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Research report

A pilot study comparing opaque, weighted bottles with conventional, clear bottles for infant feeding ☆

Alison K. Ventura [a,b,*], Rebecca Pollack Golen [a]

[a] Department of Nutrition Sciences, College of Nursing and Health Professions, Drexel University, 1505 Race Street, Mail Stop 1030, Philadelphia, PA 19102, USA

[b] Department of Kinesiology, College of Science and Mathematics, California Polytechnic University, One Grand Avenue, San Luis Obispo, CA 93407, USA

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ABSTRACT

It is hypothesized that the visual and weight cues afforded by bottle-feeding may lead mothers to over-feed in response to the amount of liquid in the bottle. The aim of the present pilot study was to test this hypothesis by comparing mothers' sensitivity and responsiveness to infant cues and infants' intakes when mothers use opaque, weighted bottles (that remove visual and weight cues) compared to conventional, clear bottles to feed their infants. We also tested the hypothesis that mothers' pressuring feeding style would moderate the effect of bottle type. Formula-feeding dyads ($N = 25$) visited our laboratory on two separate days. Mothers fed their infants from a clear bottle one day and an opaque, weighted bottle on the other; bottle-order was counterbalanced across the two days. Infant intake was assessed by weighing each bottle before and after the feeding. Maternal sensitivity and responsiveness to infant cues was objectively assessed using the Nursing Child Assessment Feeding Scale. Mothers were significantly more responsive to infant cues when they used opaque compared to clear bottles ($p = .04$). There was also a trend for infants to consume significantly less formula when fed from opaque compared to clear bottles ($p = .08$). Mothers' pressuring feeding style moderated the effect of bottle type on maternal responsiveness to infant cues ($p = .02$) and infant intake ($p = .03$). Specifically, mothers who reported higher levels of pressuring feeding were significantly more responsive to their infants' cues ($p = .02$) and fed their infants significantly less formula when using opaque versus clear bottles ($p = .01$); no differences were seen for mothers who reported lower levels of pressuring feeding. This study highlights a simple, yet effective intervention for improving the bottle-feeding practices of mothers who have pressuring feeding styles.

Introduction

Although the prevalence of childhood obesity has stabilized over the past decade, the number of children who are obese is still high (Ogden, Carroll, Kit, & Flegal, 2014; Skinner & Skelton, 2014) and obese children continue to incur significantly higher lifetime medical costs compared to their normal weight peers (Skinner & Skelton, 2014). A recent report from the Institute of Medicine (IOM) highlights the first years of life as a critical period for obesity prevention efforts (Institute of Medicine, 2011), in part because excessive weight gain during infancy may program children to be at higher risk for obesity and related comorbidities later in life (Ong & Loos, 2006; Sacco, de Castro, Euclydes, Souza, & Rondo, 2013). To this end, the IOM report outlines several evidence-based recommendations for promoting the development of healthy eating, activity, and sleep patterns during early childhood, one of which encourages measures to help caregivers recognize and feed in response to infant hunger and fullness cues, especially during bottle-feeding (Institute of Medicine, 2011).

Abbreviations: Clear, clear, conventional bottles; Opaque, opaque, weighted bottles; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; IOM, Institute of Medicine; WHO, World Health Organization; BMI, Body Mass Index.

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* Corresponding author.
E-mail address: akventur@calpoly.edu (A.K. Ventura).

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A focus on responsive bottle-feeding stems from evidence that caregivers may feed in response to amount of milk or formula in the bottle instead of in response to infant hunger and satiation cues (Crow, Fawcett, & Wright, 1980; Wright, Fawcett, & Crow, 1980). Thus, bottle-feeding may facilitate a pressuring feeding style, whereby a caregiver may encourage an infant to finish the bottle (Thompson et al., 2009), leading to higher risk for overfeeding, rapid weight gain, and obesity for bottle-fed infants (Crow et al., 1980). Overfeeding may occur regardless of whether breast milk or formula is in the bottle, as infants who were predominantly bottle-fed (human or non-human milk) gained more weight per month across the first year of life compared to infants fed directly from the breast (Li, Magadia, Fein, & Grummer-Strawn, 2012).

The few published interventions aimed at educating caregivers about responsive bottle-feeding practices have had limited success (Ciampa et al., 2010). For example, one intervention educated bottle-feeding mothers about recognizing infant satiation cues and discouraged them from feeding bottles containing more than 6 ounces to their 0–4-month-old infants (Kavanagh, Cohen, Heinig, & Dewey, 2008). The intervention was unsuccessful because both the intervention and control group showed no change in bottle-emptying behaviors and the intervention group showed significantly greater weight and length gain than the control group, contrary to the researchers' hypotheses (Kavanagh et al., 2008).

