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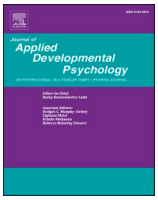

An intervention focused on maternal sensitivity enhanced mothers' verbal responsiveness to infants

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ABSTRACT

We investigated the effectiveness of an intervention aimed at enhancing maternal sensitivity on mothers' verbal responsiveness to infants. Forty-four mothers from low-income, Brazilian homes and their 3-month-old infants were randomly assigned to intervention (n = 22) and comparison (n = 22) groups. The intervention spanned eight monthly home visits, during which mothers were trained to acknowledge and respond to infants' behaviors. Maternal verbal responsiveness was assessed during dyadic free play when infants were 11 and 18 months old. We computed the probability that mothers would follow infants' behaviors with verbal unimodal (only verbal) or multimodal (simultaneous verbal and non-verbal) responsiveness. We found higher proportions of multimodal verbal responsiveness in the intervention group than in the comparison group at both ages. Infants in the intervention group displayed more communicative behaviors than did infants in the comparison group. Interventions focused on maternal sensitivity may support maternal verbal responsiveness and early language development.

Infants learn about the world through everyday interactions with caregivers. As infants vocalize, gesture, and touch objects, they communicate their interests to parents, who in turn respond within a brief time window. The "infant act—parent respond—infant act" sequence (Bornstein, Tamis-LeMonda, Hahn, & Haynes, 2008) captures the transactional, everyday interactions that support infants' language, cognitive, social, and emotional skills (Sameroff, 2009; Spinelli, Fasolo, & Mesman, 2017; Tamis-LeMonda, Bornstein, & Baumwell, 2001; Tamis-LeMonda, Bornstein, Kahana-Kalman, Baumwell, & Cyphers, 1998; Tottenham, Shapiro, Flannery, Caldera, & Sullivan, 2019). Mothers' prompt responsiveness to infant behaviors is a defining feature of the broader construct of maternal sensitivity (Ainsworth, Blehar, Waters, & Wall, 1978; Isabella, Belsky, & Von Eye, 1989).

In particular, *verbal* responsiveness refers to child-directed speech that follows and corresponds in meaning with child behaviors, such as when a mother names or describes an object of the infant's attention, imitates or expands on a child's vocalization, affirms a child's actions, and so on (Haebig, McDuffie, & Weismer, 2013; Roskam, Brassart, Loop, Mouton, & Schelstraete, 2015; Spiker, Boyce, & Boyce, 2002; Tamis-LeMonda et al., 2001). Maternal verbal responsiveness is a prominent feature of parent-infant communication in countries around the world (Bornstein, Putnick, Cote, Haynes, & Suwalsky, 2015), and relates to

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infant language development (Belsky & Fearon, 2002; Landry et al., 2012; Merz et al., 2015; Tamis-LeMonda, Kuchirko, & Song, 2014; Wade, Jenkins, Venkadasalam, Binnoon-Erez, & Ganea, 2018), especially in the first two years (Vallotton, Mastergeorge, Foster, Decker, & Ayoub, 2017). Moreover, multimodal input—the coupling of language with actions such as gestures and touch—may further enhance infant learning. Mothers who coordinated their verbal and manual contingent behaviors by handling and talking about objects of infant interest extended the duration of infants' attention toward jointly shared objects, thus enhancing opportunities for infants to learn language (Suarez-Rivera, Smith, & Yu, 2018).

Responsiveness may be especially important for children's language development in low-income households, where positive mother-infant interactions may buffer the stressors of poverty. A meta-analysis showed that associations between responsiveness and child language skills were larger in mothers from low- than middle-to-upper socioeconomic status (SES) households, lending support to a high return on investment in early interventions (Madigan et al., 2019). On average, however, mothers from low socioeconomic households display lower verbal responsiveness to their infants than do mothers from middle and high socioeconomic strata. Factors associated with poverty, including poor mental health, may impede mothers' ability to perceive and respond to infants' signals (Bernard, Nissim, Vaccaro, Harris, & Lindhiem, 2018; Parsons, Young, Rochat, Kringelbach, & Stein, 2011; Verkuijl et al., 2014), and place children at risk for delays in language and school readiness skills (Landry, Smith, Swank, & Guttentag, 2008; Tempel, Wagner, & Mcneil, 2009).

