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Factorial validation analysis of the Baby and Children's Eating Behavior Questionnaires in Samoa

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ABSTRACT

Survey instruments for assessing eating behaviors in infancy and early childhood have yet to be validated among Pacific Islanders, among whom the prevalence of pediatric obesity is steadily increasing. This study aimed to evaluate Baby Eating Behavior Questionnaire (BEBQ) and Children's Eating Behavior Questionnaire (CEBQ) factor structures against data collected from mother-infant dyads in Samoa. The BEBQ was administered across two time points: approximately 2 months (mean = 2.37 [SD = 0.34]; N = 105) and 4 months postpartum (mean = 4.22 [SD = 0.44]; N = 117). The CEBQ was administered at approximately 21 months postpartum (mean = 21.45 [SD = 1.72]; N = 113). Both the original four-factor BEBQ and seven-factor CEBQ models failed to replicate in confirmatory factor analyses. BEBQ data from 2 and 4 months demonstrated acceptable fit to a nine-item, two factor model, generated by elimination of factors with low internal reliability. A series of exploratory factor analyses on CEBQ data from 21 months postpartum ultimately revealed 16-item, three-factor structure. There was little correlation between BEBQ and CEBQ scores, suggesting either that infant feeding behaviors before and after weaning are not strongly associated, or that the BEBQ and CEBQ function better in cross-sectional, rather than longitudinal analyses. Newly derived CEBQ factors raise concerns regarding whether original CEBQ items and factors were sufficiently theoretically distinct. Study results suggest that demographic and cultural differences may impact both BEBQ and CEBQ factor structure. Further qualitative research is necessary to address these issues.

1. Introduction

There is strong evidence that early environmental cues contribute to interindividual differences in appetite traits and eating behaviors that shape susceptibility to obesity and concomitant cardiometabolic diseases (Martin-Gronert & Ozanne, 2005; McMillen et al., 2005). While infants are believed to possess an innate ability to self-regulate energy intake at birth, both genetic and early environmental factors influence the development of eating behaviors that evolve throughout childhood (Ashcroft et al., 2008; Dubois et al., 2007). For example, parental feeding practices, including excessive control and emotional use of food, may desensitize infants to physiologic hunger and satiety signals.

The most used tool for assessing eating behaviors in children is the Child Eating Behavior Questionnaire (CEBQ). Wardle et al. (2001) developed this parent-report survey in the UK, using three samples of families with children aged 2 to 9. The 35-item instrument assesses four "food approach" and four "food avoidance" dimensions of eating behavior. "Food approach" measures include *food responsiveness* (five items), *enjoyment of food* (four items), *emotional overeating* (four items), and *desire to drink* (three items). "Food avoidance" measures include *satiety responsiveness* (five items), *slowness of eating* (four items), *emotional undereating* (four items), and *food fussiness* (six items).

Abbreviations: CEBQ, Children's Eating Behavior Questionnaire; FR, food responsiveness; EF, enjoyment of food; EOE, emotional overeating; DD, desire to drink; SR, satiety responsiveness; SE, slowness of eating; EUE, emotional undereating; FF, food fussiness; GA, general appetite; CFA, confirmatory factor analysis; EFA, exploratory factor analysis; BEBQ, Baby Eating Behavior Questionnaire; BMI, body mass index; TLI, Tucker-Lewis Index; CFI, the Comparative Fit Index; RMSEA, RMSEA, and root mean square error of approximation.

