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Development and validation of the baby eating behaviour coding system (BEBECS) to assess eating behaviour during complementary feeding

Iratxe Urkia-Susin [a,b,*], Jone Guenetxea-Gorostiza [c,d], Diego Rada-Fernandez de Jauregui [b,c], Leire Mazquiaran-Bergera [c,d], Olaia Martinez [a,b], Edurne Maiz [d,e]

[a] Department of Pharmacy and Food Science (G3S Research Group), Faculty of Pharmacy, University of the Basque Country UPV/EHU, Unibertsitateko Ibilbidea 7, 01006, Vitoria-Gasteiz, Araba, Spain
[b] Bioaraba Health Research Institute, Nutrition and Food Safety Group Araba University Hospital, Vitoria-Gasteiz, Spain
[c] Department of Preventive Medicine and Public Health, Faculty of Pharmacy, University of the Basque Country UPV/EHU, Unibertsitateko Ibilbidea 7, 01006, Vitoria-Gasteiz, Araba, Spain
[d] Biogipuzkoa Health Research Institute, Mental Health Group, Donostia, Spain
[e] Department of Clinical and Health Psychology and Research Methodology, Faculty of Psychology, University of the Basque Country UPV/EHU, Tolosa Hiribidea 70, 20018, Donostia, Gipuzkoa, Spain

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ABSTRACT

Eating behaviour in children is a matter of study for which diverse tools have been designed. Coding systems for videotaped meals allow the extraction of detailed *in vivo* information; however, there is no tool available for infants following a Baby-Led Weaning (BLW) method. This study aimed to create and validate a new tool to assess eating behaviour in infants during weaning, applicable regardless of the complementary feeding method. The Baby Eating Behaviour Coding System (BEBECS) was developed comprising time variables, behaviours, feeder-led actions, and other meal-related variables. Sixty videos of infants aged 6–18 months following spoon-feeding (SF) or BLW methods were coded by two trained coders. These scores were analysed together with intake and maternal ratings of liking and calmness. Additionally, combined analysis and internal comparison assessed the possible differences in BEBECS variables between SF and BLW. Inter-rater and test-retest reliability had good to excellent agreement: Cohen's Kappa >0.75, Lin's CCC >0.70, and Intraclass Correlation Coefficient >0.75, for almost all variables. Infants' liking and intake of the offered food correlated positively with meal duration and total count of mouth approaches but negatively with having leftovers and time between mouth approaches. Infants' calmness and tiredness were negatively correlated. More food than initially offered was available during the meal in BLW but not in SF. There was a tendency towards more autonomous behaviour in BLW infants regarding changes observed in the time the food was in the mouth at each stage (6, 12, and 18 months). In conclusion, BEBECS has the potential to be a valid tool for application in the research of infant eating behaviour during weaning by trained coders.

1. Introduction

A child's diet evolves rapidly from milk-based to solids during the first year of life, and this early stage is crucial for the development of eating habits (Alles et al., 2014). Establishing healthy eating behaviours in childhood may lead to desirable eating habits in adulthood (Aune et al., 2017; Barends et al., 2019; Masztalerz-Kozubek et al., 2022). Moreover, BMI and overweight in childhood predict type 2 diabetes (Hu et al., 2020), and class II/III obesity (Woo et al., 2019), and are associated with overall cancer mortality (Nuotio et al., 2021) in adulthood. Therefore, it is important to study factors influencing the development of eating behaviour in children to establish healthy eating habits in early life.

The eating behaviour of babies and children has been assessed using questionnaires (Loewen & Pliner, 2000; Wardle et al., 2001) and also by observationally coding their behaviour (Fries et al., 2017; Hetherington et al., 2016; Moding et al., 2014). Questionnaires usually depend on parental reports, which might not be completely reliable considering reporting biases (Pesch & Lumeng, 2017). However, observational

* Corresponding author. Department of Pharmacy and Food Science, Faculty of Pharmacy, University of the Basque Country EHU-UPV, Unibertsitateko Ibilbidea 7, 01006, Vitoria-Gasteiz, Araba, Spain.
E-mail address: iratxe.urkia@ehu.eus (I. Urkia-Susin).

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Abbreviations

ADiff	Approaching Difficulties
AFE	Available Food at the End
BEBECS	Baby Eating Behaviour Coding System
BLW	Baby-Led Weaning
BT	Tired Behaviour
ET	Ending Time
FLG	Feeder-Led Grabbing
FLM	Feeder-Led Mouth approach
FLMr	Refusal of the Feeder-Led Mouth approach
FIM	Food-in-Mouth time
FTM	Food-to-Mouth time
MA	Mouth Approach
MB	Meal Beginning
MD	Meal Duration
ME	Meal Ending
MFP	More Food Provided
RBME	Refusal-Based Meal Ending
ST	Starting Time
SF	Spoon-feeding

coding applied to video recordings allows the detailed capture of the moment (e.g., actions, behaviours, sounds, etc.) (Hetherington et al., 2016). This "*in vivo*" information cannot be obtained from self-reported questionnaires (Pesch & Lumeng, 2017). Some studies record videos in the laboratory setting for stricter control of experimental variables (Pesch et al., 2018), however, recording at home allows the researcher to capture the naturalistic environment of mealtimes (Penilla et al., 2022). This context will have more ecological validity, be less demanding, and more feasible (Hetherington & Rolls, 2018). However, some aspects should be controlled in these scenarios, mainly, taste interactions when complex foods are tested and differing levels of experience between participants regarding the test food media (Young & Drewett, 1998).

Over the last almost two decades, an alternative complementary feeding method called "baby-led weaning" (BLW) has become popular (Brown et al., 2017). This is proposed as an alternative to parent-led complementary feeding, which is usually based on spoon-feeding (SF) with puréed food (Rapley & Murkett, 2008). Its fundamental principle entails letting the infant be in charge of their own feeding process, setting the pace and deciding the amount they want to eat (Brown et al., 2017). Consequently, scientific evidence has been growing concerning this approach, suggesting that BLW compared to the parent-led SF method does not differ regarding energy, zinc, or iron intake (Alpers et al., 2019; Boswell, 2021). Moreover, there is no increased choking risk compared to SF, and the oral motor skills of infants may be improved (Fangupo et al., 2016). Further research should confirm this, however, the available literature does indicate that BLW might reduce the overweight risk and food fussiness, as well as enhance satiety responsiveness (Boswell, 2021). That might help to act against child neophobia or rejection of non-familiar food, which has been described to generally arise in toddlers around two years of age (Maiz & Balluerka, 2016). BLW is related to responsive feeding practices and is thought to be effective in enhancing the acceptability of new foods (Brown & Lee, 2015). Neophobia is usually related to fruit and vegetables (Dovey et al., 2008; Maiz & Balluerka, 2016; C. M. Taylor & Emmett, 2019), these being key elements of balanced and healthy diets during childhood and adulthood (World Health Organization, 2020).