There are several possible explanations for the lack of success of previous interventions, one of which may be that an educational intervention is not enough to override mothers' tendencies to feed in response to visual cues afforded by the bottle. Studies of adults' eating behaviors have shown that contextual factors (e.g. the size of the serving bowl or spoon) have a strong influence the amount of food consumed (van Kleef, Shimizu, & Wansink, 2012; Wansink, van Ittersum, & Painter, 2006), and that manipulation of these factors may be more effective than education for reducing adults' portion sizes (Sobal & Wansink, 2007). Likewise, modification of contextual cues related to bottle-feeding may better facilitate mothers' abilities to respond to their infants' hunger and satiation cues. Another possible explanation is that not all bottle-feeding mothers overfeed their infants and failure to account for individual differences in mothers' habitual use of pressuring bottle-feeding practices may have hindered previous researchers' abilities to find intervention effects (Anzman-Frasca, Stifter, Paul, & Birch, 2014). Thus, mothers' habitual use of pressuring feeding practices may be an important moderator of intervention success.

The purpose of the present pilot study was to explore whether removal of contextual cues related to the amount of formula in the bottle (i.e., providing mothers with opaque and weighted bottles that remove the mothers' ability to see or feel the amount of formula in the bottle) would improve mothers' sensitivity and responsiveness to infant cues and decrease tendencies to overfeed compared to when mothers use conventional, clear bottles. Additionally, the present study explored whether mothers' level of pressuring feeding style moderates effects of bottle type on maternal sensitivity and responsiveness to infant cues and infant intake during bottle-feeding.

Methods

Participants

Mothers and their 1- to 24-week-old formula-feeding infants ($N = 25$) visited our laboratory for two days of testing; all data were collected between June 2013 and February 2014. Infants were exclusively ($n = 22$) or predominantly (>80% of feeds; $n = 3$) formula-fed. No infants had been introduced to solid foods. Infants who were preterm or had medical conditions that interfered with feeding were excluded from this study. Mothers were recruited from ads in local newspapers, Women, Infant & Children (WIC) offices, fliers posted in the greater Philadelphia area, and online sites (e.g., www.craigslist.com). Mothers were compensated a total of $95 for their participation. All study procedures were approved by the Office of Regulatory Affairs at Drexel University, and informed consent was obtained from each mother at study entry. This trial was registered at clinicaltrials.gov (NCT02111694).

Procedures

Mother–infant dyads visited our laboratory on two separate days for approximately two hours each day. Testing days were either consecutive ($n = 3$) or separated by one ($n = 21$) or two ($n = 1$) days to minimize effects of maturation on feeding behaviors. During the three days prior to and throughout the experimental period, mothers were asked to refrain from introducing additional foods or liquids to their infants. Each of the testing sessions occurred at the same time of day to control for infants' circadian rhythms and variation in intake (Matheny, Birch, & Picciano, 1990).

Anthropometrics

A trained research assistant collected weight and length/height measurements in triplicate for infants and mothers using an infant scale/infantometer (models 374 and 233; Seca, Hamburg, Germany), and adult scale/stadiometer (model 736; Seca, Hamburg, Germany), respectively. Infant weight and length measurements always occurred prior to the observed feeding session and infants were changed into a fresh diaper and light-weight "onesie" immediately prior to weighing to control for diaper weight and clothing thickness. Infant anthropometric data were normalized to z-scores using the World Health Organization (WHO) Anthro software version 3.0.1 (http://www.who.int/childgrowth/en/); age- and sex-specific percentiles were calculated based on these z-scores. Mothers' weight and height data were used to calculate Body Mass Index (BMI = weight [kg]/height [m]^2). Mothers also reported their pre-pregnancy weight, which, along with measured height, was used to calculate pre-pregnancy BMI.

Feeding observation

Mothers were instructed to feed their infants as they normally would at home using the bottles we provided. Infants were fed their typical formula during both visits. All formulas were prepared (e.g., reconstituted, if powdered) and poured into the bottles by a trained research assistant. The bottles given to mothers were glass bottles with latex, low flow nipples (Evenflo, Ohio USA). Infants were given either 118 or 236 mL bottles dependent upon the size of bottles typically used at home; each infant received the same size bottle on both testing days. During one testing day, mothers were given a bottle that had not been manipulated in any way (a conventional, clear bottle; hereafter referred to as "clear"). During the other testing day, mothers were given a bottle that had a 60-g metal plate attached to the bottom of the bottle and was covered with a silicone fitted sleeve (an opaque, weighted bottle; hereafter referred to as "opaque"). Presentation of bottle type was counterbalanced across the two days of testing. Infant intake was assessed by weighing the bottle pre- and post-feeding using a top-loading balance (model PM 15; Mettler, Greifensee, Switzerland).