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Despite its widespread use, subsequent efforts to validate CEBQ factor structure in other populations have produced mixed results. Broadly, these studies use either confirmatory factor analysis (CFA, which tests data against a hypothesized factor structure) or exploratory factor analysis (EFA, which describes underlying factor structure without specifying an *a priori* hypothesis), or both. Studies using CFA generally demonstrate data fitting reasonably well to the original factor structure, albeit requiring slight modifications (Domoff et al., 2015; Mallan et al., 2013). However, CFA revealed poor fit in both an ethnically diverse American (Sparks & Radnitz, 2012) and Singaporean (Quah et al., 2017) cohort, leading the authors to pursue subsequent exploratory analyses. The Singaporean data (Quah et al., 2017) generated a seven-factor structure, with *food responsiveness* items loading onto *enjoyment of food* and *emotional overeating*. The American data (Sparks & Radnitz, 2012) generated the most distinct model published to date, consisting of just 15 items loading onto three factors. Exploratory analyses in other populations have revealed diverse solutions. For example, while a study in Chilean children (Santos et al., 2011) reported a seven-factor solution in congruence with Wardle et al. (2001), studies in both Dutch (Sleddens et al., 2008) and Swedish (Svensson et al., 2011) children revealed a different seven-factor solution that combined *emotional overeating* and *food responsiveness*. In a Chinese cohort, Cao et al. reported a 19-item, seven-factor solution that split *food responsiveness* into two factors, while eliminating *satiety responsiveness* and *enjoyment of feeding* altogether (2012). Variation in model outcomes across these diverse populations suggests a need to optimize the CEBQ by setting, accounting for potential environmental and cultural differences that may impact the way respondents interpret survey components.

The Baby Eating Behavior Questionnaire (BEBQ) was adapted from the CEBQ for use with milk-fed infants. The four-factor survey assesses *enjoyment of food* (four items), *food responsiveness* (six items), *slowness of eating* (four items), *satiety* responsiveness (three items) and one additional item measures *general appetite* (Llewellyn et al., 2011). Only one study to date has evaluated BEBQ factor structure (Mallan et al., 2014). In this Australian cohort, the original BEBQ model demonstrated poor fit. Removal of *satiety responsiveness* resulted in a three-factor model with adequate fit.

To our knowledge, validation of neither the CEBQ nor BEBQ has been attempted in the Pacific Islands. Pacific nations are in the midst of epidemiologic transition and currently exhibit the fastest growth rates in obesity prevalence worldwide (Hawley & McGarvey, 2015). Samoa exhibits characteristics typical of many Pacific Island nations: it is a middle-income country where 80% of adults exceed body mass index (BMI) cutoffs for overweight/obesity (Hawley et al., 2014). In a recent study (Choy et al., 2017), 16.1% of Samoan children ages 2–5 years old met criteria for overweight/obesity, demonstrating the need for early intervention. Given how appetite, satiety, and self-regulation of dietary intake influence obesity development, the ability to measure these traits early in life and apply intervention appropriately may be especially useful in these high obesity risk settings.

Thus, this study sought to validate the BEBQ and CEBQ (Wardle et al., 2001) in Samoan infants through factor analysis of longitudinally collected survey data. A secondary aim was to evaluate the consistency of feeding traits through the infant-toddler transition. To our knowledge, this is the first study to assess eating behaviors longitudinally *via* combined BEBQ and CEBQ administration.

2. Methods

2.1. Participants

The participants of this study were originally recruited for a prospective birth cohort study, *Foafoaga O le Ola* (*Beginnings of Life*), consisting of 160 mother-infant dyads (Arslanian et al., 2020). Briefly, mothers were recruited at 35–40 weeks gestation at the Tupua Tamasese Meaole (TTM) Hospital in Apia, the Samoan capital city. Only mothers older than 18 years of age with singleton, uncomplicated pregnancies were eligible for the study. Following a maternal prepartum assessment, mothers and their infants participated in further assessments at four time points: immediately postpartum (mean = 6.4 days), and when infants were approximately two months, four months, and 21 months old. Of the original 160, 105 families participated in the two-month visit; 12 families were recovered for the four-month visit, resulting in the participation of 117 families, while 113 families participated in the 21-month visit. Bentler and Chou (1987) proposed that factor analysis generally requires a sample size ten times the number of estimated parameters. As do many CEBQ validation studies, the present analysis falls short of this benchmark given the large number of survey items (Cao et al., 2012; Santos et al., 2011; Sleddens et al., 2008; Sparks & Radnitz, 2012; Svensson et al., 2011; Viana et al., 2008). Importantly, Wolf et al. (2013) demonstrated that no general rule of thumb suffices for determining factor analysis sample size requirements. Nevertheless, small sample sizes remain a significant constraint which limits the interpretation of study results.

Mothers gave their written informed consent for all study procedures, and protocols were approved by both the Yale University Institutional Review Board (HIC #2000021076) and the Health Research Committee at the Samoa Ministry of Health.