In light of SES disparities in children's language and cognitive skills, several interventions have been developed to promote mothers' general sensitivity or verbal responsiveness in low-income households. For example, the Infant Behavior Program (IBP), encouraged mothers to describe and acknowledge appropriate infant behavior, ignore inappropriate behavior, and avoid negative talk. Mothers used more positive parenting skills following the intervention and their infants were more verbal during infant-directed play compared to a comparison group of dyads (Garcia, Rodriquez, Hill, Lorenzo, & Bagner, 2019). Other interventions specifically target maternal verbal responsiveness to support infant development. For example, the Play and Learning Strategies (PALS) focused on practices such as attending to and understanding young children's communicative signals, responding promptly and contingently, following and maintaining the child's lead in play rather than redirecting the child's attention, using scaffolding strategies to support children's language development, and implementing positive behavior management strategies (Landry et al., 2017). An intervention that targeted 166 families with full-term and very low birth weight newborns showed moderate to strong effects on mothers' responsiveness and quality of stimulation that then mediated the intervention's effect on children's language (Landry et al., 2008). The evaluation of the internet-based version of PALS led to increases in parenting knowledge and observed language-supportive parenting behaviors, which positively related to infant language behaviors (Feil et al., 2020). Although IBP and PALS interventions led to improved language-supporting parenting behavior and child language skills, neither evaluated impacts on maternal verbal responsiveness specifically.

Current study

We tested whether an intervention that trained mothers to acknowledge and respond to their infants' behaviors—the Maternal Sensitivity Program (MSP)—would enhance verbal responsiveness in mother-infant dyads from low-income households in Salvador, Brazil. The Maternal Sensitivity Program (MSP) spanned eight home visits and addressed overall maternal sensitivity to infants' distress, exploratory, and prosocial behaviors. Three of the eight visits focused on joint attention, turn-taking, and contingent and rich vocabulary.

The randomized controlled trial on MSP impacts showed that mothers in the intervention group interpreted the meaning of their infants' behavior more often, asked infants more questions, and were less intrusive than were controls at the posttest. Results suggested an increase in infants' global development (Alvarenga, Cerezo, Wiese, & Piccinini, 2020). Building on the evidence of MSP's benefits for overall maternal sensitivity, we aimed to assess specific effects of the intervention that may impact infant language development. Thus, we developed procedures to evaluate mothers' contingent talk in response to infants' ongoing behaviors and coordination of their verbal and manual contingent responses (multimodal responsiveness), factors shown to enhance infants' language learning.

We examined whether MSP enhanced mothers' unimodal and multimodal verbal responsiveness (i.e., verbal replies without accompanying gesture or touch, and verbal replies accompanied by gesture and touch). Additionally, we assessed mothers' "redirection"—behaviors in which mothers directed their infants to an object or activity that differed from the infant's current focus, as a contrast to responsiveness. Dyads were seen twice, one month and again eight months after completing the intervention, when infants were 11 and 18 months old.

We asked whether: (1) mothers in the intervention group would display more frequent unimodal and multimodal verbal responsiveness following their infants' behaviors compared to mothers in the comparison group; and (2) whether observed group differences would be sustained across the two follow-up periods, or instead fade over time. We hypothesized that maternal unimodal and multimodal verbal responsiveness would be greater for intervention than comparison group mothers; that redirection would be greater for comparison than intervention group mothers; and that intervention effects would persist over time.

Method

Participants

Forty-four mother-infant dyads were recruited from health care centers in two low-income communities in Salvador, Brazil, in 2013–2015. Eligible pregnant women and mothers of infants under three months of age were tracked by family records available at two Family Health Units. Participants were recruited between the seventh month of pregnancy and the second month after birth and were randomly assigned to the intervention or comparison group (22 in each). Mothers with severe chronic health conditions and mothers under 19 years of age were ineligible for participation. The infants, all born full-term, had no physical malformations or chronic health problems. Fig. 1 describes sample retention along with enrollment and different phases of data collection, intervention, and data analysis.

Somewhat more infants in both groups were male than female (intervention: 59%; comparison: 64%). Mother's age averaged 27.2 years ($SD = 5.83$) in the intervention group and 28.1 ($SD = 5.81$) in the comparison group. Mothers' average years of schooling was 10.6 ($SD = 2.59$) in the intervention group and 10.5 ($SD = 3.21$) in the comparison group. Demographic data did not differ between intervention and comparison groups (see Table 1).

Fewer than 20% of mothers reported having minor physical health problems such as hypertension or hypothyroidism (intervention: 18.2%; comparison: 14.3%). Mothers' average scores on minor psychiatric disorders fell below the cutoff, indicating no risk for mental disorders in intervention 5.18 ($SD = 4.40$) and comparison group mothers 5.52 ($SD = 3.38$). Chi-square analyses and t-tests indicated no differences between intervention and comparison groups on physical health or minor psychiatric disorders ($X^2 = 0.12$; $p = .52$; $df = 1$; $t = 0.28$; $p = .77$; $df = 41$, respectively). Further analysis considering attrition at 18 months (see Fig. 1) revealed no significant differences in demographics and maternal physical or mental health between the groups.

