants ($p < 0.001$), but mixed-fed infants did not differ from either breast-fed ($p = 0.109$) or bottle-fed babies ($p = 0.464$). In each case the size of the difference was small to medium (d = 0.26–0.43).

Male infants scored significantly higher on 'food responsiveness' [$t(2339.535) = 3.621$, $p < 0.001$] and 'general appetite' [$t(2363.694) = 5.309$, $p < 0.001$], and lower on 'satiety responsiveness' [$t(2365) = -3.625$, $p < 0.001$] than females, although the differences were small (d = 0.149–0.218). No differences were found between MZ and DZ twins for any of the eating behaviours, nor were scores associated with the age of the infants at BEBQ completion.

Discussion

This paper describes the development of a psychometric, parent-report measure of appetite during the milk-feeding phase of infancy. Four dimensions emerged, with 17 items tapping four distinct feeding traits and one item describing general appetite. 'Enjoyment of food' (4 items) related to the infant's perceived liking of milk and of feeding in general, 'food responsiveness' (6 items) evaluates how demanding the infant is with regard to being fed and his or her level of responsiveness to cues of milk and feeding, 'slowness in eating' (4 items) measures the speed with which an infant typically feeds, and 'satiety responsiveness' (3 items) assesses how easily the infant gets full during a feed. The item 'My baby has a big appetite' correlated with all scales, and may be used as a stand-alone item to measure overall appetite. The BEBQ factors showed consistency with the CEBQ scales on which they were based, and were the same constructs anticipated from the literature search and pilot work. These findings indicate that before infants have been introduced to solid foods, there are at least four distinguishable and measurable appetitive traits.

In keeping with studies of the CEBQ, the constructs were inter-correlated. 'Satiety responsiveness' and 'slowness in eating' were positively correlated and the size of the correlation was only slightly smaller than in older children (0.52–0.67) (Wardle et al., 2001). This accords well with the idea that faster eating outpaces the onset of physiological satiety mechanisms which take several minutes to develop in response to food intake, and therefore tends to be associated with higher energy intake (Andrade, Greene, & Melanson, 2008; Spiegel & Jordan, 1978).

There was an inverse association between 'food responsiveness' and 'satiety responsiveness', also smaller than at later ages (−0.36 to −0.51) (Sleddens et al., 2008; Viana, Sinde, & Saxton, 2008); and a negative association between 'food responsiveness' and 'slowness in eating' which is also seen in older children (−0.23 to −0.53) (Viana et al., 2008; Wardle et al., 2001). These indicate that infants who are more demanding about being fed and more responsive to food cues tend also to be less sensitive to internal satiety. 'Enjoyment of food' was correlated with 'satiety responsiveness', although not as strongly as at later ages (−0.59 to −0.70) (Sleddens et al., 2008; Wardle et al., 2001) indicating that infants who enjoy feeding tend also to be lower in satiety responsiveness, perhaps as a result of reward pathways overriding basic appetite regulation.

'Enjoyment of food' and 'food responsiveness' were not significantly correlated, which was surprising given the size of the correlation observed between these two traits in children (0.44–0.78) (Carnell & Wardle, 2007; Sleddens et al., 2008; Viana et al., 2008; Wardle et al., 2001). The non-significant finding was not the result of lack of variation in 'enjoyment of food' as this trait showed moderate associations was the other two eating behaviours (−0.36 and −0.45). It is possible that these two characteristics are independent of one another at this early age.

The single item measuring 'general appetite' showed moderate associations with all four of the scales such that infants who enjoyed feeding more, were more food responsive, fed faster and were less sensitive to internal cues of satiety were also rated as having a bigger overall appetite, indicating that this item measures overall appetite avidity. Collectively, these findings indicate that the same dimensions of appetite that are seen in childhood are present at a very early age, and show similar interrelationships, although the dynamics of the associations are not as well-established as at older ages.