2.2. Eating behavior

The BEBQ was verbally administered to mothers when infants were two and four months old. The CEBQ was administered to mothers when infants were 21 months old. Importantly, the CEBQ was originally developed among children over age 2. While slightly under this age cutoff, infants aged 21 months were analyzed using the CEBQ because the BEBQ was specifically designed for exclusively milk-feeding infants. Indeed, both Cao et al. (2012) and Mallan et al. (2013) included infants under age 2 in previous CEBQ validation studies. For both questionnaires, parents responded to each item on a 5-point Likert-type scale with word anchors, ranging from “never (1)” to “always (5).” Per the original development papers, scale scores were calculated by taking the mean of the item ratings; higher scores reflected greater exhibition of the behavior (Llewellyn et al., 2011; Wardle et al., 2001).

2.3. Statistical analysis

CFAs were performed using Lavaan (Rosseel, 2012) against the original four-factor BEBQ and eight-factor CEBQ models (Llewellyn et al., 2011; Wardle et al., 2001). Since missing data were limited to one response per timepoint (0.05% across all timepoints), full information maximum likelihood estimation was implemented for all CFAs. Factor variance was fixed to one. Model fit was evaluated using 4 fit indices: chi-squared statistic (X^2), the Tucker-Lewis Index (TLI), the Comparative Fit Index (CFI), and the root mean square error of approximation (RMSEA). Given the lack of clear cutoff criteria, acceptability of model fit was assessed by relative closeness of fit indices to ideal values: normed X^2 (X^2/df) < 2 (Schermelleh-Engel et al., 2003), RMSEA<0.06, TLI and CFI approaching 0.90 (Hu & Bentler, 1999). For all original factors, Cronbach's α coefficients were used to assess internal reliability. When CFA revealed poor model fit, optimization of factor structure was attempted by consulting item-factor loadings and modifications indices.

If model optimization failed to produce adequate fit indices, exploratory factor analysis (EFA) was conducted with FactoMineR (Lê et al., 2008), using principal axis factoring with varimax rotation, as in the original CEBQ development study (Wardle et al., 2001). For ease of comparison, most previous validation studies using exploratory analysis have reported varimax rotated results (Cao et al., 2012; Mallan et al., 2013; Quah et al., 2017; Santos et al., 2011; Sirirassamee & Hunchangsith, 2016; Sleddens et al., 2008; Svensson et al., 2011). In cases of missing data, listwise deletion was used. Scree plots of eigenvalues were consulted to determine number of factors to retain. As in Sparks and

Radnitz (2012), loading cut-off was set to >0.4. Items that cross-loaded >0.3 onto other factors were eliminated. Only factors with at least three theoretically cohesive items were retained in the final model. Newly proposed factors are presented in quotes, as opposed to the original factors, which are identified with italics.

Relationships between BEBQ and CEBQ scales over time were assessed with Pearson's or Spearman's correlations, depending on normality. All statistical analyses were conducted in RStudio v1.2.135.

3. Results

3.1. Participant characteristics

Maternal and infant characteristics are reported in Table 1. At two months postpartum, 70.5% of infants were exclusively breastfeeding, 9.5% were formula feeding, and 20% were mixed feeding (a combination of breast milk and formula). At the four-month postpartum visit, exclusive breastfeeding had declined to 59.8%; 15.4% were formula feeding, and 24.8% were mixed feeding.

3.2. BEBQ at 2 months postpartum

The *a priori* four-factor model fit data collected at 2 months postpartum poorly according to all fit statistics (X^2/df = 2.09, CFI = 0.77, TLI = 0.72, RMSEA = 0.10 (90% CI: 0.08–0.12)) (Table 2). For *food responsiveness* and *satiety responsiveness*, all factor loadings were > 0.4 and significant ($p < 0.001$). However, low factor loadings were observed across items corresponding to *enjoyment of food* and *slowness of eating*. These factors also demonstrated low internal reliability (Cronbach's α of 0.17 for *enjoyment of food* and −0.02 for *slowness of eating*). Closer inspection of items comprising the *enjoyment of food* scale revealed a significant ceiling effect, with "5 (always)" representing nearly 90% of responses. "My baby fed slowly," from the *slowness of eating* scale also exhibited a similar ceiling effect. Sequential removal of items with low factor loadings led to deidentification of the model. Implementation of modification indices also failed to improve model fit.