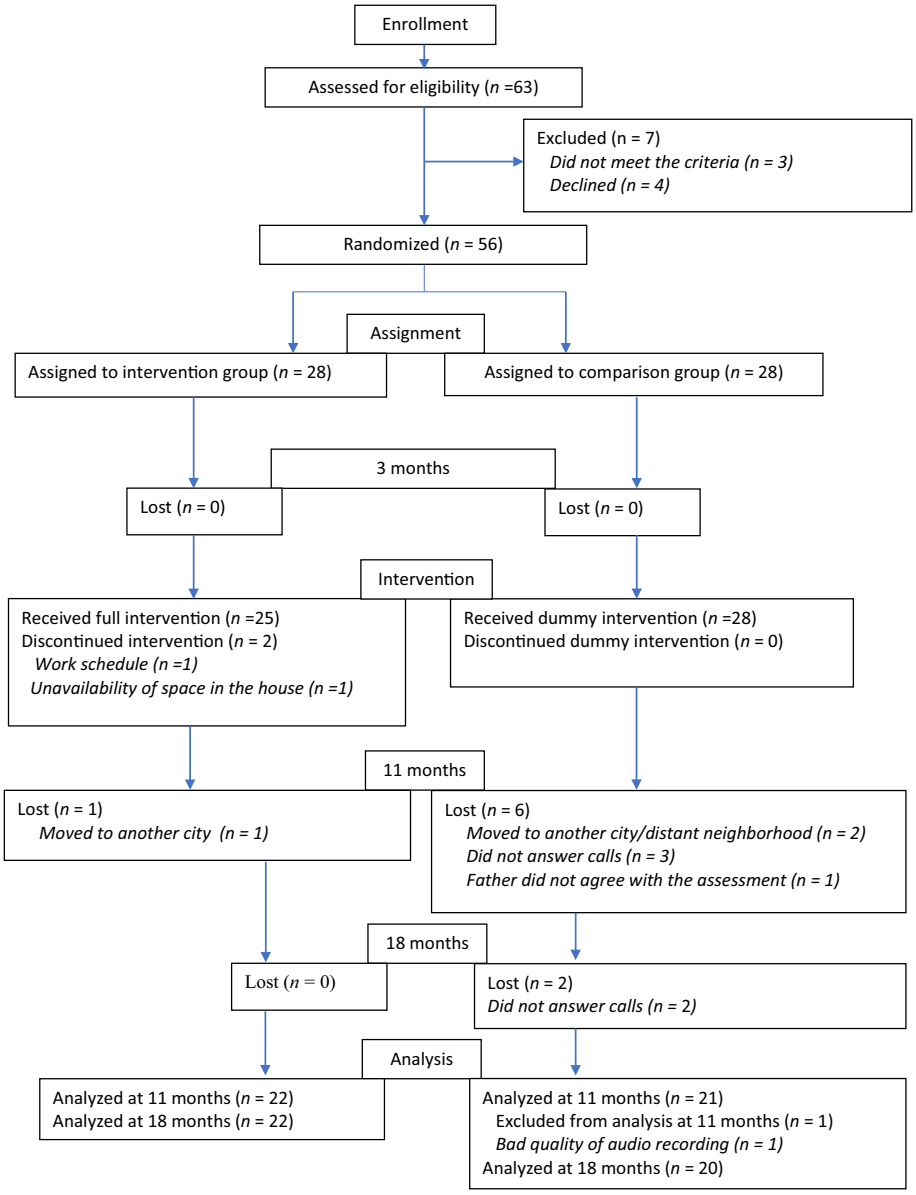

Fig. 1. Flow diagram of sample retention in the study.

Procedures

Researchers explained the study to mothers, who then signed informed consent for the research during recruitment.[7] At infants' third month, dyads from both groups received a home visit involving questionnaires and videorecording of mother-infant interaction. Mothers provided demographic and reported on their mental health using the Self-Reporting Questionnaire of Minor Psychiatric Disorders (SRQ-20). Upon completion of questionnaires, dyads were video-recorded during 10 min of free-play with a standard set of toys (rattle, rubber puppy, and small rubber ball). From video recordings, researchers coded the frequencies of infant behavior (smiles, vocalizations, and cries), maternal contingent sensitive responses (talking, smiling, holding/rocking, touching/stimulation following infant behaviors), and maternal intrusiveness (interrupting infant behavior, limiting infant movement or access to objects, causing excessive tactile, auditory, or visual stimulation) to establish the equivalence of the two groups before program implementation (Alvarenga et al., 2020). Interrater reliability was established based on 10 videos and reached 0.77 for the maternal behaviors and 0.68 for the child behaviors (Cohen's Kappa). Intervention and comparison groups did not differ in infant behavior and maternal overall sensitivity before program implementation (See Multimedia Component 1).