Some previous studies (Fries et al., 2017; Hetherington et al., 2016; Moding et al., 2014) have assessed child eating behaviours from coded video recordings but following a parent-led SF method. The closest experiences to BLW assessment are those comparing SF to finger food; nevertheless, these are still based on parent-led approaches (Drewett et al., 2003; Parkinson & Drewett, 2001; Parkinson et al., 2004). However, the previous tools are not suitable to evaluate wanting in BLW complementary feeding, as it was assessed by direct measures based on behaviours in response to a food offer (i.e., leaning forward or reaching for food, turning head away or looking away, arching back or pulling body away). In a BLW context, there is no external offer of food, therefore, these behaviours do not arise. Thus, to date, no validated tool is available to measure behaviours related to food preferences in babies following a BLW complementary feeding method. Moreover, there is a need for higher quality evidence to understand the possible effects of baby-led feeding practices in children (Caroli et al., 2022), which this tool might help to achieve.

Therefore, the main objective of the present study was to create and validate a coding system to assess the eating behaviour of infants during weaning following a BLW or SF complementary feeding method.

2. Material and methods

2.1. Participants

Twenty-nine infants from the *Dastatuz* trial (Urkia-Susin et al., 2021), whose mothers were recruited from September 2019 to December 2022, formed part of this study. *Dastatuz* is a quasi-experimental trial evaluating the influence of maternal diet (during the last trimester of pregnancy and breastfeeding) and the child's complementary feeding method in relation to the child's acceptance of novel foods. Pregnant women were the main target throughout the first stage of the study, and researchers subsequently focused on infants during complementary feeding. Detailed information on the mother's characteristics has been presented before (Urkia-Susin et al., 2024, manuscript submitted for publication). The mean age of mothers was 36.16 years, 63.85% were of normal weight, most were of middle economic status (63.08%), married or with a long-term partner (95.38%), and 84.62% had university-level studies at recruitment. Regarding children, 13 were girls (44.8%) and mean values for weight and length at birth were: 3.24 kg (0.36) and 49.43 cm (1.74), respectively. At six months of age, the BMI z-score was −0.56 (SD = 0.91, n = 23), −0.80 (SD = 0.56, n = 20) at 12 months, and −0.64 (SD = 1.57, n = 10) at 18 months (reference values for z-score calculation were taken from Sobradillo et al., 2004). As part of the inclusion criteria for the *Dastatuz* trial, all infants were breastfed at birth. Lactating situation and weaning methods were evaluated each time videos were filmed using online *ad hoc* questionnaires.

Pregnant women were informed via midwife consultations or pregnancy-related centres and contacted the research team if interested in enrolling in the study. If the interested women fulfilled the inclusion criteria [detailed in Urkia-Susin et al. (2021)], they were recruited before entering the third trimester of pregnancy. Following the procedure approved by the Ethics Committee of the Basque Country (PI2019096), mothers signed an informed consent for the use of the videotapes. Videos were recorded at home by each infant's parents, which were then handed over to the research team. They were informed that the videotapes would be used to assess the reality of mealtimes (i.e., infant behaviour in general).

2.2. Study design

Videos considered for this validation were collected until the June 15, 2023 (see Fig. 1), not necessarily all those expected for the whole study from each family, as *Dastatuz* is still ongoing and participants are at different stages depending on their recruitment date. Half the videos were from participants belonging to the BLW group and the other half from those from the SF group (Fig. 1). Children were assigned to the SF or BLW group based on the intentions expressed by their parents at the time of recruitment, understanding that their adherence to one or other method was going to be better depending on their own motivation.