Given these findings, all *enjoyment of food* and *slowness of eating* items were eliminated, and factor structures of *food responsiveness* and *satiety responsiveness* were reevaluated. CFA revealed acceptable fit (X^2/df = 1.64, CFI = 0.95, TLI = 0.93, RMSEA = 0.08 (90% CI: 0.03–0.12)) to the nine-item, two factor model (Table 3). An EFA was also attempted but did not produce theoretically meaningful factors.

Table 1
Participant characteristics.

Maternal characteristics			Mean (%) (*n* = 117)
Maternal education			
Primary school incomplete			6 (5.1%)
Primary school			16 (13.6%)
High School			66 (56.4%)
College/University			27 (23.1%)
Postgraduate degree			1 (0.9%)
Missing			1 (0.9%)
Infant characteristics	**2 moths postpartum (*n* = 105)**	**4 months postpartum (n = 117)**	**21 months postpartum (*n* = 113)**
Sex (male)	55 (52.4%)	63 (53.8)	59 (52.2%)
Age (months)	2.37 (0.34)	4.22 (0.44)	21.45 (1.72)
Current feeding status			
Exclusively breastfeeding	74 (70.5%)	70 (59.8%)	–
Mixed breast−/formula feeding	21 (20.0%)	29 (24.8%)	–
Exclusively formula-feeding	10 (9.5%)	18 (15.4%)	–

Table 2
Standardized factor loadings for the *a priori* 5-factor BEBQ model.

	2 months		4 months	
	Cronbach's α	Factor loading	Cronbach's α	Factor loading
Food responsiveness	0.77		0.44	
My baby frequently wanted more milk than I provided		0.798		0.546
If allowed to, my baby would take too much milk		0.731		0.204
Even when my baby had just eaten well, s/he was happy to feed again if offered		0.655		0.130
My baby was always demanding a feed		0.571		0.219
If given the chance, my baby would always be feeding		0.446		0.048
My baby could easily take a feed within 30 min of the last one		0.739		0.599
Enjoyment of food	0.15		0.29	
My baby seemed contented while feeding		0.098		0.327
My baby loved milk		2.919		0.930
My baby became distressed while feeding[a]		0.077		−0.069
My baby enjoyed feeding time		−0.029		0.208
Satiety responsiveness	0.79		0.29	
My baby got full up easily		0.889		0.638
My baby got full before taking all the milk I think s/he should have		0.733		0.701
My baby found it difficult to manage a complete feed		0.633		−0.056
Slowness of eating	−0.02		0.11	
My baby finished feeding quickly[a]		0.466		0.094
My baby took more than 30 min to finish feeding		−0.396		0.765
My baby fed slowly		−0.033		0.357
My baby sucked more and more slowly during the course of a feed		−0.115		−0.187

[a] Items are reverse-coded.

3.3. BEBQ at 4 months postpartum

The *a priori* four-factor model also fit data collected at 4 months postpartum poorly according to all fit statistics (X^2/df = 2.527, CFI = 0.58, TLI = 0.50, RMSEA = 0.11 (90% CI: 0.09–0.12)) (Table 1). While alternative factor structures were developed through implementation of modification indices, none outperformed the two-factor model generated from the 2-moth data, which demonstrated good fit (X^2/df = 0.95, CFI = 1.00, TLI = 1.02, RMSEA = 0.00 (90% CI: 0.0–0.07)) (Table 3). Two items, "If given the chance, my baby would always be feeding" and "My baby found it difficult to manage a complete feed," did not load significantly, but were retained to allow for easier comparisons to 2-month data.

3.4. CEBQ

The *a priori* eight-factor CEBQ model demonstrated poor fit to data collected at 21 months postpartum according to all fit statistics (X^2/df = 2.08, CFI = 0.68, TLI = 0.64, RMSEA = 0.10 (90% CI: 0.09–0.11)) (Table 4). *Slowness of eating, satiety responsiveness* and *food fussiness* all demonstrated low internal reliability (Cronbach's α < 0.4) (Table 4),

Table 3
Standardized factor loadings for modified 2-factor BEBQ structure.