After the 3-month assessment, dyads in the intervention group received the Maternal Sensitivity Program. Dyads in the comparison group received printed material on child development by mail. When infants were 11 months of age (Time 1), both groups were visited in their home and video-recorded during a 10-min free-play session with a new set of toys (multi-colored plastic cups and a small toy that played a song when activated). Mothers completed the SRQ-20 questionnaire to assess maternal mental health.

A final follow-up home visit was conducted when children reached 18 months of age (Time 2). Dyads were video-recorded during a 10-min free-play session using a new set of toys (a turtle-shaped toy with docking geometric pieces that fit together and a medium-sized ball).

[7] This study was registered and approved by the Brazilian National Commission for Research Ethics (CEP-CONEP/process number: 15240213.0.0000.5577).

Table 1
Socio-demographic Characteristics.

Variable	Intervention	Comparison	t or χ^2	p
Infant's gender				
Male	13 (59%)	14 (64%)	$\chi^2 = 0.96$	0.75
Female	9 (41%)	8 (36%)		
Mother's age				
Mean	27.2	28.1	$t(42) = 0.54$	0.59
SD	5.83	5.81		
Mother's Education (years)				
Mean	10.6	10.5	$t(42) = -0.15$	0.87
SD	2.59	3.21		
Other children				
No	10 (45%)	12 (55%)	$\chi^2 = 0.36$	0.54
Yes	12 (55%)	10 (45%)		
Per capita income (reais)[a]				
Mean	298	230	$t(42) = -0.11$	0.91
SD	135	129		
Cohabitation with the father				
Yes	4 (18%)	5 (23%)	$\chi^2 = 0.14$	0.50
No	18 (81.8%)	17 (77%)		

Note. $n = 22$ for intervention and comparison groups.
[a] 1 US$ = 2.34 BRL (Brazilian reais in September 2013). Brazilian minimum wage in 2013 was R$ 678,00 (Brazilian reais). Thus, the sample's average monthly per capita income was about half the minimum wage. This sample is comparable to US families whose income is well below the poverty line.

Videos were subsequently coded for maternal verbal responsiveness. All questionnaires and standardized measures were collected via one-on-one interviews in which researchers read items to mothers and documented their responses. All intervention and data collection procedures were implemented in Portuguese, the mothers' native language.

Intervention – The Maternal Sensitivity Program (MSP)

The Maternal Sensitivity Program (Alvarenga et al., 2020) is a short intervention based on video feedback and live modeling procedures. The aim of the intervention is to increase maternal contingent responsiveness in areas relevant to infant socioemotional and cognitive development. For the socioemotional dimension, the intervention sought to improve mothers' contingent and appropriate responses to infants' social initiatives and distress. For the cognitive dimension, the program focused on promoting mothers' contingent and appropriate responses to infants' exploratory behaviors, encouraging mothers to use lexically diverse vocabulary describing the events and objects in the foci of infants' attention.

This intervention was created to promote positive development in infants living in impoverished communities in Brazil. In Brazil, 23.1 million children and adolescents between 0 and 14 years old live in poverty and have poor access to mental health care (IBGE, 2016). Researchers and professionals who serve this population face many challenges, including a lack of funding, poor infrastructure, and few trained specialists available to provide services (Pedersen et al., 2019). MSP was designed to address these challenges by providing low-cost video feedback and live modeling strategies that can be delivered in the home by well-trained undergraduate Psychology students. Such program components are critical to successful parenting interventions in low- and middle-income countries (Britto, Ponguta, Reyes, & Karnati, 2015; Eshel, Daelmans, De Mello, & Martines, 2006; Pedersen et al., 2019). To support model fidelity, the intervention includes an easy-to-follow manual with a coding system for sequentially analyzing mother-infant interaction during live visits and from video-recorded data (the Coding of Early Maternal and Child Interaction/CITMI-R; Trenado, Cerezo, Sierra-García, & Pons-Salvador, 2020).