Analysis of video records

Videos were recorded onto Secure Digital cards (SanDisk, California, USA), and then imported into an event recorder program (Observer XT, version 10.5; Noldus Information Technology, Heerlen, the Netherlands). Mother and infant behavior during each feeding was coded using the Nursing Child Assessment Feeding Scale (NCAFS) (Sumner & Spietz, 1994). This scale contains six subscales, four of which describe maternal attributes (Sensitivity to Cues, Response to Child's Distress, Social-Emotional Growth Fostering, and Cognitive Growth Fostering) and two of which describe infant attributes (Clarity of Cues and Responsiveness to Caregiver). The present analyses focused on the Sensitivity to Cues and Response to Child's Distress subscales because these scales primarily focus on maternal responsiveness to infant hunger and satiation cues during feeding interactions. The Sensitivity to Cues (hereafter referred to as "sensitivity") scale measures the degree to which the mother is able to understand and respond to her child's cues. This scale provides a global measure of how sensitive the mother is to the infant's needs during the feeding interaction (Sumner & Spietz, 1994). The Response to Child Distress (hereafter referred to as "responsiveness") scale assesses the mother's response to her child's potent disengagement cues, which, in the feeding interaction, are predominately hunger and fullness cues (Sumner & Spietz, 1994). This scale measures the extent to which the mother both recognizes and acts appropriately in response to the infant's potent disengagement cues. The infant Clarity of Cues scale was included as a covariate in all analysis of maternal sensitivity and responsiveness. The NCAFS has been widely used in parenting research and has well-established validity and reliability for assessing maternal sensitivity and responsiveness and infant clarity of cues in samples of low-income and minority mother–infant dyads (Sumner & Spietz, 1994). For example, previous validation studies have illustrated that lower scores on the NCAFS subscales are significantly associated with known risk factors for poor quality of parent–child interaction, such as past death of child, low maternal self-concept, and prenatal social or emotional problems (Sumner & Spietz, 1994). Further psychometric studies indicated acceptable internal consistency for the maternal sensitivity ($\alpha = 0.60$) and responsiveness ($\alpha = 0.69$), and infant clarity of cues subscales ($\alpha = 0.60$) (Sumner & Spietz, 1994). In the present sample, the Cronbach's alpha values for the subscales were as follows: maternal sensitivity ($\alpha = 0.55$) and responsiveness ($\alpha = 0.71$), and infant clarity of cues ($\alpha = 0.71$).

Video-records for both feeding observations were available for 22 dyads; for 3 dyads, video-records for one feeding observation were unavailable due to errors in the operation of the video-recorder. The 47 video-records were coded by four raters whom, prior to the start of coding, attended a three-day training on the NCAFS. All raters successfully passed the final training examination, thus were certified in the NCAFS coding system. Inter-rater reliability was determined by the common-coding of 15 videos by at least two raters. Each rater double coded five videos to determine intra-rater reliability. Inter- and intra-rater reliability were established using Pearson's correlation coefficients, and were $r = 0.86$ and $r = 0.90$, respectively. Coding occurred over a four month period and raters met regularly to resolve questions and concerns that arose during the course of coding.

Questionnaires

Upon arrival to our laboratory and prior to each feeding observation, mothers reported the time and amount of their infants' last feeding. Immediately after each feeding observation, mothers were asked two yes/no questions related to their perceptions of the bottles: (1) Did you like using the bottle we gave to you? (2) If available, would you use this type of bottle at home?

Mothers completed a demographics questionnaire, which asked questions about the mother's race, ethnicity, family income, education level, parity, and marital status. Mothers also completed the Infant Feeding Styles Questionnaire (IFSQ) (Thompson et al., 2009), which assesses maternal behaviors (e.g., control) and beliefs (e.g., concern about feeding) related to infant feeding. Questionnaire items are used to calculate 5 feeding style scores: laissez-faire (example item: "I think it is okay to prop an infant's bottle"), restrictive (example item: "It's important for the parent to decide how much an infant should eat"), pressuring (example item: "I try to get my child to eat even if s/he seems not hungry"), responsive (example item: "My child knows when s/he is hungry and needs to eat"), and indulgent (example item: "I allow my child to drink sugared drinks to keep him/her from crying or being fussy"). Higher scores indicate stronger adherence to the feeding style. We focused on the pressuring feeding style subscale as a possible moderator of the effect of bottle type on infant intake because this subscale includes items indicative of feeding in response to the amount of milk in the bottle. The IFSQ was validated in a sample of low-income, black mother–infant dyads recruited from WIC clinics (Thompson et al., 2009). All subscales were validated using confirmatory factor analysis and the pressuring feeding subscale, in particular, showed good predictive validity and reliability ($\alpha = 0.80$) (Thompson et al., 2009). In the present sample, the Cronbach's alpha for the pressuring feeding scale was $\alpha = 0.70$.