	Original factor	2-month loadings	4-month loadings
Food responsiveness			
My baby frequently wanted more milk than I provided	FR	0.733	0.358
If allowed to, my baby would take too much milk	FR	0.745	0.381
Even when my baby had just eaten well, s/he was happy to feed again if offered	FR	0.709	0.277
My baby was always demanding a feed	FR	0.626	0.409
If given the chance, my baby would always be feeding	FR	0.425	0.267
My baby could easily take a feed within 30 min of the last one	FR	0.731	0.386
Satiety responsiveness			
My baby got full up easily	SR	0.901	0.641
My baby got full before taking all the milk I think s/he should have	SR	0.762	0.699
My baby found it difficult to manage a complete feed	SR	0.668	−0.049

suggesting a systematic deficiency in assessing "food avoidance." Thus, items that were originally reverse-coded to measure "food avoidance" (*e.g.*, "My child finishes his/her meal quickly" from *slowness of eating*) were unreversed to allow inclusion in "food approach" scales, and all remaining items measuring *slowness of eating*, *satiety responsiveness*, and *food fussiness* were removed from subsequent analyses. As additional changes based on modification indices did not significantly improve model fit, an exploratory approach was adopted to identify a more parsimonious factor structure.

Using the remaining 25 items, principal axis factoring with varimax rotation extracted five factors with eigen values greater than one, accounting for 61.8% of variance in the data. This model was not retained because most items loaded on multiple factors. Examination of the scree plot indicated that a three-factor model may fit the data. After eliminating low- and cross-loading, 15 items loaded onto three theoretically distinct factors. One factor, which we named "dysregulated eating," contained four *food responsiveness* items, three *emotional undereating* items, and two *emotional overeating* items. The second factor, which we named "joy of eating," contained one item from *enjoyment of food*, one item that belonged to *food fussiness* when reverse-coded, and one item from *emotional undereating*. The last factor, which we named "attraction to food," contained one item from *enjoyment of food*, one item that belonged to *satiety responsiveness* when reverse-coded, and one item from *desire to drink*. This model accounted for 47.8% of variance in the reduced 15-item CEBQ (Table 5).

3.5. Infant eating behaviors across time

Table 6 shows correlation coefficients between variables from all surveys and timepoints. Significant correlations are largely confined to variables from the same survey instrument.

4. Discussion

Data collected from Samoan mother-infant dyads failed to replicate the original four-factor BEBQ and eight-factor CEBQ structures. Instead, BEBQ data fit a nine-item, two-factor structure. CEBQ data from 21 months postpartum generated a 16-item, three-factor structure. Reasons for this are likely multifactorial. Differences in cohort characteristics (age, ethnicity, and socioeconomic status) between ours and the development studies and cultural variations in eating behavior norms are likely contributing factors. Further, the poor reproducibility of BEBQ and CEBQ factor structures across studies is well-documented, suggesting underlying weaknesses in construct validity. Clark & Watson, 1995 detail considerations for ensuring construct validity in scale development, many of which were neglected when the BEBQ and CEBQ were developed.

Table 4
Standardized factor loadings for the *a priori* seven-factor CEBQ model.