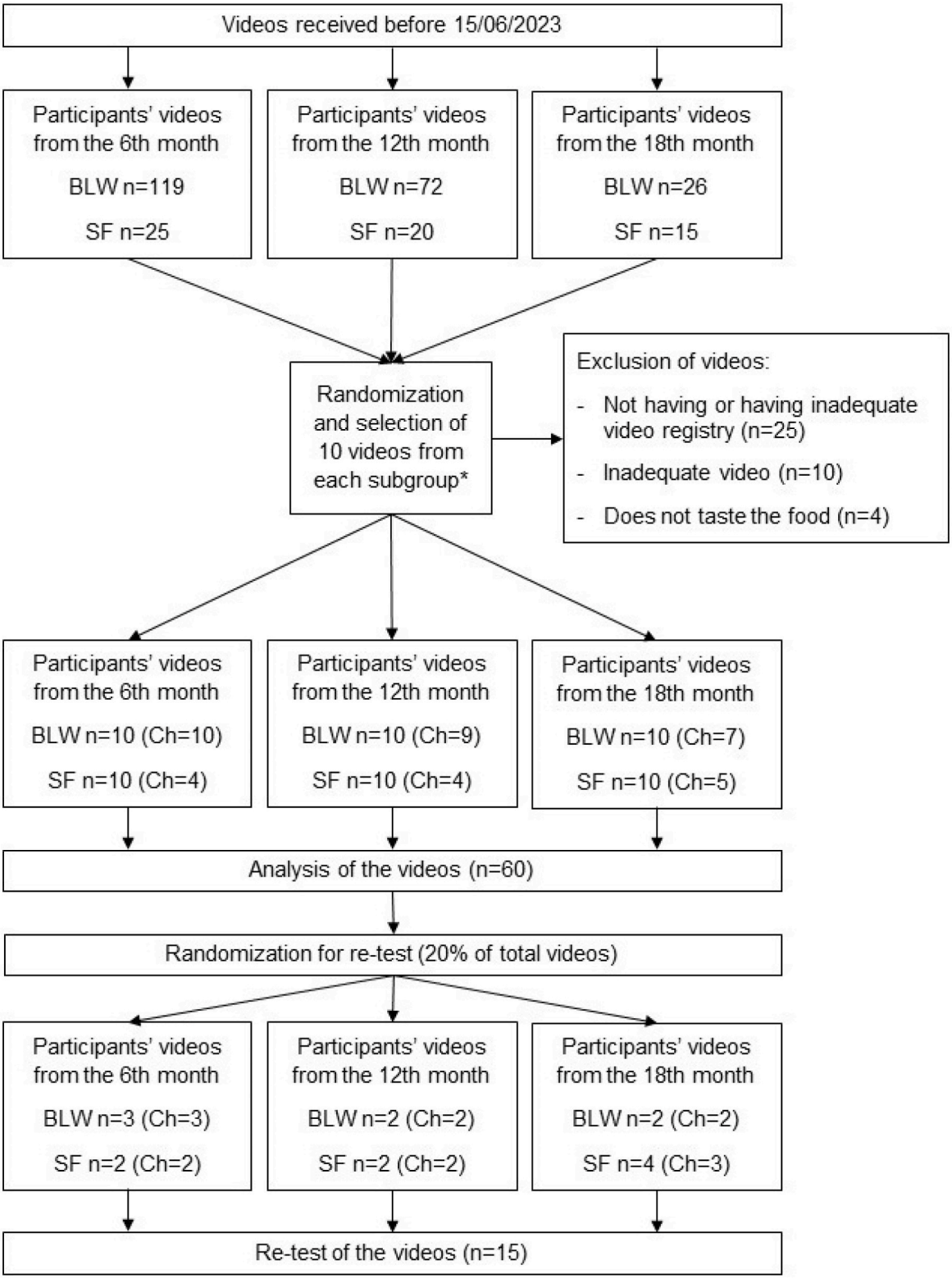

Fig. 1. Randomisation of videos chosen for BEBECS validation. Sample numbers refer to videos. BLW, Baby-Led Weaning; SF, Spoon-feeding; Ch, number of children. All the final recordings came from twenty-nine participants. *Research group decision based on a previous study (Hetherington et al., 2016).

Thus, participants included in the BLW group were those who reported their intention to follow a BLW approach for weaning, defined as a complementary feeding style where the infant is self-fed and in charge of the eating process. Whereas participants who stated they were going to spoon-feed their children were included in the SF group. Once the complementary feeding age was reached, dietary recommendations offered to the families were coherent with their choices and, therefore, with the experimental group they were assigned to.

To ensure coherence with the items included in the coding system, the initial BEBECS proposal was based on the literature and then discussed and adjusted considering expert advice. Professionals from the nutrition, psychology, food science, and pharmacy fields were involved

in this process, as previously recommended (Hetherington & Rolls, 2018). Likewise, "Best practice highlights" from Pesch and Lumeng (2017) were also complied with for methodological considerations.

2.3. Procedure and measures

Participants had an individual meeting with the researchers and received written and oral instructions on the setting and procedure for videotaping. Each family sent between one and three videos for each timepoint (6, 12, and 18 months), and all were considered for sampling (Fig. 1).

2.3.1. Setting and filming instructions

To keep the atmosphere as natural as possible, the recording was conducted at participants' homes or familiar dining places. Required material included a smartphone (for recording), a high chair for the baby to sit in (or they could sit on the caregiver's lap), support for the smartphone, and the chosen food. It was explained that the framing should be centred to capture both the baby and the table where the food or plate was offered (an image of a framing example was given). No zoom should be applied and adequate lighting should be assured. Moreover, background sounds (e.g., working washing machine, microwave) and distractions (e.g., toys, TV) should be avoided, favouring a calm setting. The home setting should not be so distressful as to difficult the identification of signs related to food, which could be confused with those arising from other stimuli (Pesch & Lumeng, 2017).

Families were told to record either the lunch or afternoon snack in the usual dining area of the house. To standardise the readiness to eat, they had to ensure that the baby did not eat anything for at least an hour before filming the meal.

Regarding the offered food, families were asked to offer a new fruit or vegetable to the baby, which had to be offered alone, not accompanied by another foodstuff. If a purée was offered, the chosen food should be ground or smashed alone or just with some potato to thicken the texture. The fact of offering a novel food was established, as suggested in the literature, to control for previous experiences and familiarity (Hetherington & Rolls, 2018; Sullivan & Birch, 1990).

In addition, instructions on when to begin and end the recording were given. It should begin once the baby was sitting and before offering the food or plate, whereas, it should end once the meal was over. The meal was considered to be over if the caregiver or feeder identified the baby's usual signs of satiety or the baby rejected the offered food three times in a row, as suggested previously (Hetherington et al., 2016; Mennella & Beauchamp, 1997).

2.3.2. Taping record

At the end of the filming session, caregivers had to complete a taping record. This record gathered data regarding the moment of the day (lunch or afternoon snack), food offered, times tasted (preferably not tasted before), cooking style (e.g., raw, boiled, roasted, etc.), initial and final quantity (in grams, ml, or home measurements), who offered the food (e.g., the baby fed themselves, the mother, etc.) and if that was the usual condition, calmness and liking by the baby (3-point Likert scale), and some free text to describe the ingredients and preparation of the dish offered.

Information regarding food intake was reported by the caregiver, indicating measured quantities (in grams or millilitres) or assessed as house measures (e.g., half an apple) for initial and final quantity. Home measures were then converted into grams following an established protocol developed for the study based on the portion sizes proposed by More and Emmett (2015). If there was more food offered during the meal, participants added it to the reported initial quantity.

Calmness and liking were reported by the caregiver by selecting a response from a 3-point Likert scale. Answer options for calmness were 1 = *agitated*, 2 = *not calm nor agitated*, and 3 = *calm*. Liking responses were categorised as 0 = *not clear*, 1 = *not liked*, and 2 = *liked*. Maternal ratings were used for the comparison with coded variables from videos from previous research (Hetherington et al., 2016; Nekitsing et al., 2016).

The caregiver had to indicate whether the baby had tasted that particular food before to ensure the novelty of the chosen food, as previously recommended (Hetherington & Rolls, 2018). Finally, the exact date and the participant's personal code were reported by the caregiver to situate the recording in time and relate it to the corresponding participant, respectively.

2.3.3. Coding

A guide was developed for the BEBECS tool, where the definition of the measured variables was specified (see Supplementary Material S1 and S2). Coders used the guide as a training tool. Two trained coders (IUS and JGG) coded all videos, and a third (EM) participated when discrepancies occurred. Measured variables are presented in Table 1. Some were extracted directly from the recordings (primary variables) and others were derived from them (secondary variables). All were classified depending on the observation unit, which could be each mouth approach or the whole meal.

At the beginning of the process, some other variables were considered but finally dismissed either because they were found to be subjective aspects or due to disagreements between coders (low inter-rater reliability). For instance, coding "eating difficulties" was disregarded because it was difficult and subjective to assess if the offered food was slippery or undercooked based on the video recordings. Concerning "distracted behaviour", this was based on the baby's gaze, however, this was not possible to evaluate because of the close framing of the baby in the video recordings and the impossibility of assuring the engagement with the feeder. Coding "plays with food" was also disregarded as it was difficult to objectively assess when it was considered to be playing (which would be considered a negative behaviour) and when it was part of the exploration of the food (considered a positive behaviour).