The intervention was delivered over the span of eight home visits, from the infant's third to tenth month of age. Home visits lasted 1 h and adhered to the following script: video recording (the mother and the infant were filmed for 5 min while playing); video coding (the interventionist left the mother alone for about 15 min to examine the recording using the CITMI-R coding scheme); video feedback (the interventionist showed the mother four to six scenes from the video and discussed the targeted behaviors with the mother for about 20 min); live modeling (the interventionist interacted with the infant, modeling to the mother sensitive responses to infants' behaviors and subsequently encouraged her to participate in the interaction for about 5 min); closure (10-min conversation during which the interventionist emphasized the mother's progress in displaying sensitive responses to her infant and encouraged her to continue practicing the learned skills). The main emphasis of the home visit was to (a) reinforce each mother's sensitive behaviors and positive reactions to infants; and (b) flag insensitive behaviors. Each month the visit addressed a specific sensitivity-related topic on ways that mothers could meet the needs of their infants and respond to infants' new behaviors and skills. The eight topics focused on infant's interactive potential, social contingency, intrusiveness, turn-taking, joint attention, emotion socialization, rich and contingent vocabulary use, and locomotion and expansion of the infant's world. Although maternal verbal responsiveness was not the focus of the intervention, visits that targeted turn-taking, joint attention, and rich and contingent vocabulary included content on maternal verbal responsiveness. Interventionists were two undergraduate Psychology students who received extensive training (20 h of theoretical discussions followed by 20 h of mother-child interaction video coding with CITMI-R). Prior to starting intervention implementation with participants, interventionists performed one complete intervention, which was video recorded and discussed under supervision. Interventionists attended weekly two-hour supervision sessions with the first author spanning the beginning of the home visits to the completion of intervention for the 22 dyads.

Comparison group

From the infant's third to the tenth month, mothers in the comparison group received magnets that displayed the primary behavioral skills they should expect to observe in their infants, which were mailed on a monthly basis. Each magnet contained four pictures of infants displaying different behaviors and a short statement below the picture. For example, the third-month magnet showed a picture of an infant looking at his/her hands, followed by the caption “I like to look at my hands and play with them”.

Measures

Maternal mental health

We assessed maternal mental health with the Self-Reporting Questionnaire of Minor Psychiatric Disorders (SRQ-20; Harding et al., 1980). The SRQ-20 is a yes/no 20-item screening scale of symptoms of common mental disorders. Scores above 7 indicate possible mental health disorders. The Brazilian version of the scale used in this study showed strong internal consistency (Cronbach's alpha = 0.86; Gonçalves, Stein, & Kapczinski, 2008).

Observational measures and coding procedures

Working with video recording from the 11- and 18-month visits, two observers coded the four initial minutes of each free-play session for infants' communicative and exploratory behaviors and mothers' responses. We made the decision to analyze 4 min of the interaction for two reasons. First, when we analyzed the full 10-min sessions, we found that the number of behaviors mothers and infants displayed in the first half of the session was similar to the number displayed in the second half. Second, in many of the recordings, mothers were interrupted by relatives, siblings, and neighbors after the first few minutes of interaction, precluding our ability to capture the full 10 min.

Our intent was to capture sequences of infant and mother behavior, what infants did, and how their mothers reacted. Our procedures reflect

the resources available to us. We used an interval-sampling strategy, dividing the 4 min into sixty 4-s intervals, and pencil-and-paper recording. During the first 2 s of each interval, we asked coders to note whether the infant displayed communicative behaviors (vocalizing, gesturing, smiling, or crying), or exploratory behaviors (touching, handling, or trying to reach toys, body, or clothes), or both. (Initially we had contemplated a third code, passive, but it wasn't needed; one of the two codes always applied). Almost all intervals were coded for exploratory behavior; fewer intervals were coded for communicative behavior. We then asked coders to note the mother's reaction to each infant communicative and each infant exploratory behavior within the 4-s window. This approach retained the temporal ordering of infant and mother behaviors. Specifically, maternal behaviors that followed infant behaviors were coded as verbal or nonverbal responsiveness, verbal or nonverbal redirection, or absence of response when mothers simply observed infants while they played. Verbal and nonverbal were not mutually exclusive; both could be coded.

Maternal *verbal responsiveness* captured statements that keyed into infant's preceding behavior and referred to the object of the infant's attention or activity. Verbal responsiveness included mothers' interpretations of the infant's wishes, needs or intentions; acknowledgment, support, or encouragement of infant behavior; or naming and referring to an attribute or specific feature of the object or activity.

Non-verbal responsiveness referred to maternal physical actions directed to the object of the infant's attention or activity, such as pointing, touching, manipulating, or handling an object that the infant was trying to reach. This code also included maternal behaviors that provided physical scaffolding to help the infant move toward the object, such as when a mother held the infant by the hand to support standing or moving to the object of attention.