	Cronbach's α	Factor loadings
Food responsiveness	0.76	
My child is always asking for food		0.273
If allowed to, my child would eat too much		0.710
Given the choice, my child would eat most of the time		0.701
Even if my child is full up, s/he finds room to eat his/her favorite food		0.768
If given the chance, my child would always have food in his/her mouth		0.714
Enjoyment of food	0.53	
My child loves food		0.530
My child is interested in food		0.352
My child looks forward to mealtimes		0.821
My child enjoys eating		0.190
Emotional overeating	0.73	
My child eats more when worried		0.642
My child eats more when annoyed		0.554
My child eats more when anxious		0.768
My child eats more when s/he has nothing else to do		0.652
Desire to drink	0.59	
My child is always asking for a drink		0.252
If given the chance, my child would drink continuously throughout the day		0.885
If given the chance, my child would always be having a drink		0.665
Slowness of eating	−0.03	
My child finishes his/her meal quickly[a]		0.629
My child eats slowly		0.026
My child takes more than 30 min to finish the meal		−0.576
My child eats more and more slowly during the course of a meal		−0.398
Emotional undereating	0.54	
My child eats less when s/he is angry		0.631
My child eats less when s/he is tired		0.525
My child eats more when s/he is happy		0.249
My child eats less when upset		0.768
Food fussiness	0.07	
My child refuses new foods at first		0.592
My child enjoys tasting new foods[a]		−0.397
My child enjoys a wide variety of foods[a]		−0.433
My child is difficult to please with meals		0.739
My child is interested in tasting food s/he hasn't tasted before[a]		−0.565
My child decides that s/he doesn't like a food, even without tasting it		0.622
Satiety responsiveness	0.39	
My child has a big appetite[a]		0.456
My child leaves food on his/her plate at the end of a meal		−0.235
My child gets full before his/her meal is finished		−0.427
My child gets full up easily		−0.363
My child cannot eat a meal if s/he has had a snack just before		−0.601

[a] Reverse-coded items.

Enjoyment of food and *slowness of eating* failed to replicate in our BEBQ data. Notably, while the original BEBQ was originally developed using retrospective data, we collected data concurrently. Differences in timing of data collection may influence the accuracy of maternal reporting. In the only other BEBQ validation study to date, Mallan et al. (2014) analyzed data collected concurrently from Australian *New Beginnings* cohort mothers at 4 months postpartum and proposed a three-factor model which dropped *satiety responsiveness* altogether. Their results raise concerns regarding the construct validity of the original "food avoidance" factors. Interestingly, Mallan et al. hypothesized that

Table 5
Reduced CEBQ: 3-factor varimax rotated solution of principal axis factor analysis.

		Original scale	Factor 1 loading	Factor 2 loading	Factor 3 loading
Factor 1: Dysregulated eating (27.3% variance)	If allowed to, my child would eat too much	FR	0.69	0.15	0.03
	Given the choice, my child would eat most of the time	FR	0.60	0.19	0.14
	Even if my child is full up, s/he finds room to eat his/her favorite food	FR	0.74	0.10	0.24
	If given the chance, my child would always have food in his/her mouth	FR	0.70	0.17	0.10
	My child eats more when annoyed	EOE	0.56	0.04	0.07
	My child eats more when anxious	EOE	0.77	0.00	0.13
	My child eats less when s/he is angry	EUE	0.60	−0.02	0.05
	My child eats less when s/he is tired	EUE	0.61	−0.10	−0.12
	My child eats less when upset	EUE	0.66	0.04	0.12
Factor 2: Joy of eating (10.3% variance)	My child enjoys eating	EF	−0.07	0.65	0.10
	My child eats more when s/he is happy	EUE	0.04	0.82	0.19
	My child enjoys tasting new food	FF	0.23	0.55	−0.01
Factor 3: Attraction to food (10.3% variance)	My child is interested in food	EF	0.03	0.20	0.87
	My child is always asking for a drink	DD	0.05	0.00	0.48
	My child has a big appetite	SR	0.26	0.13	0.61

differences in breastfeeding prevalence may underlie discrepancies in model fit. Specifically, Mallan et al. suggested that mothers of exclusively breastfeeding infants may confuse *satiety responsiveness* with feeding difficulties. Insufficiency of breastmilk may also influence whether infants exhibit food-avoidant behaviors.

The low reproducibility of BEBQ factor structure may also be linked to population-specific norms. The BEBQ was developed in a 78.1% White-British cohort (Van Jaarsveld et al., 2010), compared to our sample of 100% Samoan individuals. For example, the overwhelming majority of mothers indicated their infants always "fed slowly" at 4 months (94.0%). Yet, 46.3% of mothers reported their infants never "took more than 30 minutes to finish feeding," suggesting that maternal perceptions of slow feeding may vary by culture. Improving the clarity of BEBQ items for respondents may increase the cross-cultural reproducibility of BEBQ factor structure.

