



Development of a live coding method to assess infant/toddler food acceptance

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Abstract

Validated measures predicting infant consumption of nutrient supplements or fortified foods are essential for the success of nutritional interventions to improve undernutrition. Behavioural coding of food acceptance is one promising approach, though the required time and resources are limiting. The overarching goal of the present study was to adapt a video coding (VC) protocol for use as a live coding (LC) method to assess infant food acceptance in naturalistic settings. Infants ($n = 59$; ages 7–24 months) were fed a small-quantity lipid-based nutrient supplement (SQ-LNS) mixed with a familiar food by caregivers in the State of Morelos, Mexico. Trained coders used a VC scheme to rate infant acceptance of each spoon offer using a 4-point scale. The VC scheme was subsequently adapted for use as an LC method to be used in participant homes and a video live coding (VLC) method to monitor reliability. Reliability and validity of the LC method were tested in a subsample of dyads ($n = 20$). Intraclass correlation coefficients (ICCs) indicated that the inter-rater reliability between coders using the LC method was moderate or good when compared to VC methods (ICCs = 0.75 and 0.87). Live coded acceptance scores were also moderately associated with consumption of the SQ-LNS ($\rho = 0.50$, $p = 0.03$). The LC scheme demonstrated initial reliability and validity as an assessment of infant food acceptance. Since VC is both resource and time-intensive, the LC scheme may be useful for assessing infant food acceptance in resource-limited settings.

KEYWORDS

complementary feeding, infant and child nutrition, undernutrition

1 | INTRODUCTION

A variety of nutritional interventions, including micronutrient fortification and supplementation, have been used to address concerns of undernutrition during the first 2 years of life (Bhutta et al., 2008). Regardless of the selected nutritional approach, infant consumption of the

target supplement or fortified food is essential for intervention success. If infants do not consume the supplement or fortified food at its recommended dosage, the child is unlikely to experience the intended intervention outcomes, such as improved nutritional and health status, growth, cognitive development and motor development (Das et al., 2019; Phuka et al., 2011). Given the critical role of consumption in the success

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of nutritional interventions, it is important to identify predictors of consumption, such as the degree to which the infants like or accept the target food or supplement mixture.

In supplementation trials, acceptability of the target supplement is typically assessed before and during the intervention using maternal perceptions of infant liking using Likert scales (Adu-Afarwuah et al., 2011; Phuka et al., 2011; Rothman et al., 2015). Understanding mothers' perceptions of her child's liking are important because these ratings may relate to the likelihood that she will offer the food again in the intervention trial and beyond. Additionally, mothers and caregivers have the opportunity to observe their child's responses to a variety of different foods, so their ratings may be a good indicator of how well the child likes the target food compared to other foods. Liking ratings, however, have several limitations. First, these ratings are subjective and influenced by other factors, such as social desirability, the mother's own (dis)liking for the food (Howard et al., 2012; Kaar et al., 2016) and her perceptions of the supplement as a food or medicine (Bourdier, 2009). Second, the criteria mothers use to evaluate liking may vary from person to person, making it difficult to compare liking ratings across participants within a given study (Hetherington et al., 2016). Third, evidence suggests that liking ratings, particularly when assessed using a global rating scale, may not detect subtle differences in infants' liking (Forestell & Mennella, 2007; Madrelle et al., 2017; Nekitsing et al., 2016). For these reasons, it is important to consider other measures of infant food acceptance.

In the broader food acceptance literature, behavioural coding of infants' responses during feeding is an established approach to measuring food acceptance that is more objective than parent ratings (Fries et al., 2019; Hetherington et al., 2016; Pesch & Lumeng, 2017). In this method, trained experimenters categorise infants' responses according to standard criteria, which allows for objective comparisons between participants (Pesch & Lumeng, 2017). A variety of infant behavioural responses have been captured in food acceptance coding schemes, including rejection behaviours (e.g., crying/fussing, pushing spoon away; Hetherington et al., 2016; Moding et al., 2014), positive behaviours or interest in the food (e.g., reaching towards the spoon, leaning forward; Moding et al., 2014) and facial movements indicating distaste (Forestell & Mennella, 2007, 2012; Hetherington et al., 2016; Oster, 2004). These coded infant responses have been associated with maternal liking ratings and food consumption (Forestell & Mennella, 2007; Hetherington et al., 2016; Nekitsing et al., 2016), but this coding approach is highly resource and time-intensive. For example, the coding requires a computer and often access to expensive coding software. It also requires an extended period of time to train coders to reliability standards and to complete the coding of participant videos (Chorney et al., 2015; Pesch & Lumeng, 2017).