Maternal *verbal redirection* pertained to verbal statements that were unrelated to the infant's preceding behavior, object of attention, or activity. Verbal redirection included a mother naming, asking questions about, verbally directing the baby's attention to, or describing attributes of toys/objects outside the infant's focus of attention.

Non-verbal redirection was characterized by maternal physical actions that were unrelated to the infant's preceding object of attention or activity, such as actions that restricted or impeded the infant's contact with the object of attention. Non-verbal redirection included removing an object from the infant's hands or visual field or placing a toy in the baby's visual field or hand while the infant engaged with a different object.

In a second step, we recoded the initial mother codes into five mutually exclusive and exhaustive codes: (a) *unimodal verbal responsiveness*—nonverbal not also coded; (b) *multimodal verbal responsiveness*—both verbal and nonverbal responsiveness coded); (c) *unimodal verbal redirection*—nonverbal not also coded; (d) *multimodal verbal redirection*—both verbal and nonverbal redirection coded); and (e) *other*, which grouped codes that were not the focus of our analyses—mothers' non-verbal only responsiveness, non-verbal only redirection, and absence of response.

Observer agreement

Two female Psychology Undergraduate students, 22 and 23 years old, coded all videos. Training consisted of undergraduate assistants spending 10 h reading and discussing theoretical material on verbal responsiveness and reviewing the coding manual with the first author. Observers then took a simple test that assessed their ability to discern differences between codes. Next, the observers together coded two sample videos (not from the current study), stopping after coding each 4-s interval to check the registered codes and discuss disagreements with the first author. Finally, we calculated agreement based on 10 videos coded by the two observers. The value of kappa was 0.74 for infant behavior codes and 0.73 for maternal behavior codes. To produce kappas of this magnitude for these codes, given their probabilities and distributions, the estimated accuracy of the observers would be 94% for the infant codes and 88% for the mother codes (computed by the KappaAcc program, Bakeman, 2018). Half of the remaining videos were then coded by each observer.

Data analysis

Our procedures resulted in pairs of infant-mother codes, the first an infant behavior and the second the mother's reaction. These pairs were processed by the General Sequential Querier (GSEQ; Bakeman & Quera, 2011). Statistics were computed for each dyad at each time. First, we produced simple probabilities for infant behavior. Expressed as percentages (that necessarily sum to 100%), these were the portion of dyad pairs that began with either an infant communicative or an infant exploratory behavior. Initially we had considered computing conditional probabilities for the mothers' following behavior (the five categories listed earlier), separately for infant communicative and infant exploratory behavior. We decided instead to compute simple probabilities for the five mutually exclusive and exhaustive maternal reactions, collapsed across infant's preceding behavior, for two reasons. First, for several infants, few or no code pairs begin with an infant communicative behavior. If we regarded their conditional probabilities as missing—a conditional probability cannot be computed if the given behavior does not occur—we would reduce the number of dyads available for analysis substantially (two or fewer instances of infant communicative behavior were coded for 11 infants at Time 1 and 5 infants at Time 2). Second, we aimed to characterize how mothers responded to their infant's behavior, whether communicative or exploratory; thus simple probabilities made conceptual sense.

The simple infant and maternal probabilities (expressed as percentages) were analyzed with a linear mixed-effect model for group with time as the repeated measure (IBM SPSS 27). We assessed effect sizes with partial eta squared (η^2_p) for the group effect and with generalized eta squared (η^2_G) for effects that included repeated measures (Bakeman, 2005; Olejnik & Algina, 2003). Cohen (1988) wrote that values of 0.01, 0.06, and 0.14 represented small, medium, and large effects for eta squared. Additionally, we assessed effect sizes for mean differences between groups and over time with Cohen's d and d_z, respectively. Cohen wrote that values of 0.20, 0.50, and 0.60 represented small, medium, and large effects for d and d_z. We interpret these values as indicating thresholds for effects of the size specified.

Results

Infant behaviors

The mean number of code pairs for infant communicative behavior across groups and times varied from 6.3 to 13.5 (range: 0–27); the comparable values for exploratory behavior were 69.8 to 73.8 (range: 60–90). As noted in the previous paragraph, the percentages analyzed were based on these pairs. The mean number of intervals coded for infant communicative behavior across groups and times varied from 5.1 to 10.5 (range: 0–20); comparable values for exploratory behavior were 59.7 to 60 (range: 55–60). Thus, as noted earlier, essentially every interval was coded for at least one infant exploratory behavior.