2.3.3.1. Eating behaviour events. Meal Beginning (MB) was a continuous variable that expressed when the food was presented to the baby for the first time. Meal ending (ME) was a continuous variable that indicated when the plate was taken away from the baby. Meal duration (MD) was a continuous variable representing the time interval between MB and ME. These three variables were measured for the whole meal.

Mouth approach (MA) was a continuous variable that counted every time the food touched the baby's mouth, lips, or tongue (detailed definition in Supplementary Material S1). Total MA was derived from its total count.

Starting time (ST) was the timepoint when the food touched the mouth of the baby. Ending time (ET) was the timepoint when the baby or feeder took the food out of the mouth of the baby. Derived from these two variables, Food-to-mouth time (FTM) was the time interval between ET and the next ST; and Food-in-mouth time (FIM) was the time interval in which the food remained in contact with the mouth of the baby. Median FTM and FIM were considered secondary variables calculated for the whole meal.

Refusal-based meal ending (RBME), a categorical primary variable (0 = no; 1 = yes, 2 = not applicable), was coded positively (=1) when the child showed signals of refusal (i.e., looks away, turns head away, arches back, pulls body away, pushes the spoon away, gets fussy, cries, or verbalises refusal), and the meal ended afterwards as a result of this refusal. This was coded for the whole meal.

2.3.3.2. Caregiver actions. Parent-child interactions can condition feeding context and eating-related behaviours, which is why they are usually included in coding systems assessing eating behaviour in children (Dovey et al., 2008; Parkinson & Drewett, 2001).

Feeder-led grabbing (FLG) was a continuous variable that measured the number of times the feeder tried to help the baby grab the food or

Table 1
Classification of the variables coded following the BEBECS coding system.

	Coded for each mouth approach		Coded for the whole meal (total counts or median)	
	Primary variables	Secondary variables	Primary variables	Secondary variables
Eating behaviour events			Meal Beginning (MB) Meal Ending (ME)	Meal Duration (MD) = ME-MB
	Mouth Approach (MA)			Total Mouth Approaches (count)
	Starting Time (ST) Ending Time (ET)	Food-in-Mouth (FIM) = ET – ST of the same MA Food-to-Mouth (FTM) = ET – ST of the next MA		Median FIM Median FTM
			Refusal-Based Meal Ending (RBME)	
Caregiver actions	Feeder-Led Grabbing (FLG)			Total FLG (count)
	Feeder-Led Mouth Approach (FLM)			Total FLM (count)
	More Food Provided (MFP)			Total MFP (count)
Child behaviour	Refusal of the Feeder-Led Mouth approach (FLMr)			Total FLMr (count)
	Tired (BT)			Total BT (count)
Food-related aspects	Approaching difficulties (ADiff)[a]			Total ADiff (count)[a]
			Available Food at the End (AFE)	

[a] Removed from the final version of the BEBECS tool.

cutlery used for the meal (filled with food) in each MA. The total count of FLG actions was calculated for the whole meal. The feeder-led mouth approach (FLM), also a continuous variable, expressed the number of times the feeder tried to put the food into the baby's mouth in each MA. The total count of FLM actions was calculated for the whole meal.

More Food Provided (MFP) was a dichotomous variable identified for each MA and expressed the addition of more food to the table/plate during the meal that was not presented before. The total count of MFP actions was calculated for the whole meal.

2.3.3.3. Child behaviour. Refusal of the feeder-led mouth approach (FLMr) was a continuous variable that counted how many times the baby did not accept the FLM action for each MA. The total count of FLMr behaviours was calculated for the whole meal.

Tired (BT) was a dichotomous variable that was coded positively (=1) if the baby was yawning, rubbing their face, crying, or emitting low-pitched vocalisation (complaining). Based on the literature, these behaviours were deemed to reflect a "tired" behaviour (Day, 2014; Thomas, 2016) and have been related to food avoidance in recent studies (Corlett, 2010; Wright et al., 2021). Tired behaviour was assessed for each MA, looking for the aforementioned signals. The total count of tired behaviour was calculated for the whole meal.

2.3.3.4. Food-related aspects. Approaching difficulties (ADiff) was a dichotomous variable that scored one if the infant had difficulties (e.g., food falling or grabbing difficulties, and mouth-hand coordination issues) approaching the offered food to the mouth. The total count of ADiff was calculated for the whole meal.

Available food at the end (AFE) was a dichotomous variable that was positively coded (=1) if there were leftovers when the meal was considered to be ended. AFE was coded for the whole meal.

2.4. Combined analysis and internal comparison

Combined analysis and internal comparison were conducted to test the applicability of BEBECS to compare study groups consisting of infants following an SF or BLW method for complementary feeding. Therefore, half of the coded videos were from the SF group (n = 30) and the other half from the BLW group (n = 30), as reflected in Fig. 1. Variables of interest were compared to assess possible differences between groups: MD, total tired behaviour, total FLG, total FLM, total FLMr, Total MA, intake, median FTM, median FIM, total MFP, overall score, RBMA, AFE, liking, and calmness. It should be noted that the combined analysis and internal comparison were mainly based on secondary variables as these offer information about the whole meal.

2.5. Statistical analysis

Primary variables were considered for validation analysis. Reliability between coders was assessed by Cohen's Kappa for dichotomous or categorical variables and by Lin's concordance correlation coefficient (Lin's CCC) for continuous variables. Strength of agreement based on Cohen's Kappa values was interpreted as 0, no agreement; 0–0.20, slight agreement; 0.20–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, substantial agreement; 0.81–1, almost perfect agreement (Landis & Koch, 1977). Lin's CCC measures precision and accuracy between bivariate pairs of observations and interpretation was based on $<$ 0.20, poor and $>$0.80, excellent (Altman, 1991).

Test-retest reliability was evaluated by the intraclass correlation coefficient (ICC), selecting a two-way mixed-effects model (following instructions from Koo & Li, 2016). Likewise, consistency type was selected for continuous variables, while for categorical or dichotomous variables, the absolute agreement type was chosen. Values $<$ 0.50 indicated poor reliability, from 0.5 to 0.75 moderate reliability, from 0.75 to 0.9 good reliability, and values $>$ 0.9 were indicative of excellent reliability.

Associations between BEBECS variables and other external variables, such as intake, calmness, and liking, were assessed by Spearman's Rho correlation coefficient. Interpretation of results was: weak for ρ values $<$ 0.3, moderate for ρ values between 0.3 and 0.6, and strong for ρ values $>$ 0.6 (Akoglu, 2018; Dancey & Reidy, 2007). The Bonferroni correction was applied and the value for statistical significance was set at $p <$ 0.0015. In order to assess how variables relate to each other, principal component analysis was performed on eight continuous main variables, applying varimax rotation. Number of factors were automatically set following criteria of $>$1.0 eigenvalues and a maximum of 25 iterations.