One possible solution that retains the objectivity of experimenter ratings but reduces the time and resources required is to use a simplified coding system to capture infant food acceptance. For example, the Feeding Infants: Behaviour and Facial Expression Coding System (FIBFECS; Hetherington et al., 2016; Nekitsing et al., 2016) includes a single 4-point rating scale to capture infants' acceptance of a target food in response to each spoon offer. Scores from this simple rating scale, applied to videos of feeding interactions, have been associated

Key messages

- Current measures to assess infant food acceptance in nutritional interventions are limited.
- This study presents a live coding scheme and protocol that can be used to objectively rate infants' food acceptance in naturalistic settings.
- The coding method demonstrated initial reliability with video coding methods and was associated with infants' consumption of a target food.
- The live coding protocol may be particularly useful for assessing infant food acceptance in resource-limited settings.

with infant consumption and maternal liking ratings (Hetherington et al., 2016; Nekitsing et al., 2016). This type of simple behavioural coding could be ideal to assess infant acceptance of target fortified foods because it allows for objective comparisons across infants, but requires less time and fewer resources (e.g., coding software is not needed) compared to more intensive behavioural coding. However, for this coding scheme to be used in naturalistic settings, such as in participant homes, it would be ideal to further reduce the number of resources required, especially in contexts where cameras may not be culturally pertinent or tolerated.

Validated measures that predict infant consumption of nutrient supplements or fortified foods are critical to the success of nutritional interventions to prevent or improve undernutrition. The present study focused on infant acceptance of small-quantity lipid-based nutrient supplements (SQ-LNS) mixed with local foods. Our overarching goal was to establish initial reliability and validity for a live coding (LC) method to be used as an assessment of infant food acceptance in naturalistic settings. Such a method could be used by researchers and/or professionals and would retain the objectivity of experimenter ratings of food acceptance, while also reducing the required time and resources compared to more intensive behavioural coding methods. To address our overarching goal, the specific aims of this study were to: (1) Establish reliability between infant acceptance scores derived from the LC method compared to infant acceptance scores derived from video coding (VC) methods and (2) establish criterion validity by examining the association between infant acceptance scores derived from LC and infant consumption (in grams) of the supplement mixture during feeding.

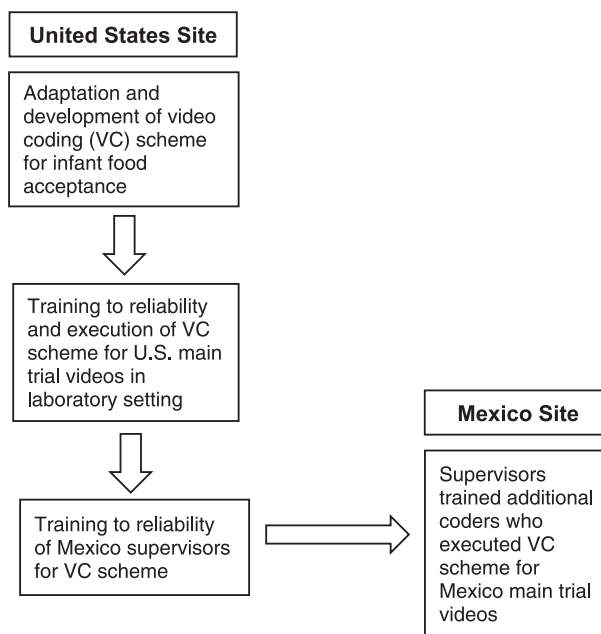
2 | METHODS

2.1 | Study design and setting

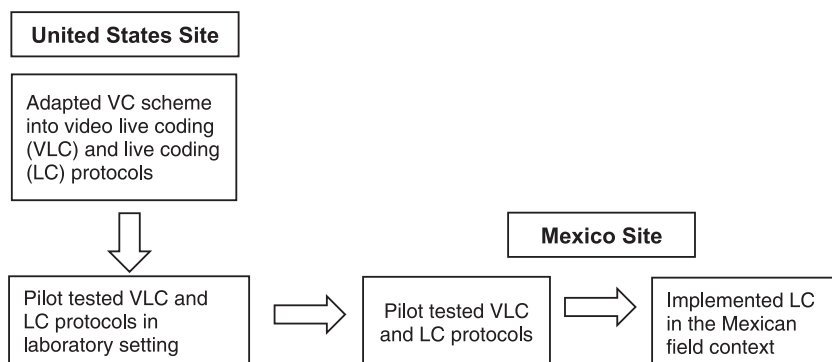
The Global Alliance for Improved Nutrition (GAIN) Palatability Study was designed to assess acceptability of two versions of SQ-LNS (sweetened and unsweetened; Nutriset), among infants and toddlers

FIGURE 1 Overview of acceptance coding scheme adaptation and implementation in the United States and Mexico

1. Video coding (VC) protocol development and implementation



2. Live coding (LC) protocol development and implementation



(7–24 months). The study protocol was implemented in two settings: a laboratory at an academic medical centre in a metropolitan area in the United States (The University of Colorado Anschutz Medical Campus, Children's Eating Laboratory) and participant homes in semi-urban communities in south-central Mexico (State of Morelos). In both settings, infants were randomly assigned to receive either the sweetened (standard) or unsweetened version of SQ-LNS. Caregivers fed the assigned supplement version (20 g) mixed with a local food of their choosing (e.g., banana and yogurt) to their child during two feeding sessions separated by a 2-week home exposure period. The decision to allow caregivers to select the local food was made to increase ecological validity since there is no universally consumed complementary food in Mexico. Study procedures and results of the main trials have been published previously (Okronipa et al., 2020).