Means for the number of intervals and the percentage of pairs coded for infant communicative behavior were moderately higher for the intervention than the comparison group with marginal significance (p = .064 and 0.069), and moderately and significantly higher at Time 2 than Time 1 (see Table 2 and Fig. 2). Means for the number of intervals coded for infant exploratory behavior rounded to 60 because, for most infants, all 60 intervals were coded for one or more exploratory behaviors; however, for values rounded to the thousandth see Table 2. Means for the percentages of pairs coded for infant exploratory behavior are not given in Table 2 because they are simply the complement of communicative behavior (i.e., EXP % = 1 – COM %, where EXP = exploratory and COM = communicativeness) and thus were moderately lower for the comparison than the intervention group.

Table 2
Percentages for maternal responses to infant behavior and associated statistics.

	M				*SD*				Analysis of variance statistics[a]					
	Time 1		Time 2		Time 1		Time 2		η^2			*p*		
Variable	Inter.	Comp.	Inter.	Comp.	Inter.	Comp.	Inter.	Comp.	Group	Time	G × T	Group	Time	G × T
# intervals with COM code	7.9	5.1	11	8.6	(5.8)	(5.4)	(5.6)	(4.5)	0.085	0.070	0.001	0.064	0.017	0.76
# intervals with EXP code	60[b]	60[c]	60[b]	60[d]	(0.2)	(1.1)	(0.2)	(0.0)	–	–	–	–	–	–
# infant–mother code pairs	80	77	87	85	(12)	(10)	(12)	(9.7)	0.033	0.12	0.001	0.26	0.002	0.74
% pairs coded infant COM	12	7.5	15	13	(7.5)	(7.4)	(7.4)	(6.3)	0.082	0.072	0.007	0.069	0.015	0.44
% pairs coded for maternal: Unimodal verbal responsiveness	24	18	25	26	(13)	(10)	(8.4)	(9.8)	0.044	0.032	0.034	0.19	0.11	0.10
Multimodal verbal responsiveness	17	12	38	30	(9.7)	(6.2)	(12)	(15)	0.15	0.46	0.004	0.012	<0.001	0.58
Unimodal verbal redirection	2.2	2.1	1.4	1.7	(2.8)	(3.3)	(2.0)	(3.1)	0.000	0.013	0.001	0.90	0.34	0.80
Multimodal verbal redirection	22	23	12	9.5	(15)	(12)	(7.7)	(8.8)	0.005	0.20	0.005	0.65	<0.001	0.57
Other (including nonverbal)	34	45	24	33	(25)	(19)	(9.4)	(12)	0.15	0.11	0.001	0.013	0.001	0.72

Note. Inter = intervention, *Comp* = comparison; COM = infant communicative, EXP = infant exploratory; G × T = group by time. Due to missing observations, $n = 22$ for the intervention group at Times 1 and 2 but 21 for the comparison group at Time 1 and 20 at Time 2. The *# intervals* is the number of intervals of 60 containing one or more COM codes or one or more EXP codes. The mean number of intervals containing an EXP code, rounded to hundredths, ranged from 59.67–60.00. The maternal percentages are the percentages of infant–mother code pairs coded for the five mutually exclusive and exhaustive categories listed and thus sum to 100%.

[a] $df = 1, 39$ due to zero COM scores for two comparison group infants at Time 1 (thus precluding a COM percentage). η^2 is η^2_p for Group and η^2_G for Time and G × T effects (see text for details). No statistics are reported for # intervals with EXP code due to essentially no variability.

[b] Mean, rounded to 10^{-3}, was 59.955; 1 score was 59 and 21 were 60.

[c] Mean, rounded to 10^{-3}, was 59.667; 2 scores were 59, 1 was 55, and 17 were 60.

[d] Mean rounded to 10^{-3}, was 60.000; all 21 scores were 60.

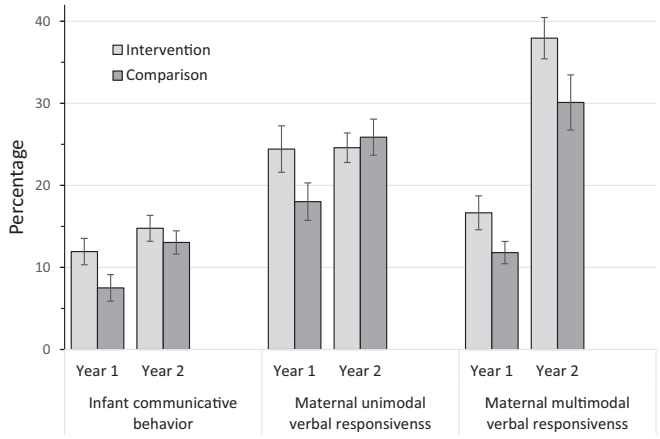

Fig. 2. Infant Communicative Behavior and Maternal Unimodal and Multimodal Verbal Responsiveness.
Note. Bars show mean percentages with 95% confidence intervals for infant communicative behavior and maternal unimodal and multimodal verbal responsiveness, separately by group and year. Effect size and statistical significance for these variables are given in Table 2.