Study data were collected and managed using REDCap electronic data capture tools hosted at Drexel University (Harris et al., 2009). REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing: (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for importing data from external sources.

Data analysis and interpretation

All analyses were conducted using SAS v.9.4 (SAS Institute Inc., North Carolina, USA). Data were thoroughly cleaned and assessed for normality prior to data analysis. The first aim of the study was to assess whether (1) mothers showed greater levels of sensitivity and responsiveness to infant cues, and (2) infants consumed less formula, when fed from opaque bottles compared to clear bottles. To address this aim, we used repeated-measures Analysis of Variance (ANOVA) to assess the effect of condition (i.e., bottle type: clear vs. opaque) on mother's levels of sensitivity and responsiveness, and infant intake (mL), intake per kilogram body weight (mL/kg), feed duration (min), and feed rate (mL/min). We also assessed possible effects of testing day (first vs. second), bottle size (118 or 236 mL bottles), and order of bottle presentation (opaque, clear vs. clear, opaque) on maternal sensitivity and responsiveness and infant intake. The second aim of this study was to examine whether mothers' level of pressuring feeding style moderated the effect of bottle type on mothers' sensitivity and responsiveness and infant intake. To address this aim, pressuring feeding style was first transformed into a dichotomous variable using a median split, meaning mothers were classified as having high versus low pressuring feeding style. Pressuring feeding style was then included in the model testing the effect of bottle type on mothers' sensitivity and responsiveness, and infant intake. Moderation was determined by a significant interaction between bottle type and pressuring feeding style. In preliminary analyses, we also assessed whether other characteristics of mothers (age, parity, education level, pre-pregnancy or current weight status) or infants (age, sex, weight status) moderated the effect of bottle-type on maternal sensitivity and responsiveness or infant intake; we did not find significant interactions between bottle-type and any of these characteristics. All analyses were controlled for infant age and hunger index (amount consumed at last feeding/time since last feeding). Analyses examining maternal sensitivity and responsiveness were controlled for infants' clarity of cues from the NCAFS. Effect sizes were estimated using partial eta squared (η^2_p) or Cohen's d_z statistics (Lakens, 2013). Results are presented as means or least squared means ± standard errors. We used $p < .05$ as a criterion for statistical significance of main and interaction effects. Additionally, because this was a pilot study with a small sample size, we also noted statistical trends, defined as $p < .10$.

Results

Sample characteristics

Table 1 presents sample characteristics. With respect to infant characteristics, the sample consisted of slightly more females than males. Infants were approximately 12 weeks of age (range = 1.6–23.8 weeks) at study entry and average weight-for-length percentile score was 75.6 ± 4.9. Mothers were 26.9 ± 1.4 years of age. Average BMI at study entry was 31.7 ± 1.2 and average pre-pregnancy BMI was 30.8 ± 2.3. The majority of mothers participated in federal assistance programs (e.g. WIC; 92%) and had a family income level of less than $15,000 per year (63%). Seventy-six percent of mothers were non-Hispanic black, 12% were non-Hispanic white and 12% were Hispanic black.

Effect of bottle type on mothers' sensitivity and responsiveness

There was no effect of testing day on mothers' level of sensitivity (F[1, 19] = 1.84, p = .19, η^2_p = 0.09) or responsiveness (F[1, 19] = 1.60, p = .22, η^2_p = 0.08). There was also no effect of order of bottle presentation on maternal sensitivity (F[1, 20] = 0.00, p = .98, η^2_p = 0.00) or responsiveness (F[1, 20] = 0.40, p = .54, η^2_p = 0.02), and no effect of bottle size on maternal sensitivity (F[1, 19] = 0.76, p = .40, η^2_p = 0.04) or responsiveness (F[1, 19] = 0.98, p = .33, η^2_p = 0.05). As illustrated in Table 2, there was no overall effect of bottle-type on mothers' sensitivity (F[1, 19] = 0.47, p = .50, η^2_p = 0.02). There was, however, a significant effect of bottle-type on maternal responsiveness to infant cues during the observed feeding interactions (F[1, 19] = 4.69, p = .04; η^2_p = 0.20). Mothers showed significantly greater levels of responsiveness during the opaque compared to the clear condition.