The development of the LC scheme involved several steps which are detailed in Figure 1. The US team was responsible for adapting existing VC schemes (Hetherington et al., 2016; Mennella & Beauchamp, 1997; Nekitsing et al., 2016) for use in the present study and training coders at both sites to implement the final VC scheme.

The US team also adapted the VC protocol into both a video live coding (VLC) protocol, used as an intermediate reliability method, and an LC protocol. Both protocols were initially tested in the US laboratory setting, then subsequently pilot tested and applied to the Mexican field context by the Mexico team. To establish initial reliability and validity of the LC method to assess infant food acceptance, a subsample of caregivers ($n = 20$) from the main trial in Mexico participated in a third feeding session, after completing their participation in the main trial, where the child was offered the unassigned supplement version mixed with a local food. The session was live coded and recordings were subsequently coded using the VLC and VC protocols.

All study procedures were approved by the Institutional Review Boards (IRB) of the Colorado Multiple IRB (COMIRB), the National Institute of Public Health (Ethics Research, Biosafety and Research Committees), Mexico, and the University of California, Davis. Written informed consent was obtained from all caregivers for their own and their children's participation in the study and caregivers received an incentive for their time.

2.2 | Participants

Caregivers at the Mexico site were recruited from six health centres in four municipalities in Morelos state (Emiliano Zapata, Xochitepec, Temixco and Coatetelco). They were eligible to participate in the study if they were between 18 and 50 years of age, lived within the defined municipalities and were the primary feeder (reported to feed the child at least 50% of the time or more). Families were not eligible to participate if the child's mother or father had food allergies, the primary caregiver could not read or write, or if they were enrolled in another programme that provided nutritional supplements at the time of this study. Infants/toddlers were eligible to participate if they were between 7 and 24 months of age, born at term (>37 weeks gestation), had begun complementary feeding, had been exposed to nuts (including peanuts) and did not have any food allergies, intolerances or other reported illnesses or metabolic disorders that could affect food intake.

A total of 59 dyads completed the first two feeding sessions and the 2-week home exposure period in Mexico. Of these participants, a subsample ($n = 20$) was selected to participate in a third study visit for the LC trial. It is typically recommended that researchers assess reliability for at least 10%–25% of the study sample for behavioural coding schemes (Chorney et al., 2015). The sample size here represents approximately 33% of the original study sample, which exceeds this recommendation. Participants were selected to represent a balance of infants (7–12 months) and toddlers (13–24 months), as well as a balance of participants who were assigned the sweetened and unsweetened version of the supplement. Participants from the main trial were contacted in a randomised order until these balanced numbers were achieved.

2.3 | Data collection procedures

Before each feeding session, a field worker weighed the food-supplement mixture in a container on a food scale and recorded the weight to the nearest 0.1 g. Caregivers were then asked to sit in their usual feeding position and the research team set up two cameras. One camera was fixed (i.e., a camera on a tripod) and a second was mobile (i.e., a tablet held by a research assistant), which allowed the research assistant to make adjustments when the caregiver or child changed their position. Caregivers were asked to feed the child as they normally would and at their usual pace until they thought the child was full or when the child refused the mixture three consecutive times, whichever came first. Caregivers were also asked to use a standard spoon (approximately 16.5 cm in length) provided by the research team, when feeding, to facilitate behavioural coding described below. Infants/toddlers who were capable of self-feeding were allowed to do so. The entire feeding was recorded by the two cameras. At the end of each feeding session, the mixture was weighed again, and the amount of food consumed was calculated as the difference between the pre- and postweights.

2.3.1 | VC protocol development

The process for developing the LC protocol to assess infant/toddler food acceptance is detailed in Figure 1. Briefly, a VC scheme was adapted from existing coding schemes and used as the basis for three coding protocols used in this study: VC, video live coding (VLC: an intermediate step between VC and LC) and LC. The coding scheme used in all three coding protocols was the same and was adapted from existing coding schemes, including the FIBFECS (Hetherington et al., 2016; Nekitsing et al., 2016). The coding scheme consists of a 4-point scale (0 = refused, 1 = enforced, 2 = accepted and 3 = anticipated). Each of the four codes has objective definitions and criteria (see Table 1) to capture infants' degree of acceptance in response to each spoonful of food offered by the caregiver or child. Since this coding scheme was originally validated for use with infants during weaning (approximately 4–6 months of age; Hetherington et al., 2016), it was adapted for use with older infants and toddlers as described previously (Johnson et al., 2021).