For the combined analysis and internal comparison, some primary variables and all secondary variables were considered, as previously explained. The Mann-Whitney *U* test was conducted for the comparison between study groups (SF and BLW) for continuous variables. χ^2 was used for categorical or dichotomous variables or Fisher's test for variables with response option frequencies $<$ five. The Bonferroni correction was applied and the value for statistical significance was set at $p <$ 0.005. Effect sizes were evaluated by r (r $<$ 0.3 small effect size, 0.3 $<$ r $<$ 0.5 medium effect size, r $>$ 0.5 large effect size) (Rosenthal, 1991) and

Cramer's V (V < 0.05 none or very weak, 0.05 < V < 0.10 weak, 0.10 < V < 0.15 moderate, 0.15 < V < 0.25 strong, V > 0.25 very strong) (Akoglu, 2018).

Statistical analyses were conducted using IBM-SPSS software (IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY; IBM Corp). The Clinical Research Ethics Committee of the Basque Country (CEIC-E) approved this study (September 25, 2019, PI2019096). Study participants filled out a written consent form before their enrolment in the study. This study complied with the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013). TREND statements (Jarlais et al., 2004) were followed as reporting standards.

3. Results

3.1. Children characteristics

Considering answers from completed questionnaires, at six months (n = 27) 85.2% of the infants were breastfeeding, two infants were formula-fed, and two followed a mixed lactation. Mashed food 0–10% of the time was used by 48.1% and finger foods 91–100% of the time by 33.3%. At 12 months (n = 19), 15 respondents reported breastfeeding their infants, three were formula-fed and one followed a mixed lactation. Mashed food 0–10% of the time was used by 52.6% of the respondents and finger foods 91–100% of the time by 36.8%. At 18 months (n = 13), nine respondents declared breastfeeding, one was formula-fed, two were following a mixed lactation, and one was not lactating anymore. Mashed food 0–10% of the time was used by 84.6% and 61.5% declared using finger foods 91–100% of the time.

At the SF group, for six months videos, two meals of two children and three meals of two children were considered. For 12 months, one meal of one child and three meals of three children were coded. And for 18 months, one meal of two children, two meals of one child, and three meals of two children were analysed. Regarding the BLW group, for six months videos, a meal of 10 children was coded. For 12 months, a meal of 9 children and two meals of one child were analysed. Finally, for 18 months, a meal of four children and two meals of three children were considered.

3.2. Inter-rater reliability

Reliability between coders was assessed by Cohen's Kappa and Lin's CCC for dichotomous or categorical variables and continuous variables, respectively (see Tables 2 and 3). Results from Cohen's Kappa ranged between substantial to almost perfect agreement. Similarly, Lin's CCC outcomes were excellent or almost excellent.

3.3. Test-retest reliability

ICC was used to assess test-retest reliability (see Table 4). Retest coding was performed in 20% of randomly selected previously coded videos and over three weeks from the last video coded for the initial test, as suggested in previous studies (Hulley & Cummings, 1993; Pesch & Lumeng, 2017; Polit, 2014). Results show that all coefficients ranged from good to excellent reliability (ICC >0.75), except ADiff, which was poor for coder 1 and moderate for coder 2, and FLMr (moderate for coder 1, good for coder 2).

Table 2
Inter-rater reliability for dichotomous and categorical primary variables.

Variables	Cohen's Kappa	Standard error
Refusal-Based Meal Ending	0.81	0.01
Approaching Difficulties	0.91	0.02
Available Food at the End	0.90	0.01
More Food Provided	0.81	0.03
Tired Behaviour	0.75	0.04

Table 3
Inter-rater reliability for continuous primary variables.

Variables	Lin's CCC	%95 CI
Meal Beginning	0.98	0.97–0.98
Meal Ending	1.00	1.00–0.99
Starting Time	1.00	1.00–1.00
Ending Time	1.00	1.00–1.00
Feeder-Led Grabbing	0.73	0.70–0.75
Feeder-Led Mouth approach	0.92	0.92–0.93
Refusal of the Feeder-Led Mouth approach	0.81	0.79–0.82

Lin's CCC, Lin's Concordance Coefficient Correlation; 95% CI, 95% Confidence Interval.

Table 4
Test-retest reliability for all primary variables for each coder.

Variables	Coder 1		Coder 2	
	ICC	95% CI	ICC	95% CI
RBME	0.76	0.70–0.80	0.98	0.98–0.99
ADiff	0.26	0.14–0.37	0.54	0.45–0.62
AFE	1.00	–	0.94	0.93–0.95
MFP	0.88	0.84–0.90	0.88	0.85–0.90
Tired, Behaviour	0.82	0.78–0.86	0.79	0.74–0.83
Meal Beginning	0.99	0.98–0.99	1.00	1.00–1.00
Meal Ending	1.00	0.70–1.00	1.00	1.00–1.00
Starting Time	1.00	1.00–1.00	1.00	1.00–1.00
Ending Time	1.00	1.00–1.00	1.00	1.00–1.00
FLG	0.76	0.71–0.81	0.76	0.71–0.81
FLM	0.98	0.97–0.98	0.98	0.98–0.99
FLMr	0.57	0.48–0.64	0.85	0.82–0.89

ICC, Intraclass Correlation Coefficient; 95% CI, 95% Confidence Interval; RBME, Refusal-Based Meal Ending; ADiff, Approaching Difficulties; AFE, Available Food at the End; MFP, More Food Provided; FLG, Feeder-Led Grabbing; FLM, Feeder-Led Mouth approach; FLMr, Refusal of the Feeder-Led Mouth approach.

3.4. Association of BEBECS with other reference variables

The association between BEBECS and other reference variables (i.e., mother-reported liking, mother-reported calmness, and intake) are presented in Table 5. According to the results, both mother-reported

Table 5
Spearman's rho (ρ) correlation between BEBECS and external reference variables.