It will be interesting to track eating behaviours from infancy into childhood to ascertain how stable they are over time and whether the size of the inter-correlations increases. There is strong tracking of appetitive traits measured using the CEBQ between ages 4 and 11 (Ashcroft, Semmler, Carnell, van Jaarsveld, & Wardle, 2008). A recent study reported that a single item measure of infant appetite at 6 weeks ('At present, how would you describe your baby's appetite'; 'very poor', 'poor', 'all right', 'good', 'very good') was positively associated with CEBQ 'enjoyment of food' and negatively with 'satiety responsiveness' measured 5–6 years later (Parkinson, Drewett, Le Couteur, & Adamson, 2010), although effect sizes were small suggesting that individual differences in appetite avidity that are manifested during the first few weeks may have some continuity but also some differences in the long-term. We anticipate that the clustering of constructs will increase post-weaning as both dietary variety and choice increase.

It was noteworthy that the same factor structure was reproduced in all of the subgroups examined, highlighting the robustness of the four dimensions of infant appetite even in infants who had feeding problems, or were very premature, or who were born with a very low birth weight. Nevertheless, the BEBQ was able to distinguish between some of the sub-groups in terms of mean scores. There were small sex differences, with male infants being slightly more responsive to cues of feeding and milk, slightly less sensitive to internal cues of satiety, and having a larger appetite than female infants. The satiety difference is similar to results from 11-year-old children where boys scored significantly lower on CEBQ 'satiety responsiveness' (Carnell and Wardle, 2008). Two smaller studies reported differences that were not significant but were of a similar magnitude for CEBQ 'food responsiveness' (Sleddens et al., 2008; Wardle et al., 2001).

In this sample, prematurity was associated with a smaller overall appetite, characterised by lower food responsiveness, lower enjoyment of food, a slower feeding pace, a higher sensitivity to satiety, and a smaller overall appetite. This finding supports evidence that decreasing gestational age is associated with increasing rates of postnatal growth retardation during the first few months of life due to feeding problems and poor appetite which may be a consequence of immaturity and clinical instability (Cooke, Ainsworth, & Fenton, 2004; Cooke & Embleton, 2000; Embleton, Pang, & Cooke, 2001). The same pattern of findings was observed for infants with reported feeding problems – they enjoyed food less, were less responsive to feeding cues, slower feeders, more satiety sensitive, and had a smaller overall appetite than infants without feeding problems.

There were some surprising findings related to feeding mode. Breast-fed infants tended to be more responsive to cues to feed and less satiety sensitive than either mixed-fed or bottle-fed infants, and they had a larger overall appetite than those who were bottle-fed. These findings were unexpected given the protective effect of breast-feeding on infant growth rate and later obesity risk that has sometimes been observed in epidemiological studies (Gillman et al., 2001; Gluckman, Beedle, Hanson, & Vickers, 2007; Harder, Bergmann, Kallischnigg, & Plagemann, 2005; Owen, Martin, Whincup, Smith, & Cook, 2005). They do not support the hypothesis proposed by some researchers that one of the mechanisms through which breast-feeding attenuates weight gain is to upregulate the infant's satiety sensitivity by providing them with better opportunity to control their intake, or because breast milk contains biologically active substances that promote satiety such as leptin (Bartok & Ventura, 2009). However, it may be the case that mothers of infants who had good appetites and fed well were better able to persist with breast-feeding; accounting for the association. Lastly, infants born heavier enjoyed food more, fed more quickly, were less satiety sensitive and had a larger overall appetite than infants born smaller. This is not surprising given the increased energy requirements of larger babies.

There are limitations to this study. The BEBQ is a parent-report measure and could be subject to bias. In particular, bottle-feeding and breast-feeding are slightly different behaviourally, so it is important to validate the BEBQ using measures of observed milk-feeding behaviour of both bottle-feeding and breast-feeding infants to check that the items are equally valid for both feeding methods. However, because it was based upon the CEBQ which has been validated against behavioural measures in children (Carnell & Wardle, 2007), and because the factor structure and pattern of inter-correlations was the same, we believe it can be used with some confidence. Conclusions drawn from PCA must be generalised with caution (Field, 2005) and replication of the factor structure in singletons is needed to confirm the underlying dimensions. This is particularly important given that twins tend to be born earlier and smaller than singletons (Buckler & Green, 2004; Grumbach et al., 1986). Nonetheless, the factor structure was the same for all subgroups examined, suggesting that birth weight and gestational age do not affect the underlying dimensions of appetite in infants. Data on the BEBQ in singletons is currently being collected, and the questionnaire is being translated into a number of different languages which will make it possible to compare the internal validity and reliability of the questionnaire in singletons and in different populations of infants.