2.3.2 | VC protocol implementation

To facilitate VC, recordings of each feeding were segmented into food offers that began when the caregiver (or child) started moving towards the child's mouth with a spoonful of food. Offers ended in two ways: (1) when the food contacted the child's tongue or (2) when the child refused the food. Only the first 10 offers were coded to ensure consistency across infants. Coding was completed using a video player (Windows Media Player, 2013) and spreadsheet software (Microsoft Excel, 2016) to record codes.

Three supervisors from the US site (Kameron J. Moding, Rebecca Boenig and Abigail E. Flesher) trained two bilingual coders (Cloe Rawlinson and Harriet Okronipa) using video examples of infant behaviours, group discussions and practice assignments completed independently. All video examples were recorded from a prior infant/toddler feeding study in the Children's Eating Laboratory. Once coders disagreed infrequently on codes (after several weeks of training), their coding abilities were tested on four videos. These videos, called gold standard videos, were selected to test each coder's ability to score the range of possible behaviours the coders may see in the larger coding trial. To accomplish this goal, supervisors selected videos that included a range of infant/toddler ages (7–24 months), all four codes from the scheme and instances of caregiver feeding, co-feeding and self-feeding. Each gold standard video was also coded by one supervisor (Rebecca Boenig) who served as the gold standard (or expert) coder for the US site. Both coders demonstrated excellent reliability on the coding scheme compared to the gold standard coder on the four videos (Intraclass correlation coefficient [ICC] for Coder 1 = 0.99; Coder 2 = 0.95), which indicates that they were producing comparable codes to the expert coder. These two coders became the gold standard coders and supervisors for the Mexico team. They trained two field worker coders from the Mexico site using the same process with child feeding videos from the US site, as well as videos from the local context in Mexico. During training of the Mexico team coders, both supervisors in the United States and Mexico reviewed

TABLE 1 Acceptance coding scheme and definition of codes^a

| Refused (0) | Caregiver-fed | Self-feeding or co-feeding |
|--|--|---|
| A score of zero (refusal) is given when the child does not open his/her mouth for an offer of food. | The caregiver offers the child a bite, but the child does not open his/her mouth for the food. Select this code if the child happens to get a taste of the food even though his/her mouth remains shut. | Select this code for all offers where the child does not taste the food. (Ultimately, if the spoon enters the mouth you will select codes 1, 2 or 3.) |
| Enforced (1) | | |
| A score of 1 (enforced) is given when the child opens his/her mouth for a bite, but only after the food/spoon touches the child's lips. | Select this code when the caregiver offers the child a bite, but the child only opens his/her mouth after the spoon has touched his/her lips. In cases where the child is resisting the offer but happens to have his/her mouth open, select this code. Also, if the child is crying and the caregiver puts the spoon into the mouth, select this code. | Select this code in cases where both the caregiver and the child have their hand on the spoon, the caregiver seems to be controlling the offer (the child may be resisting and is not willingly allowing the offer) and the spoon touches the child's lips before he/she opens the mouth. |
| Accepted (2) | | |
| A score of 2 (acceptance) is given when the food is close to the child's mouth (less than a spoon's length away) when the child opens his/her mouth to accept the bite. | Select this code when the caregiver offers the child a bite of food and the child opens his/her mouth to accept the bite when the spoon is less than a spoon's length away. In cases where the child's mouth is already open and the child easily takes the bite, select this code. | Select this code in cases where both the caregiver and the child have their hand on the spoon, the caregiver seems to be controlling the offer and the child opens their mouth when the spoon is less than a spoon's length away. |
| Anticipated (3) | | |
| A score of 3 (anticipation) is given when the child opens his/her mouth for a bite when the spoon is at a distance (a spoon's length or more) from the mouth and the food is accepted. | Select this code when the caregiver offers the child a bite and the child opens his/her mouth when the spoon is <i>at a distance</i> (a spoon's length or more) from the mouth and the child accepts the food. | Select this code if the child willingly feeds him/herself a bite of the food. In cases where the child and the caregiver both have their hand on the spoon and the <i>child seems to help direct the spoon towards their mouth</i> , select this code regardless of the spoon's distance away when the child opens his/her mouth to accept the spoon offer. |

^aThis coding scheme was adapted from prior coding schemes (Hetherington et al., 2016; Mennella & Beauchamp, 1997; Nekitsing et al., 2016).

recorded videos to ensure that the acceptance coding scheme could be applied accurately in the local context. After careful consideration, no additional modifications were made to the video acceptance coding scheme used at both sites. The two field worker coders from Mexico also demonstrated excellent training reliabilities (ICCs for both coders = 0.99) and drift reliabilities during coding of the study videos (ICCs for both coders = 0.99).