Variables	Liking		Calmness		Intake	
	ρ	*P* value	ρ	*P* value	ρ	*P* value
RBME	0.105	0.424	−0.064	0.625	0.018	0.892
MD, s	0.387	0.002	0.120	0.362	**0.415**	< **0.001**
Total Tired Behaviour	0.103	0.433	−0.317	0.014	−0.005	0.969
AFE	−0.346	0.007	−0.114	0.384	−0.318	0.013
Total MFP	0.086	0.514	0.149	0.255	0.109	0.405
Total MA	**0.562**	< **0.001**	0.100	0.448	**0.581**	< **0.001**
Median FIM, s	0.092	0.486	0.040	0.762	−0.188	0.149
Median FTM, s	**−0.403**	**0.001**	−0.054	0.684	−0.387	0.002
Total FLG	0.061	0.646	0.195	0.135	−0.009	0.947
Total FLM	0.130	0.324	−0.147	0.262	0.043	0.744
Total FLMr	−0.149	0.255	−0.129	0.328	−0.045	0.731

RBME, Refusal-Based Meal Ending; MD, Meal Duration; AFE, Available Food at the End; MFP, More Food Provided; MA, Mouth Approach; FIM, Food-in-Mouth time; FTM, Food-to-Mouth time; FLG, Feeder-Led Grabbing; FLM, Feeder-Led Mouth approach; FLMr, Refusal of the Feeder-Led Mouth approach; s, seconds. All variables have 58 degrees of freedom. Statistically significant ($P < 0.0015$) results are in bold.

liking and intake correlated with the same four variables, i.e., positively with MD (weak and moderate, respectively), negatively with AFE (weak for both), positively with total MA (moderate for both), and negatively with median FTM (moderate and weak, respectively). Furthermore, there was a weak negative association between mother-reported calmness and total tired behaviour. A positive association was found between some external reference variables: liking and intake ($\rho = 0.620$, $p < 0.001$), and liking and calmness ($\rho = 0.329$, $p = 0.010$).

Based on Spearman's Rho correlation regarding associations with the Intake and Liking variables (see Table 5), an overall score was calculated that was proposed to be indicative of "wanting". MD, total MA, FTM, and AFE were used to calculate the overall score. MD, total MA, and FTM, all continuous variables, were categorised into deciles (value range: 0–10) for standardisation purposes. Then, depending on the direction of the aforementioned associations, these new variables, as well as AFE, were added or subtracted, resulting in the following equation: Overall score = categorised MD + categorised total MA – categorised FTM – AFE. The higher the overall score, the higher the "wanting" level of the infant.

3.5. Factor analysis: internal consistency

Three dimensions were extracted which accounted for the 68.8 % of total variance and from 51.3 % to 79.9 % of the specific variance of the variables included in the analysis (Fig. 2). Principal component 1 explained 30.7 % of the whole variance and showed the highest factor values for Mouth Approach, Meal Duration, tired Behaviour and Feeder-led Grabbing (all of them positive). From these, Mouth Approach and Meal Duration contributed to dimension two, while Feeder-led Mouth Approach and Tired Behaviour loaded on to dimension 3. Food-to-Mouth time and Food-in-Mouth time loaded on to dimension 2 positively (0.80 and 0.67) while Mouth Approach did negatively (−0.61). Food-in-Mouth loaded on to the third dimension, as well, but with a lower factor (−0.30). In this last dimension Refusal to the Feeder-led Mouth Approach showed the highest factor (0.80), followed by Feeder-led Mouth Approach (0.60).

3.6. Combined analysis and internal comparison outcomes

To apply BEBECS and compare results from participants following an SF or BLW method for complementary feeding, combined analysis and internal comparison were carried out. Mann-Whitney *U* test results are presented in Table 6. Total FLM and total MFP presented statistically significant differences between both study groups, with a large and medium effect size, respectively.

IQR, Interquartile Range; U, Mann-Whitney U; r, effect size estimate from Rosenthal (1991); MD, Meal Duration; FLG, Feeder-Led Grabbing; FLM, Feeder-Led Mouth approach; FLMr, Refusal of the Feeder-Led Mouth approach; MA, Mouth Approach; FTM, Food-to-Mouth time; FIM, Food in Mouth time; s, seconds; MFP, More Food Provided; RBME, Refusal-Based Meal Ending; AFE, Available Food at the End. Central

Table 6
Comparison between Spoon-Fed and Baby-Led Weaning groups.

Variables	SF (n = 30)	BLW (n = 30)	U	*P* value	r
	Mean (SD)[1]/Median (IQR)[2]				
MD[2], s	425 (1190)	353.5 (937)	341.5	0.109	−0.293
Total Tired Behaviour[2]	0 (13)	0 (17)	423.5	0.656	−0.081
Total FLG[2]	0 (11)	0 (15)	455	0.935	0.015
Total FLM[2]	**9.5 (50)**	**0 (38)**	**257**	**0.003**	**−0.539**
Total FLMr[2]	0 (15)	0 (4)	395	0.324	−0.180
Total MA[1]	25.90 (18.62)	18.43 (16.23)	335	0.089	−0.311
Intake[1]	46.85 (42.10)	29.82 (33.93)	322	0.058	−0.346
Median FTM[2], s	11 (75)	11 (127)	486	0.594	0.097
Median FIM[2], s	2 (15)	2.5 (12)	510	0.358	0.168
Total MFP[1]	**1.53 (0.82)**	**2.73 (2.27)**	**583**	**0.032**	**0.391**
Overall score[1]	6.07 (6.56)	3.20 (7.36)	346	0.123	−0.281
	Frequency (%)		**χ^2**	***P* value**	**Cramer's V**
RBME	17 (56.7)	14 (46.7)	0.68	0.711	0.107
AFE	24 (80)	24 (80)	0	1.000	0.00
Liking	23 (76.7)	17 (56.7)	4.50	0.105	0.274
	Frequency (%)		**Fisher's**	***P* value**	**Cramer's V**
Calmness	21 (70)	22 (73.3)	0.26	1.000	0.041