Effect of bottle type on infant feeding behaviors

There was no effect of testing day on infant intake, F(1, 23) = 0.12, p = .73, η^2_p = 0.00. There was also no effect of order of bottle presentation (F[1, 24] = 0.05, p = .82, η^2_p = 0.00) or bottle size (F[1, 24] = 0.67, p = .42, η^2_p = 0.02) on infant intake. As illustrated in Table 2, there was a statistical trend for infants to consume significantly less formula (p = .08, η^2_p = 0.13) and formula per kg body weight (p = .08, η^2_p = 0.12) when fed from an opaque bottle compared to when fed from a clear bottle. There were no differences between the two conditions for the duration (p = .74, η^2_p = 0.00) or rate (p = .43, η^2_p = 0.02) of feeding.

Table 1
Percent (n) or Mean ± SE values for sample characteristics (N = 25).

Infant characteristics:	
Sex, % female	60.0 (15)
Age at study entry, weeks	12.3 ± 1.5
Birth weight-for-age percentile	50.3 ± 5.7
Birth weight-for-length percentile	39.1 ± 7.9
Weight-for-age percentile at study entry	50.3 ± 5.1
Weight-for-length percentile at study entry	75.6 ± 4.9
Maternal/familial characteristics:	
Age at study entry, years	26.9 ± 1.4
BMI, kg/m² at study entry	31.7 ± 1.2
Pre-pregnancy BMI	30.8 ± 2.3
Parity (% primiparous)	32.0 (9)
Federal assistance (WIC)	91.7 (22)
Family income level[a]	
<$15,000/year	62.5 (15)
$15,000 to <35,000/year	29.2 (7)
>$75,000/year	8.3 (2)
Level of education	
Did not complete high school	4.4 (1)
High school degree	56.5 (13)
Some college/vocational degree	21.7 (5)
Bachelors or graduate degree	17.4 (4)
Racial/ethnic category	
Non-Hispanic White	12.0 (3)
Non-Hispanic Black	76.0 (19)
Hispanic Black	12.0 (3)
Marital status	
Married	20.0 (5)
Living with, not married to father	44.0 (11)
In a relationship with, but not living with father	16.0 (4)
Single	20.0 (5)

Table 2
Effect of bottle type (clear vs. opaque) on maternal sensitivity and responsiveness, infant intake, feeding behaviors, and mothers' perceptions (N = 25).

	Clear[a]	Opaque[a]	F	p	η^2_p
Maternal sensitivity and responsiveness[b]					
Sensitivity[c]	11.5 (0.4)	11.2 (0.4)	0.47	.50	0.02
Responsiveness[d]	8.2 (0.4)	9.3 (0.4)	4.69	.04	0.20
Infant intake and feeding behaviors					
Intake (mL)	125.6 (7.5)	112.3 (7.1)	3.41	.08	0.13
Intake per kg body weight (mL/kg)	22.0 (1.3)	19.7 (1.4)	3.27	.08	0.12
Feed duration (min)	15.0 (1.7)	15.5 (1.9)	0.11	.74	0.00
Feed rate (mL/min)	9.6 (0.7)	8.9 (0.8)	0.66	.43	0.02

Note: Clear = Conventional, clear bottle; Opaque = Opaque, weighted bottle.
[a] Column values are Mean (SE).
[b] From the Nursing Child Assessment Satellite Training Parent–Child Interaction Feeding Scale.
[c] Sensitivity to Infant Cues Scale; possible score range = 0–16.
[d] Response to Child Distress Scale; possible score range = 0–11.

Pressuring feeding style moderated the effects of bottle type on maternal responsiveness and infant intake

Mothers' pressuring feeding style was a significant modifier of the effect of bottle type on maternal responsiveness (F[1, 18] = 5.50, p = .03, η^2_p = 0.23; Fig. 1) and infant intake (F[1, 22] = 5.07, p = .03, η^2_p = 0.19; Fig. 2), but did not moderate the effect of bottle type on maternal sensitivity (F[1,18] = 1.16, p = .30, η^2_p = 0.06). As illustrated in Fig. 1, mothers who reported higher levels of pressuring feeding were more responsive to infant cues during the opaque condition than during the clear condition (opaque: 9.3 ± 0.5 vs. clear: 7.3 ± 0.5; p < .01, d_z = 0.72). For mothers who reported lower levels of pressuring feeding, mothers' level of responsiveness did not differ between the clear and opaque conditions (opaque: 9.2 ± 0.5 vs. clear: 9.3 ± 0.6; p = .87, d_z = 0.03). Additionally, during the clear condition, mothers who reported higher levels of pressuring feeding style were significantly less responsive to infant cues compared to mothers who reported lower levels of pressuring feeding styles (p = .02, d_z = 0.64). As illustrated in Fig. 2, infants of mothers who reported higher levels of pressuring feeding consumed significantly less during the opaque condition than during the clear condition (opaque: 105.5 ± 9.5 mL vs. clear: 131.8 ± 10.1 mL; p < .01 d_z = 0.61). For infants of mothers who reported lower levels of pressuring feeding, formula intakes did not significantly differ between the opaque and clear conditions (opaque: 121.5 ± 10.8 mL vs. clear: 117.3 ± 11.5 mL; p = .69, d_z = 0.09).