Likewise, replication failure of the original CEBQ factor structure in our cohort can be explained by demographic and cultural differences between ours and the original development samples, in addition to weak original construct validity. Again, we note that children under 2 years were not included in the original development cohort (Wardle et al., 2001). We decided to use the CEBQ for infants aged 21 months, because the BEBQ was designed for exclusively milk-feeding infants, not complementary feeding or weaned infants, for whom CEBQ items are more applicable. CEBQ factor structure was closely replicated in an Australian cohort including children under 2 years (Mallan et al., 2013). Nevertheless, there remains a possibility that our infants were too young for their mothers to properly assess eating behaviors using the CEBQ. The original factor structure also failed to replicate in a validation study conducted among Chinese infants aged 12–18 months (Cao et al., 2012). However, the authors attributed this failure primarily to cultural differences in infant feeding norms.

While Wardle et al. (2001) did not report the specific demographic characteristics of the urban and suburban families who participated in CEBQ development, age is undoubtedly not the only difference between ours and the British cohort. To what extent demographic differences impact CEBQ factor structure performance remains unclear. While most CEBQ validation studies have been conducted among predominantly Caucasian and middle-income samples (Ek et al., 2016; Sleddens et al., 2008; Svensson et al., 2011; Viana et al., 2008), data from China (Cao et al., 2012), Chile (Santos et al., 2011) and Malaysia (Loh et al., 2013) have all required re-specifications to the original CEBQ factor structure. Studies with greater within-sample diversity have produced mixed results. Only minor re-specifications were necessary for the original CEBQ factor structure to demonstrate acceptable fit to data collected from ethnically diverse samples in both Australia (Mallan et al., 2013) and the United States (Domoff et al., 2015). In contrast, an American study failed to replicate the original CEBQ structure in data collected among predominantly Hispanic and Black preschoolers, and the authors ultimately proposed a unique three-factor solution (Sparks & Radnitz, 2012).

Table 6
Correlation matrix for variables from all modified BEBQ and CEBQ models.

	FR 2mo	SR 2mo	GA 2mo	FR 4mo	SR 4mo	GA 4mo	DE 21mo	JE 21mo
SR 2mo	0.56***							
GA 2mo	0.55***	0.44***						
FR 4mo	0.37***	0.26*	0.24*					
SR 4mo	0.12*	0.26*	0.08	0.29**				
GA 4mo	0.12	0.06	0.13	0.33	0.20*			
DE 21mo	−0.06	0.04	−0.03	0.04	−0.05	0.10		
JE 21mo	0.06	0.14	0.07	−0.07	−0.05	−0.16	0.20*	
AF 21mo	0.09	0.16	−0.06	0.05	0.05	0.23*	0.49***	0.22*

Abbreviations: FR, food responsiveness; SR, satiety responsiveness; GA, general appetite; EF, enjoyment of food; FA, food avoidance; DE, dysregulated eating; JE, joy of eating; AF, attraction to food.

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Interestingly, Perez et al. found that Latinos reported higher thresholds for endorsing *emotional overeating* and lower thresholds for endorsing *food responsiveness* compared to non-Latino Whites (Perez et al., 2018). The authors also found that *food responsiveness* and *food fussiness* items either do not apply or fail to capture the lived experience of children in food insecure households.

The influence of cultural differences in eating norms and weaknesses in originally construct validity cannot be clearly distinguished in our newly derived CEBQ factors. For example, one new factor was comprised of three items which all contained the words, “enjoy” or “happy,” despite originally belonging to 3 different scales. Since connections to joy overrode other possible groupings, we named this factor, “joy of eating.” There are two non-mutually exclusive explanations for this phenomenon. First, these items may have organized together purely due to their inclusion of positive affect terms (Clark & Watson, 1995). An alternative explanation is that “joy of eating” represents a construct that characterizes eating behaviors in Samoa, where feasting continues to represent a primary means of social exchange and is central for maintaining social harmony (Hardin, 2015a, 2015b; Lameko, 2020; Ochs & Shohet, 2006).

Our second newly derived factor, “dysregulated eating,” contained items that characterize the perceived quantity and frequency of infant food consumption. We speculate that “emotional eating” is a Western concept which may be foreign to Samoans, who generally perceive feasting and eating as “cultural expressions of love and respect” that contribute to social cohesion (Lameko, 2020). Further, compared to women from Western societies, Samoan are less likely to carry internalized guilt and shame associated with overeating (Brewis et al., 1998; Wilkinson et al., 1994). Appropriate interpretation of the “dysregulated eating” scale in Samoa will require further investigation.