2.3.3 | LC protocol development

Once it was determined that the infant/toddler acceptance coding scheme (see Table 1) could be used in both the United States and Mexico contexts, the next step was to begin adapting the VC protocol into an LC protocol to be used in the field context. The US team developed an intermediate VLC protocol to allow coders to practice coding without the ability to pause or replay videos, as would be the case during LC. This method allowed more than one coder to practice LC without requiring them to be simultaneously present in the participants' home. The VLC

protocol included the use of a paper template, a pencil and a stopwatch application on a mobile phone, instead of a computer, to limit the amount of equipment that would be required for coding during future home visits. The coding template (see Supporting Information) included a table with columns for food offer number (#s 1–10), the selected acceptance code (0–3) and the offer start times, which were recorded from the stopwatch. After coding, the offer numbers, start times and acceptance codes were entered into Microsoft Excel.

The US gold standard coder watched and scored videos ($n = 5$) using the VLC protocol to identify aspects of protocol that needed to be modified for both the VLC and LC protocols. First, it was determined that only offer start times (rather than both start and end times) were needed on the coding template. These times were used for reliability purposes to ensure that coders were assigning codes to the same offer, and it was determined that start times alone were sufficient for this purpose. Second, the protocol needed to be adapted to account for offers that began but were interrupted or paused (e.g., there was a distraction in the room, caregiver waited for the child to finish swallowing) or when the child was blocked from the coder's view for any

reason. Interrupted and paused offers were marked with a code of 'X' and uncodable offers were marked with a code of '*' (asterisk). Interrupted, paused and uncodable offers were not counted towards the 10 total coded offers, so the coder kept recording codes until 10 offers were marked with an acceptance code.

After the minor modifications were incorporated into the VLC protocol, the same methods were practised as an LC protocol during laboratory visits ($n = 3$). The coder stood behind a one-way mirror and next to one of the two cameras that would be used for subsequent VC to ensure that both the live coder and subsequent video coders had the same view of the child (e.g., when the view of the child was blocked for the live coder, it would also be blocked in the recorded view). The LC method worked seamlessly in the laboratory in the United States and no additional adaptations were needed. The coding scheme and LC protocol were then adapted by the Mexico team for use in the field.

2.3.4 | LC scheme adaptation and implementation in the field context

The Mexico team began the process of adapting the LC scheme to the local context with support from the US team. First, the trained video coders from Mexico practised using the VLC method with approximately 30 videos recorded in the Mexican field context. Once coders felt comfortable with the coding method, the supervisor from the Mexico team and the coders tested the LC method in the field for feasibility. The live coder stood behind the fixed camera (i.e., the one on the tripod) for coding during the feeding. However, if the child and/or caregiver changed positions and the mobile camera (i.e., the tablet) captured a better view of the child, the live coder could move to stand behind the other camera. This change was noted on the coding sheet. After pilot testing, it was determined that no additional changes to the coding protocol or template were needed for LC in the field context.

To monitor accuracy of LC, the sessions were recorded using the methods described above and recordings of feeding sessions were subsequently coded using the VLC method to replicate similar coding circumstances (i.e., inability to pause or replay the feeding). The VLC was completed by a coder who was not present during the field visit to ensure that codes were not affected by prior knowledge of the feeding. The VLC coder used the same view of the child that was noted by the LC coder on the coding sheet.

2.3.5 | LC trial

Once there were few disagreements between coders using the LC and VLC methods, the LC trial began in Mexico. During data collection, two trained coders and one research assistant attended home visits. However, to limit the number of people entering the home, only two people (one trained coder and one research assistant) entered the home at one time. For each visit, one trained coder (e.g., Coder A)

served as the live coder and stood behind the main camera recording the child (i.e., the camera not blocked by the mother's hand when feeding the child). The coder assigned codes using the acceptance coding scheme for the first 10 offers of food using the LC method. Recordings of the feeding were subsequently coded by the second trained coder (e.g., Coder B) using the VLC method. Coders alternated between the LC and VLC roles until all 20 visits were coded using both methods. Additionally, to compare LC and VLC to the original VC scheme, the gold standard coder (who never used LC or VLC for the LC trial) subsequently coded all videos using VC. Finally, infant consumption of the supplement mixture during the feeding was determined by pre- and post-weighing the food container.

2.4 | Statistical analysis

First, descriptive statistics were calculated for the primary study variables (acceptance scores and consumption) and distributions of the variables were examined. Next, a Mann-Whitney *U*-test was used to compare median acceptance scores by supplement version (sweetened and unsweetened). Similarly, a *t*-test was used to compare mean consumption of the sweetened and unsweetened versions of the supplement.

To assess reliability between the infant/toddler food acceptance ratings derived from the three coding methods, ICCs were calculated. Mean acceptance scores were calculated for each participant using each coding method. Then, ICCs were calculated using two-way mixed effects, analysing for consistency in scores for single raters (see Bakeman & Quera [2011] and Koo & Li [2016] for additional details and formulas for calculating ICCs). These specifications were selected because the coders in this study were the only raters of interest and scores from single raters, as opposed to averaged scores, would be used in future applications of the coding scheme.

Spearman's rho (ρ) correlations were used to examine associations between acceptance scores derived from each coding method and with the amount consumed (in grams) of the food-supplement mixture during feeding. To further investigate validity, the correlations between acceptance scores and consumption were re-run separately by supplement version.