Mothers' perceptions of the bottles

After the clear condition, 80% (n = 20) of mothers indicated that they liked the clear bottle and 76% (n = 19) indicated that they would use the clear bottle at home. After the opaque condition, 68% (n = 17) of mothers indicated that they liked the opaque bottle and 64% (n = 16) indicated that they would use the opaque bottle at home. There were no significant differences between the proportion of mothers who liked the bottle during clear versus opaque

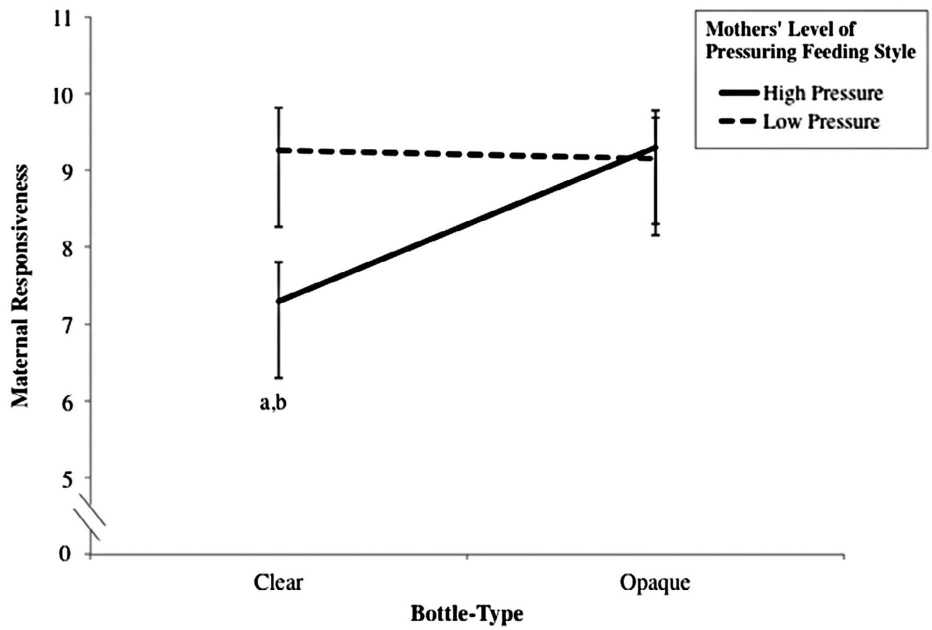

Fig. 1. Mothers' pressuring feeding style moderated the effect of bottle type on maternal responsiveness to infant cues. The interaction between bottle type and mothers' pressuring feeding style was significant ($p = .03$, $\eta^2_p = 0.23$). [a]Mothers who reported higher levels of pressuring feeding were significantly more responsive to infant cues during the opaque compared to the clear condition ($p < .01$, $d_z = 0.72$). [b]During the clear condition, mothers who reported higher levels of pressuring feeding style were significantly less responsive to infant cues compared to mothers who reported lower levels of pressuring feeding styles ($p = .02$, $d_z = 0.64$).

condition ($p = .33$) or the proportion of mothers who reported they would use the clear or opaque bottle at home ($p = .33$). Additionally, mothers with higher versus lower levels of pressuring feeding did not significantly differ for their reports of liking or willingness to use either of the bottles at home.