Like “dysregulated eating”, the final new factor, “attraction to food” characterizes the quantity and frequency of infant food consumption but generally, with more neutral language. For example, “dysregulated eating” contains the item, “If allowed to, my child would eat too much,” whereas “attraction to food” contains the item, “My child has a big appetite.” Again, whether infants with large appetites are perceived as overeating depends heavily on cultural norms. The distinction between our new factors, “joy of eating” and “attraction to food,” is also worth noting. In Western societies, enjoyment of food is commonly assumed to drive further consumption. Hardin (2015b) writes that meals in Samoa are socially evaluated based on the amount of food served, leading to eating environments characterized by frequent overabundance. In societies with strong feasting cultures, the constant expectation to overeat may lead to a greater dissociation between the enjoyment and consumption of food. Admittedly, “attraction to food” is less theoretically cohesive than “joy of eating” or “dysregulated eating,” but as previously discussed, this weakness also characterizes many factors in the original CEBQ.

This study is the first to assess infant eating behaviors longitudinally using both the BEBQ and CEBQ. BEBQ factor validation results were stable between 2 and 4 months postpartum, suggesting that eating behavior constellations remain fairly constant throughout early infancy. While “general appetite” at 4 months was correlated with “attraction to food” at 21 months, there were no other associations between BEBQ and CEBQ factors, suggesting either that little correlation exists between infant feeding behaviors before and after weaning, or that both instruments function better in cross-sectional, rather than longitudinal analyses.

Our study has several strengths. To our knowledge, ours is only the second attempt to validate BEBQ factor structure, and the first to assess eating behaviors longitudinally *via* combined BEBQ and CEBQ administration. This study also offers the first factorial validation of the BEBQ and CEBQ in a Pacific Islander population. A major weakness of our study is small sample size. Our sample size is about half that of similar validation studies, which may have negatively impacted model fit. However, a Dutch study found only moderate deviations from the original CEBQ factor structure in a validation analysis with a sample size of 135 (Sleddens et al., 2008), whereas Sparks and Radnitz (2012) found significant deviations in data collected from an ethnically diverse American cohort of 179, suggesting that sample is not the primary determinant of model fit. Since mothers were recruited during their prenatal visit at TTM hospital in Apia, our sample is also disproportionately urban compared to the general Samoan population. Our study also lacks a direct test of convergent validity (for example, analysis of sucking intensity for the BEBQ, food frequency questionnaires for the CEBQ). Note that we explicitly avoided evaluating convergent validity *via* associations between BMI and BEBQ/CEBQ scores. While several validation studies have presented positive correlations between BMI and “food approach” scores and negative correlations between BMI and “food avoidance” scores as evidence of convergent validity, these theoretical assumptions fail to account for the potential modulatory effect of food availability. Given the high prevalence of food insecurity in Samoa, any observed relationship between BMI and BEBQ/CEBQ scores can neither support nor undermine survey validity.

5. Conclusions

This study evaluated the original BEBQ and CEBQ factor structures against data collected among Samoan mother-infant dyads. Since the original factor structures demonstrated poor fit to our data, we derived new BEBQ and CEBQ models for use in Samoan populations. The scales derived in this paper are preliminary and need additional testing in larger samples. Newly derived CEBQ factors raise concerns regarding whether original CEBQ items and factors were sufficiently theoretically distinct. Further, study results suggest that demographic and cultural differences may impact both BEBQ and CEBQ factor structure. Future qualitative research is necessary to address these issues.

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CRediT authorship contribution statement

Sakura Oyama: Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing – original draft, Funding acquisition; **Kendall Arslanian**: Conceptualization, Methodology, Investigation, Writing – original draft, Funding acquisition; **Ulai Fidow**: Resources, Methodology, Writing – review and editing; **Take Naseri**: Resources, Writing – review and editing, supervision; **Christina Soti-Ulberg**: Writing – review and editing; **Nicola Hawley**: Methodology, Funding acquisition, supervision, Writing – review and editing, Resources.

Declaration of competing interest

The authors have no conflicts of interest to declare.

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