3 | RESULTS

3.1 | Participant characteristics

The demographic characteristics of the Mexican LC sample ($n = 20$) and the nutritional status of infants/toddlers are displayed in Table 2. The dyads from the main study who were selected to participate in the LC visit were not significantly different on any demographic characteristics examined compared to dyads who were not selected to participate in the LC visit. Children who participated in the LC sample represented a balance between infants (7–12 months; $n = 9$) and toddlers (13–24 months; $n = 11$), with an average age of

TABLE 2 Characteristics of caregivers and their children who participated in the live coding (LC) session compared to those who were not included in the LC session^a

| Variable | Included in LC n = 20 | Not included in LC n = 39 | p |
|----------------------------------|--------------------------|------------------------------|------|
| <i>Caregiver characteristics</i> | | | |
| Age (years) | 26.2 ± 7.5 | 26.7 ± 5.2 | 0.71 |
| Parity (#) | 1.7 ± 0.9 | 2.1 ± 1.1 | 0.14 |
| Relationship to child | | | 0.54 |
| Mother | 19 (95) | 41 (97) | |
| Grandmother | 1 (5) | 1 (2) | |
| Marital status | | | 0.21 |
| Married, living with partner | 2 (10) | 11 (26) | |
| Free union | 13 (65) | 26 (62) | |
| Other | 5 (25) | 5 (12) | |
| Education completed | | | 0.74 |
| Primary | 5 (25) | 9 (21) | |
| Secondary (junior sec) | 8 (40) | 20 (48) | |
| Preparatory (senior sec) | 4 (20) | 9 (21) | |
| Technical | 1 (5) | 3 (7) | |
| Bachelor's degree (tertiary) | 2 (10) | 1 (2) | |
| Occupation | | | 1.00 |
| Housewife | 17 (85) | 35 (83) | |
| Other | 3 (15) | 7 (17) | |
| <i>Child characteristics</i> | | | |
| Gender | | | 0.18 |
| Male | 6 (30) | 21 (50) | |
| Female | 14 (70) | 21 (50) | |
| Nutritional status | | | |
| Length-for-age z-score | -0.7 ± 0.9 | -0.9 ± 1.1 | 0.58 |
| Weight-for-age z-score | -0.3 ± 1.0 | -0.5 ± 1.0 | 0.44 |
| Weight-for-length z-score | 0.1 ± 1.0 | -0.1 ± 1.0 | 0.48 |

^aData are presented as mean ± SD or n (%).

16.0 ± 6.0 months. Although infants/toddlers who were capable of self-feeding were allowed to do so, the majority of infants (n = 15) were fed exclusively by their caregiver. The remaining infants (n = 5) engaged in more than one feeding method, with four infants/toddlers engaging in all three methods (caregiver feeding, cofeeding and self-feeding) at least once during the feeding. Dyads selected to participate were also balanced across participants who received the

unsweetened (n = 10) and sweetened (n = 10) versions of the SQ-LNS during the main trial. Most caregivers chose to mix the supplement with banana (n = 11 total; n = 4 assigned to the unsweetened version) or yogurt (n = 7 total; n = 4 assigned to the unsweetened version), but two caregivers offered the supplement alone (both assigned to the unsweetened version). The average duration of the feeding sessions was just under 3 min (mean = 2 min, 55 s); the shortest session lasted 51 s and the longest session lasted 5 min and 22 s.

3.2 | Descriptive statistics for primary measures

During the LC trial, the average coded acceptance score for the first 10 offers of food during this trial was 1.35 (SD = 0.58; median = 1.53). There were no significant differences in acceptance scores by supplement version (sweetened and unsweetened; $U = 50.50$, $z = 0.04$, $p = 1.00$). Infants and toddlers consumed an average of 21.3 g (range = 0–46 g; $SD = 15.1$) of the food-supplement mixture across the entire feeding. Consistent with the results of the main trial (Okronipa et al., 2020), there were no significant differences in consumption of the sweetened ($M = 26.10$, $SD = 15.57$) and unsweetened version ($M = 16.29$, $SD = 13.55$) of the supplement when mixed with a local food ($t = -1.35$, $p = 0.20$).

3.3 | Aim 1: Reliability

Based on existing recommendations (Koo & Li, 2016), the following cutoffs were used to determine the degree of acceptability for the reliability statistics reported below: (1) less than 0.5 = poor reliability; (2) 0.5–0.75 = moderate reliability; (3) 0.75–0.90 = good reliability and (4) greater than 0.90 = excellent reliability. Using these definitions, reliabilities between coders were moderate between VLC and LC (ICC = 0.75), good between LC and VC (ICC = 0.87) and excellent between VC and VLC (ICC = 0.93). Acceptance scores generated using the LC method were also significantly associated with acceptance scores generated using VC ($\rho = 0.87$, $p < 0.001$) and VLC ($\rho = 0.73$, $p < 0.001$).