Discussion

Findings from the present within-subject, experimental pilot study demonstrate that removal of the visual and weight cues related to the amount of formula in the bottle can improve the

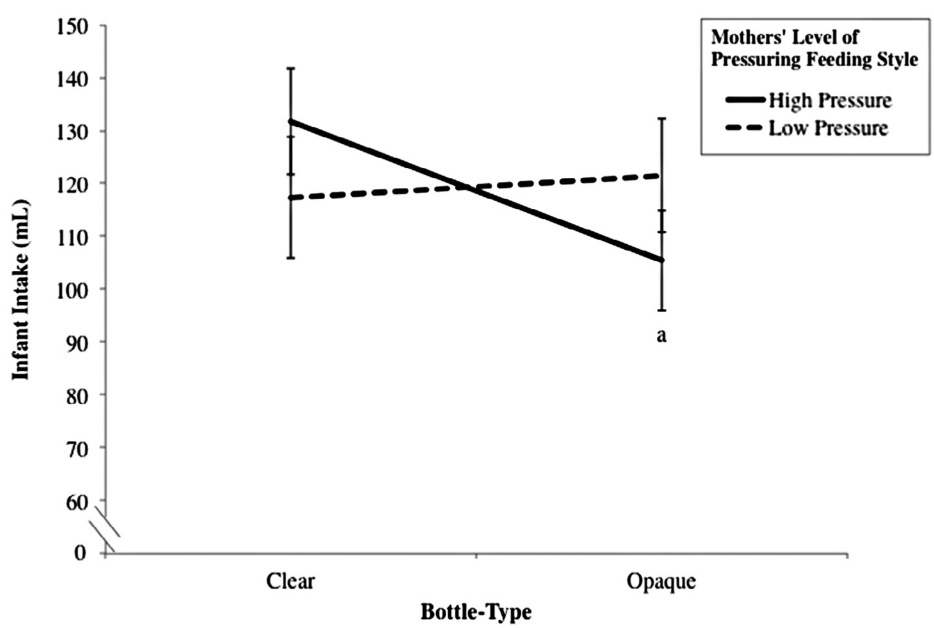

Fig. 2. Mothers' pressuring feeding style moderated the effect of bottle type on infant intake. The interaction between bottle type and mothers' pressuring feeding style was significant ($p = .03$, $\eta^2_p = 0.19$). [a]Mothers who reported higher levels of pressuring feeding fed their infants significantly less during the opaque than during the clear condition ($p = .01$, $d_z = 0.61$).

bottle-feeding practices of mothers who have pressuring feeding styles. This study also showed that the majority of mothers were as accepting of opaque, weighted bottles as they were of conventional, clear bottles, and would be willing to use these bottles at home. Thus, the present study highlights a simple, yet effective intervention that has the potential for widespread dissemination among caregivers of bottle-fed infants. Given the common usage of bottles for infant-feeding (Labiner-Wolfe, Fein, & Shealy, 2008; Li, Darling, Maurice, Barker, & Grummer-Strawn, 2004; Shealy, Scanlon, Labiner-Wolfe, Fein, & Grummer-Strawn, 2008), combined with bottle-fed infants' evidenced risk for overfeeding and rapid weight gain (Li et al., 2012), efforts to better understand mothers' feeding practices and styles related to bottle-feeding, and the extent to which these feeding practices can be improved, are necessary, and have the potential to benefit a significant portion of U.S. children during a critical period of development (Institute of Medicine, 2011).

It has been hypothesized that the inability to assess the amount of milk consumed is a benefit of breast-feeding, leading breast-feeding mothers to be more responsive to infants' hunger and fullness cues and more trusting of infants' abilities to self-regulate intake than bottle/formula-feeding mothers (DiSantis, Hodges, & Fisher, 2013; Fisher, Birch, Smiciklas-Wright, & Picciano, 2000; Taveras et al., 2004). However, the data supporting this hypothesis thus far have been observational and correlational, limiting our ability to understand causal influences of contextual cues during feeding. To our knowledge, the present study is the first to experimentally assess whether the inability to assess the amount of formula dispensed to the infant can improve mothers' responsiveness to infant cues. Our findings supported the hypothesis that contextual cues matter, as all mothers, regardless of pressuring feeding style, showed improvement in their responsiveness to infant cues when they used the opaque, weighted bottle. Studies of adults' eating behaviors have also shown that contextual cues have a strong influence on the amount of food consumed (van Kleef et al., 2012; Wansink et al., 2006), and that manipulation or removal of these cues is an effective way to increase attentiveness to feelings of hunger and fullness and reduce portion sizes (Sobal & Wansink, 2007). For example, van Kleef and colleagues illustrated that adults given larger bowls consume 71% more pasta compared to adults given smaller bowls (van Kleef et al., 2012), while Linné and colleagues demonstrated that adults consume 22% less food but report similar levels of fullness when blindfolded compared to when they consume the same meal without a blindfold (Linne, Barkeling, Rossner, & Rooth, 2002). It logically follows that the influence of contextual cues may extend to infant-feeding interactions, leading mothers to feed in response to cues such as the amount of milk or formula in the bottle rather than infant hunger and fullness cues. The present study suggests that interventions to modify contextual cues during mealtimes (Linne et al., 2002) can be translated to infant bottle-feeding interactions. However, it is important to note that the present study only assessed formula-fed infants; whether these findings would extend to breast-feeding dyads is unknown.