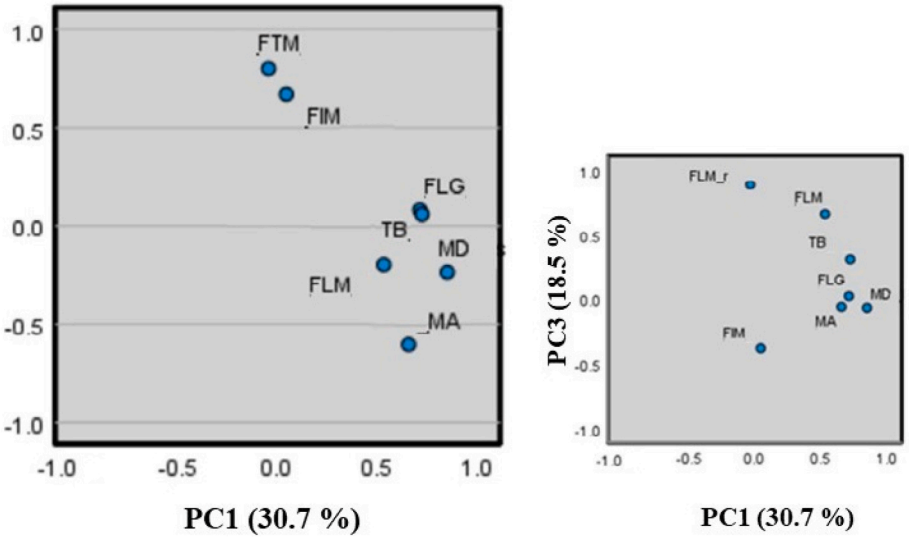

Fig. 2. Factor analysis results showing factor loadings for: MA, Mouth Approach; MD, Meal Duration; FTM: Food-to-Mouth time; FIM, Food-in-Mouth Time; FLG, Feeder-Led Grabbing; FLM, Feeder led Mouth Approach; FLMr, refusal to Feeder led Mouth Approach. PC, principal component. The chart on the left shows parameters distribution according to PC1 and PC2, main contributors to the variance, and the chart on the right shows detail of how BEBECS parameters are distributed along PC3.

tendency measures presented are mean (SD)[1] or median (IQR)[2]. Statistically significant ($P < 0.005$) results are in bold.

Analysing the sample at different timepoints (6,12, and 18 months), there was a decreasing trend in FIM of BLW infants [median (IQR) = 3 (11), 2.5 (5), 1 (5), for 6,12, and 18 months, respectively], while it was maintained in SF infants [median (IQR) = 2 (9), 2 (15), 2 (3), respectively]; however, the results were not statistically significant ($p > 0.05$). Further examinations also showed that, according to their caregivers/feeders, 90% of BLW infants were calm during mealtimes at six months compared with 50% of SF infants. These numbers dropped for BLW by 12 months of age (50% BLW and 70% SF) and increased again by the 18th month (80% BLW and 90% SF).

4. Discussion

This study accomplished its main objective, that of creating and validating a coding system to assess eating behaviours in babies (aged 6–18 months) following either a BLW or SF method during complementary feeding. In addition, combined analysis and internal comparison were conducted within the coded videos to compare both study groups (SF vs. BLW).

Regarding inter-rater reliability, coders showed almost perfect to excellent agreement. In fact, inter-rater reliabilities were higher than 0.70, as in previous studies (Van Vliet et al., 2022). The elaboration of the BEBECS guide and the training period prior to the final coding session enabled coders to improve their coding skills.

Concerning test-retest reliability, 20% of the videos were recoded and BEBECS presented a high reproducibility (ICC >0.75) for almost all variables. Only one variable, ADiff, showed unacceptable outcomes and was thus removed from the final version of BEBECS. Indeed, this variable was also problematical during the elaboration of the coding system due to coder discrepancies and difficulties in establishing a precise definition. Therefore, its removal was justified and implies that BEBECS only contains variables that are objective and easy to identify and code.

As part of the validation, variables from BEBECS were compared against reference variables, such as intake, and mother-reported liking and calmness. Following Bonferroni adjustment $p < 0.0015$ was set for statistical significance. Total MA and MDs were significantly correlated with intake and total MA and FTMs to liking. FTM and MD show tendency ($p = 0.002$) to correlated with intake and liking, respectively. The objective variable, intake, and the subjective variable, liking (mother-reported), have been used before to assess the validity of such tools and were also found to be positively associated with MD (Nekitsing et al., 2016). As reported in the present study, total MA had a positive association with liking and intake. Similarly, this association between total MA (also named "bites") and liking, as well as intake, were observed in previous studies (McNally et al., 2016; Parkinson & Drewett, 2001). This could be interpreted as the more the baby likes a food, the more times they would approach it to their mouth or accept it, and, consequently, the greater amount would be eaten. Number of bites has been suggested as a better indicator of hunger levels than MD, as the latter can be influenced by the weaning method, usually with a lower MD in self-feeding situations (McNally et al., 2016). Parkinson and Drewett (2001) reported a significant positive correlation ($p = 0.4$) between intake and *Give* (offering count) and a negative one ($p = -0.31$) between intake and turndown (refusal and rejection behaviours). Our results showed a higher correlation of total MA with both liking and intake than with MD (Table 5). A clear positive correlation was observed in previous research between liking and intake (Maier et al., 2007). Nevertheless, in a recent review, discrepancies were found in its association with infants' weight status (Pearce et al., 2022). There was a tendency showing a negative association between both liking and intake with AFE, meaning that there would be no food left at the end of the meal if the offered food was more liked. Hetherington et al. (2016) and Nekitsing et al. (2016) used "rate of acceptance" as a behaviour indicator of "wanting". It was measured in terms of time-delay response to a spoonful offered and scored with a categorical Likert-type scale (the higher the score, the shorter the delay). Since BEBECS was also designed for BLW, where there is no food offered, this aspect could not be quantified in the same way. Instead, researchers proposed a variable that would afford equivalent information: FTM. In the present study, this variable was negatively associated with liking ($p < 0.001$) and intake ($p = 0.002$). Similar to these results, Nekitsing et al. (2016) found that a longer delay in the acceptance of a food offer was related to a lower liking. Indeed, they considered "rate of acceptance" to be a simple method for measuring "wanting" in infants. This concurs with the satiety signal of decreasing rate of sucking or eating described in previous research (Hetherington, 2020; Hodges et al., 2013). So this could suggest that FTM might also work as a "wanting" predictor, although further research should confirm this. Some other signals used by previous researchers (Klesges et al., 1983; Moding et al., 2014) to evaluate child eating behaviours are turning the head away, pulling the body away, and pushing food away; however, all of them occurred in response to an offered spoonful. Finally, a negative association between tired behaviour and mother-reported calmness was observed, but it was not statistically significant to the required $p < 0.0015$. Nonetheless, it could be a consistent result, as crying and emitting low-pitched vocalisation (e.g., for complaining) were comprised under the tired behaviour definition and are signals that a parent could interpret as the opposite of calmness. If this observation is confirmed in future studies, calmness might act as an indicator of acceptance as disturbance signs have been identified as avoidance features (Corlett, 2010; Wright et al., 2021).

Factor analysis showed a positive relation between Mouth Approach and Meal Duration and inverse between these and both Food-to-Mouth and Food-in-Mouth, similarly to what it was observed in the correlation analysis. In addition, Meal Duration was positively related to feeder help actions (FLG, FLM) and to tired behaviour. This may be due to the help needed by some babies since psychomotor skills are limited in the earliest stages of the complementary feeding (Webber et al., 2021). Moreover, feeder-led actions could be enhanced pushed by subjective parental perceptions of dietary needs (Scaglioni et al., 2008, 2018). Feeder-led Mouth Approaches as well as the refusal to them were represented together and positively in dimension three, which made sense, as these parameters are necessarily related.