3.4 | Aim 2: Validity

As expected, the amount of the supplement mixture consumed during feeding (in grams) was significantly associated with acceptance scores derived from all three coding methods: VC ($\rho = 0.50$, $p = 0.03$), VLC ($\rho = 0.48$, $p = 0.04$) and LC ($\rho = 0.50$, $p = 0.03$). When infants/toddlers who were offered the supplement alone (n = 2) were excluded from analysis, associations between acceptance scores and consumption remained significant and increased in magnitude: VC ($\rho = 0.75$, $p = 0.001$), VLC ($\rho = 0.78$, $p < 0.001$) and LC ($\rho = 0.71$, $p = 0.001$). These correlations were similar when analysed by supplement version for infants/toddlers who were offered the supplement mixed with a local food (ρ range = 0.66–0.95; $p < 0.05$).

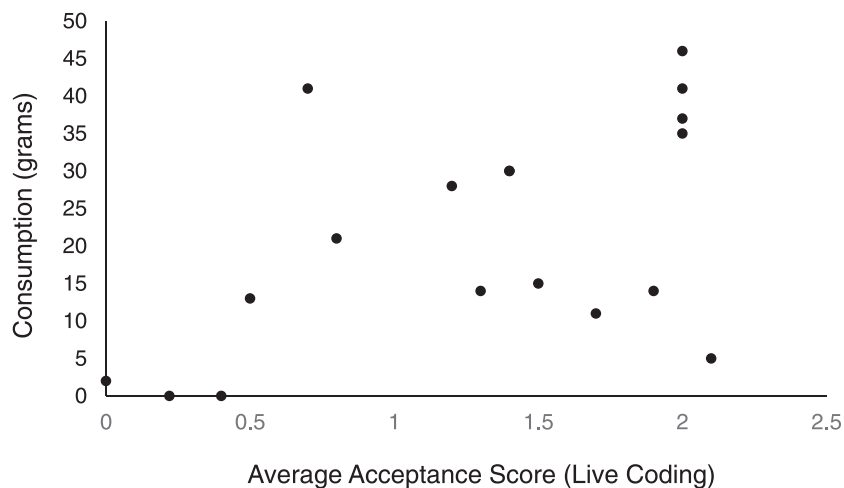


FIGURE 2 Scatter plot of consumption of the supplement by average acceptance score

See Figure 2 for a plot of the variability in consumption across the levels of food acceptance, derived from the LC protocol.

4 | DISCUSSION

The objective of the present study was to adapt a VC protocol for use as an LC method to assess infant food acceptance in naturalistic settings. Since it is essential for infants and toddlers to consume recommended amounts of fortified foods or supplements to positively impact growth and development (Phuka et al., 2011). It is important to identify possible predictors of consumption, such as infant food acceptance, before the full implementation of a randomised controlled trial. The live acceptance coding scheme used here is intended to be more objective than commonly used measures to assess food acceptance, such as maternal perceptions of infant liking (Adu-Afarwuah et al., 2011; Phuka et al., 2011; Rothman et al., 2015), while also requiring fewer resources (i.e., less time, money and personnel) compared to more intensive VC of infant behaviours. Here, coders using the LC method demonstrated good reliability with coders using the video coding methods (VC and VLC) to assess infant acceptance of SQ-LNS. Furthermore, the live coded acceptance scores were significantly correlated with consumption of the food-supplement mixture. Taken together, these results demonstrate initial reliability and validity of the LC method as an assessment of food acceptance that can be used in naturalistic settings.

In prior supplementation trials, infant food acceptance has been commonly assessed using maternal perceptions of infant liking (Adu-Afarwuah et al., 2011; Phuka et al., 2011; Rothman et al., 2015). Although such ratings are fairly easy to collect, they are limited due to their subjective nature, susceptibility to bias and the inability to compare ratings among infants due to differences in mothers' rating criteria (Hetherington et al., 2016). Conversely, experimenter-rated food acceptance scores are less susceptible to these limitations since they are based on objective, standardised criteria which allow for comparisons among infants. A prior limitation of behavioural coding is that it is resource and time-intensive (Chorney et al., 2015; Pesch &

Lumeng, 2017); however, the present study addressed these issues by using a simple 4-point rating scale to assess infant food acceptance (Hetherington et al., 2016; Johnson et al., 2021; Nekitsing et al., 2016). This coding scheme reduced the time needed to train coders compared to more intensive behavioural coding schemes and eliminated the need for expensive coding software. Furthermore, the acceptance coding scheme used as an LC method has the potential to further limit the amount of equipment required for home visits (i.e., no computers or cameras), making this method especially useful for resource-limited settings. Although further testing is needed to demonstrate that this method can be used completely live (i.e., with two people coding simultaneously for reliability without camera recordings), this study demonstrated that the LC method is comparable to VC methods.