Although we hypothesized that the use of opaque, weighted bottles would improve both sensitivity to cues and responsiveness to infant distress (i.e., hunger and fullness cues when measured within a feeding interaction) (Sumner & Spietz, 1994) for mothers, we did not find an effect of bottle type on mothers' sensitivity. One possible explanation is related to the nature of the sensitivity scale: this scale directly measures mothers' recognition of infants' subtle and potent hunger and satiation cues (e.g., "caregiver slows the pace of feeding or pauses when child shows subtle disengagement cues"), but also provides a more general assessment of the maternal behaviors that contribute to the overall quality of the feeding interaction (e.g., "caregiver positions child so that eye-to-eye contact is possible") (Sumner & Spietz, 1994). In contrast, the responsiveness to infant distress scale solely focuses on whether and how mothers' respond to the infants' potent hunger and satiation cues during the feeding interaction (Sumner & Spietz, 1994). Thus, the sensitivity to infant cues scale may have assessed a number of behaviors that we would not expect to be influenced by bottle type. Previous research that utilized this scale reported no association between maternal sensitivity to infant cues and infant weight gain between birth and 3 months of age, but found a negative association between mothers' sensitivity to infant cues and infant weight gain across 6 and 12 months of age (Worobey, Islas Lopez, & Hoffman, 2009), suggesting mothers' sensitivity to infant cues may be associated with over-feeding in older, but not younger samples of bottle-fed infants.

The influence of opaque, weighted bottles was strongest for mothers that reported higher levels of pressuring feeding style, suggesting this intervention worked best for the mothers who needed it most. Pressuring feeding style encompasses practices that are insensitive to infant hunger and satiation cues, such as encouraging an infant to finish a bottle (Thompson et al., 2009), and is associated with higher intakes for 3- to 18-month-old infants (Thompson, Adair, & Bentley, 2013). Although mothers may adopt pressuring feeding practices in response to concerns that their infants are too small (Thompson et al., 2013), these practices may ultimately lead to excessive weight gain for infants (Worobey et al., 2009). Our findings suggest that by hindering mothers' abilities to assess the amount of formula in the bottle, we can improve the feeding practices of mothers with pressuring feeding styles by increasing their responsiveness to infant cues and decreasing the amount of formula they dispense to their infants. An important question for future research would be whether these mothers would adhere to using opaque bottles in home-based settings, and whether additional education related to recognizing and responding to infant hunger and fullness cues would augment potential benefits of using opaque weighted bottles instead of conventional, clear bottles.

This pilot study provides an important basis for future research related to the influence of contextual cues on mothers' bottle-feeding behaviors. However, this study is not without limitations, and consideration of these limitations highlights important avenues for further inquiry. Effects of bottle type were assessed across two feedings within a laboratory setting. Whether these effects would be seen over longer durations and within home-based settings is unknown. Additionally, our sample was small and limited to formula-feeding mothers who were predominately black and of lower socioeconomic status. Thus, we do not know whether our findings would generalize to mothers who feed breast-milk from a bottle, or mothers of higher socioeconomic status or different races and ethnicities. Our study also included a wide age range of infants, which may have diminished effects of bottle type on mothers' sensitivity and responsiveness and infant intake. Finally, mothers and infants did not have prior experience with our bottles and nipples, meaning infants may have behaved differently had they fed from their typical bottles and nipples. However, the within-subject design of this study allowed us to control for any effects of nipple type or flow rate, given that all infants received the same nipples on both days of testing. Despite these limitations, this study contributes to our understanding of mother's bottle-feeding behaviors and how to promote more optimal feeding interactions for bottle-feeding dyads.

Conclusions

Promotion of breast-feeding for all infants is ideal, and has been the focus of previous obesity prevention efforts. However, a significant proportion of U.S. infants are formula-fed and an increasing number of infants are being fed a combination of breast milk and formula, or significant amounts of expressed breast milk from a bottle. Given these trends, novel strategies, in addition to breast-feeding promotion, are needed to reduce obesity risk for infants whose mothers chose to bottle-feed. Findings from the present study suggest that modification of the feeding experience (i.e., the type of bottle used by the mother) may be an effective strategy for optimizing bottle-feeding interactions, especially for mothers with pressuring feeding styles. Whether this effect would sustain over longer durations and within home-based settings is an important question for future research.

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