Bonferroni adjustment was considered for statistical significance to identify differences between groups ($p < 0.005$). When the BEBECS tool was used to characterise and compare the SF and BLW groups in the combined analysis and internal comparison, FLM (higher for SF) and total MFP (higher for BLW) were significantly different ($p < 0.005$). These results can be explained by the fact that, during an SF meal, each MA comes from the feeder, unlike in the BLW method. Likewise, during BLW, the caregiver or feeder adjusted the amount of food offered during mealtimes as they were encouraged not to offer large portions but to be responsive to the baby's cues (Pérez-Escamilla et al., 2017). On the contrary, during SF there is usually no addition to the amount offered in the beginning. These results might suggest the tool has low discriminant capacity, if it is assumed that it would be expectable to obtain more statistically significant differences. However, there is no previous strong literature suggesting a certain number of differences between SF and BLW regarding measured eating behaviours. Indeed, it seems that feeder-led actions might be the key to differentiate these methods. In the literature, comparison of SF with BLW methods showed similar energy intakes (Morison et al., 2016) and iron status (Daniels et al., 2018), but less fussiness (Fu et al., 2018), earlier exposure to more varied and textured foods (Morison et al., 2018) and greater satiety-responsiveness for BLW infants (Brown & Lee, 2015).

It should be noted that all the ages were mixed in the analysis, as the sample size was too small to separate them. Considering this, dividing the sample by age (6, 12, and 18 months) only served as an explorative approach, to seek possible tendencies. Split by age, FTM was higher in the BLW group for the youngest children, and this might be due to gross and fine motor skills (e.g., grabbing difficulties) (Webber et al., 2021).

Nevertheless, the difference found was far from statistically significant. FIM decreased with age in the BLW group, which could be explained by the natural development of the infant's eating skills. Results might suggest that BLW infants gain autonomy with respect to feeding themselves over time (supported by Lutter et al., 2021), which is not possible for SF infants, who might begin self-feeding later [around 12 months (Fisher & Dwyer, 2016)] and thus take more time to process food in the mouth. In addition, at six months there were almost twice the calm infants on the BLW group (90%) compared to the SF group (50%), and this trend needs to be evaluated in further studies. SF infants scored slightly higher in overall score, and FTM was similar in both study groups, suggesting that there was no great difference in "wanting" between both study groups. In a recent work, Watson et al. (2018) coincided with this point, and concluded that the complementary feeding method did not impact on new food acceptance; however, they did not work with direct observations but rather with data collected via online questionnaires. Notwithstanding, observations along timepoints in the present study are based on a limited sample size and should be further verified. To date, the literature has described a higher enjoyment of food and lower food fussiness in BLW infants compared with SF infants (Komninou et al., 2019; Masztalerz-Kozubek et al., 2022; R. W. Taylor et al., 2017).

4.1. Strengths and limitations

Considering the results from this study, BEBECS will be applicable to assess baby eating behaviour during weaning, regardless of the chosen method (SF, BLW, or a mix). For instance, this coding system will be used in the *Dastatuz* study to compare the eating behaviour of babies following different weaning methods (BLW or SF), and whose mothers followed different dietary patterns (standard diet or high fruit and vegetables diet) during pregnancy and breastfeeding. The BEBECS tool was used in a naturalistic environment but it could also be applied in a controlled environment, such as in the laboratory. The tools' versatility and ease of use make it suitable for researchers to study child eating behaviour at early ages. Moreover, BEBECS could be used along with other tools, such as the FIBFECS facial expressions codification (Nekitsing et al., 2016) (reflecting liking), to increase our knowledge of associations and dissociations between "liking" and "wanting" in infants, regardless of the complementary feeding method followed.

Training coders can be time-consuming but it allows the appropriate application of the coding system. As the videos were recorded at home by the participants, some videos did not completely fulfil the instructions given and had to be discarded. Therefore, it is important to emphasise to the participants the importance of following the instructions. Moreover, sample characteristics must be considered when generalising results as the participants of the *Dastatuz* trial were mainly highly educated and highly committed.

On the other hand, the designation of the SF and BLW study groups was based on the parents' initial feeding intentions (assessed when babies were around four months of age), so it is possible that complementary feeding methods could have been mixed throughout time. Additionally, caregivers following a BLW method have been seen to turn to a more parent-led SF method when facing stress from the baby or themselves (Black & Aboud, 2011; Fernandes et al., 2023). Furthermore, considering that the main aim of the present study was to develop and validate BEBECS for SF and BLW infants, the separate analysis depending on age involved small a sample size, thus results should be interpreted with caution. Future studies should entail a larger sample size and other setting (e.g. complex meals) or ages to reach more robust conclusions regarding discriminant capacity between complementary feeding methods.

Researchers were aware that some of the time measurements might have been influenced by unassessed factors, such as external distractions. Nevertheless, these form part of the reality of mealtimes and, consequently, the limitations of a naturalistic environment.

5. Conclusion

BEBECS has the potential to be a valid tool to code infant (aged 6–18 months) mealtime videos in a naturalistic environment (i.e., at home or a familiar dining place), to assess their willingness to eat independently of the complementary feeding method applied (SF or BLW). MD and total MA were the principal indicators of a positive willingness to accept the food when available or offered, and FTM was identified as a possible satiety indicator, inversely related to liking and intake. The combined analysis and internal comparison identified some trends and few significant differences between the groups, which would be interesting to further analyse in future research.

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Ethical statement

This study followed the Helsinki Declaration (64th WMA General Assembly, Fortaleza, Brazil, October 2013), the Standards of Good Clinical Practice and the current Spanish legislation regulating medical research involving human subjects (Royal Decree 1090/2015 on clinical trials with medicines, ethic committees involved in research with medicines and the Spanish registry of clinical trials). Confidentiality was respected in accordance with the Regulation (EU) 2016/679 of the European Parliament and of the Council of the April 27, 2016 on the protection of natural persons (regarding processing of personal data and free movement of such data) and the Law 41/2002, of the 14th of November, regulating patient autonomy and rights and obligations of information and clinical documentation.

CRediT authorship contribution statement

Iratxe Urkia-Susin: Writing – review & editing, Writing – original draft, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jone Guenetxea-Gorostiza:** Writing – review & editing, Investigation, Data curation. **Diego Rada-Fernandez de Jauregui:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Leire Mazquiaran-Bergera:** Writing – review & editing, Investigation, Data curation. **Olaia Martinez:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Edurne Maiz:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107257.

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