Observations of feeding interactions could also be used before a supplementation trial to help researchers identify which cultural components (including child, caregiver and setting factors) need to be considered when implementing the main trial. This strategy could be particularly useful since nutrition effectiveness trials tend to be less effective than predicted from efficacy trials (Tumilowicz et al., 2015). One potential explanation for lower effectiveness is the lack of adaptations to fit local contexts and conditions (Manary, 2015). To address this problem, Hybrid Type 1 Trials, which primarily aim to determine the effectiveness of the intervention and secondarily aim to understand the study context before implementation, could be used (Curran et al., 2012). For example, researchers could use the live acceptance coding scheme before the trial to identify initial acceptability of a supplement and which local foods could be mixed with the supplement to produce favourable responses from infants. Low levels of acceptance could be addressed with a variety of actions (e.g., educational or motivational messages to families, changing the supplement flavour or changing the local food with which the supplement is mixed). Furthermore, after observing feeding interactions, researchers could document information about how parents typically feed their children in the local context (e.g., utensil use, caregiver feeding vs. child self-feeding) and which people in the household are involved in feeding decisions. Information gained from these

observations could be used to tailor the delivery of the intervention to the local setting, which could increase the likelihood of positive study outcomes in nutrition supplementation trials.

Using the LC scheme before an intervention trial could also help researchers gather insights on how they could tailor culturally appropriate material and messages to mothers and families in the local context. For example, if the food is not well accepted by infants initially, intervention messages could focus on the health benefits of the supplement and the importance of repeated exposure in increasing infants' acceptance of disliked foods over time (Maier et al., 2007). Similarly, if caregiver perceptions of infant liking are negative, but acceptance ratings are positive, messages could focus on which infant/toddler behavioural cues indicate acceptance, as well as the importance of offering the supplement for health reasons even if it appears to be disliked. Conversely, if the food is very well-accepted, intervention messaging could focus on the importance of offering the food exclusively to the target child to optimise their growth, rather than sharing the food with others in the household. Additional insights may be gathered by comparing coded acceptance scores to maternal liking ratings. If there is a mismatch between assessments, it may signal that the mothers' biases (e.g., perceptions of the food, perceived benefits of the supplement and the mothers' own liking) are influencing her perceptions of infant liking (Howard et al., 2012; Kaar et al., 2016) and possibly her willingness to offer the food again in the future.

In the present study, the development and implementation of the LC scheme involved a rigorous training and reliability protocol, which was then adapted to the Mexican context with careful considerations of the local setting. These strengths of the study must be considered alongside its limitations. First, the LC trial involved a small sample, which limits our ability to generalise the success of the coding scheme to larger study samples, as well as to populations with different characteristics (e.g., higher or lower levels of income and education and differences in nutritional status and food security). Second, acceptance and consumption of the target food could be due to preferred flavours of the supplement mixed with sweet local foods. However, in our prior work (Okronipa et al., 2020), there were no significant differences in consumption based on supplement version or the local food mixed with the supplement. These results were replicated here, as there were no significant differences in consumption or acceptance by supplement version. Third, maternal liking ratings were not collected during the LC trial, so we could not compare associations between these two measures of food acceptance. However, prior research has indicated that acceptance scores using the VC scheme and maternal liking ratings are correlated (Hetherington et al., 2016; Nekitsing et al., 2016). Fourth, reliability between VC and VLC was higher than when either video method was compared to the LC method. This result could indicate that the video helps enhance reliability, though additional research is needed to address this point. Finally, the coders and supervisors for the LC scheme had been previously trained on the VC scheme using the rigorous training and reliability protocol described here. For these reasons, at this time, we cannot ensure that training new coders on

the LC scheme without prior training on the VC scheme would result in as short of a training process or reliabilities as good as the ones presented here.

5 | CONCLUSION

Infant acceptance of nutrient supplements or fortified foods is important to the success of nutritional interventions with this age group. Here, we demonstrated initial reliability and validity for a behavioural coding scheme that can be used to assess infant food acceptance live in the field or through recordings of feeding interactions. The LC method may be particularly useful when resources are constrained or when cameras are not tolerated in participant homes. The acceptance coding scheme has the potential to be used before or during an intervention trial to measure infant food acceptance and results can be used to inform modifications of study foods or to tailor messaging to caregivers who participate in the study. Each of these uses, paired with careful considerations of the local context, may help improve the quality of implementation of programmes with fortified complementary foods or supplements.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

Susan L. Johnson and Anabelle Bonvecchio Arenas conceptualised the study; Susan L. Johnson, Anabelle Bonvecchio Arenas, Kameron J. Moding, Cloe Rawlinson, Harriet Okronipa and Selene Pacheco-Miranda designed the methodology; all authors were responsible for supervision and project administration; Kameron J. Moding, Cloe Rawlinson, Harriet

Okronipa, Rebecca Boenig and Abigail E. Flesher supervised the behavioural coding presented herein; Kameron J. Moding and Harriet Okronipa performed the statistical analysis; all authors participated in the interpretation of the data; Kameron J. Moding led the writing of the manuscript; all authors read, edited and approved the final manuscript.

DATA AVAILABILITY STATEMENT

Data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

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