Another limitation relates to the retrospective nature of the questionnaire – because infants were on average 8 months old when the parents completed the questionnaire, most of them would have been weaned, and it is therefore possible that the mothers' responses were influenced by the infant's appetite for solid food. Replication of the findings using a version of the BEBQ completed by mothers during the 0–3-month period of milk-feeding would add credibility to these results; data collection using a concurrent version is underway.

The BEBQ should be a useful tool for prospective investigations of associations between infant appetite and weight gain and for cross-twin-cross-trait analyses in twin samples, to gather evidence on the causal role of these feeding behaviours in weight gain. If appetitive traits in infancy predict later adiposity, the BEBQ may have value as a screening tool for risk of excessive weight gain in order to implement early interventions to attenuate the expression of these traits. The BEBQ can also be used to explore the aetiology of infant appetite by testing predictors such as that feeding mode (bottle or breast-feeding), parental feeding style, or factors related to gestational experience influence appetite. It has already been used to demonstrate the importance of genetic factors on early life appetite (Llewellyn, van Jaarsveld, Johnson, Carnell, & Wardle, 2010).

In conclusion, the BEBQ is a comprehensive and practical measure of appetite in early infancy that will facilitate research into the predictors and outcomes of variation in appetite (the current version of the BEBQ with scoring instructions may be downloaded from the following website: http://www.ucl.ac.uk/hbrc/diet/resources.html). The findings from this study indicate that the underlying structure of appetite in infancy is the same as in older children.

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Appendix A. BEBQ items compared to the original CEBQ items.

BEBQ scale[a]	Item source[b]	BEBQ item	CEBQ item
EF	CEBQ (EF)	My baby loved milk	My child loves food
	CEBQ (EF)	My baby enjoyed feeding time	My child enjoys eating
	New	My baby seemed contented while feeding	NA
	New	My baby became distressed while feeding	NA
	NI	–	My child is interested in food
	NI	–	My child looks forward to mealtimes
FR	CEBQ (FR)	My baby was always demanding a feed	My child is always asking for food
	CEBQ (FR)	If allowed to, my baby would take too much milk	If allowed to, my child would eat too much
	CEBQ (FR)	Even when my baby had just eaten well, s/he was happy to feed again if offered	Even if my child is full up s/he finds room to eat his/her favourite food
	CEBQ (FR)	If given the chance, my baby would always be feeding	If given the chance, my child would always have food in his/her mouth
	New	My baby frequently wanted more milk than I provided	NA
	NI	–	Given the choice, my child would eat most of the time
	CEBQ (SR)	My baby could easily take a feed within 30 min of the last one	My child cannot eat a meal if s/he has had a snack just before
SE	CEBQ (SE)	My baby finished feeding quickly	My child finishes his/her meal quickly
	CEBQ (SE)	My baby fed slowly	My child eats slowly
	CEBQ (SE)	My baby took more than 30 min to finish feeding	My child takes more than 30 min to finish a meal
	CEBQ (SE)	My baby sucked more and more slowly during the course of a feed	My child eats more and more slowly during the course of a meal
SR	CEBQ (SR)	My baby found it difficult to manage a complete feed	My child leaves food on his/her plate at the end of a meal
	CEBQ (SR)	My baby got full before taking all the milk I thought s/he should have	My child gets full before his/her meal is finished
	CEBQ (SR)	My baby got full up easily	My child gets full up easily
GA	CEBQ (SR)	My baby had a big appetite	My child has a big appetite

Abbreviations: BEBQ, Baby Eating Behaviour Questionnaire; CEBQ, Child Eating Behaviour Questionnaire; EF, 'enjoyment of food'; FR, 'food responsiveness'; SE, 'slowness in eating'; SR, 'satiety responsiveness'; GA, 'general appetite'; NA, not applicable; NI, not included in the BEBQ.

[a] 4 of the CEBQ scales were not included in the BEBQ as they were considered inappropriate for milk-feeding infants ('emotional overeating'; 'emotional under-eating'; 'desire to drink'; 'food fussiness').

[b] Items that were created for the milk-feeding period are labelled 'new'.