Maternal responsiveness and redirection

Out first question was whether unimodal and multimodal verbal responsiveness would be greater in the intervention than the comparison group. For multimodal verbal responsiveness it was. The intervention group means were moderately greater than the comparison group means at both Times 1 and 2 ($d = 0.59$ and 0.58), and the omnibus group effect (over both times) was strong and statistically significant (see Table 2). The omnibus time effect (over both groups) was likewise strong and statistically significant, and the Time 2 means were strongly greater than the Time 1 means for both the intervention and the comparison groups ($d_z = 1.67$ and 1.10). The group by time interaction effect was near zero and not statistically significant, which supports the conclusion that the group difference was sustained over time.

The results for unimodal verbal responsiveness were more nuanced. The intervention group means were moderately greater than the comparison group means at Time 1 ($d = 0.53$) but were essentially the same at Time 2 ($d = -0.14$), and the omnibus group effect (over both times) was weak and not statistically significant (see Table 2 and Fig. 2). The omnibus time effect (over both groups) was likewise weak and not statistically significant: the Time 1 and 2 means were essentially the same for the intervention group ($d_z = 0.01$), but the Time 2 mean was moderately higher than the Time 1 mean for the comparison group ($d_z = 0.65$).

We also hypothesized that unimodal and multimodal verbal redirection would be less frequent in the intervention than the comparison group, but generally there was no difference. Omnibus group effects for both unimodal and multimodal redirection were near zero (see Table 2), as were mean differences, with one exception: the Time 2 intervention multimodal redirection mean was weakly higher than the comparison mean ($d = 0.36$). In contrast, the omnibus time effect was weak for unimodal redirection and strong for multimodal redirection. For both, means decreased from Time 1 to Time 2. For unimodal redirection, the means decreased weakly for the intervention group and with near-zero effect for the comparison group ($d_z = -0.25$ and -0.09). For multimodal redirection, means decreased moderately for both intervention and comparison groups ($d_z = -0.58$ and -0.76).

Our second question concerned whether group differences would be sustained over the two follow-up periods or instead fade over the seven months from Time 1 to Time 2. As noted previously, the lack of a time by group interaction effect indicates that fading was not evident. Generally, changes over time were not substantially different for the two groups; only one group by time interaction effect was weak and the rest near zero (see Table 2 and Fig. 2); with the difference between intervention and comparison groups for the one strong group effect of multimodal responsiveness being the same at Time 1 as Time 2 ($d = 0.59$ and 0.58). (See Multimedia Component 2 for correlations among main study variables)

Differences in maternal responsiveness to communicative and exploratory behaviors

The maternal responses to infant behavior reported in the previous section were to infant behavior generally, whether communicative or exploratory, and revealed a difference between intervention and comparison groups for maternal multimodal responsiveness. As stated earlier, we considered responses to infant behavior generally for conceptual and practical reasons: practically, communicative behavior was

rarely coded for many dyads (i.e., few infant-mother pairs began with a communicative behavior). This is a finding in its own right and reveals a noteworthy group difference: at 11 months communicative behavior was coded at least five times (a minimum recommended by Bakeman & Quera, 2011) for 18 of 22 infants in the intervention group (odds of 18:4) but for only 9 of 21 infants in the comparison group (odds of 9:12). The resulting odds ratio was 6.00; any odds ratio 3.00 or greater is regarded as strong (Haddock, Rindskopf, & Shadish, 1998). By contrast, comparable numbers at 18 months were 19 of 22 infants in the intervention group and 17 of 20 infants in the comparison group (odds ratio = 1.12, $p = .90$), thus this effect was limited to 11 months.

As an exploratory matter, we asked whether mothers in the intervention group would respond with greater multimodal responsiveness equally to their infant's communicative and their infant's exploratory behavior. Conditional probability means (expressed as percentages) for maternal responsiveness, given infant communicative and given infant exploratory behavior, respectively, were 19% and 16% at Time 1 ($d_z = 0.12, p = .58$) and 46% and 37% at Time 2 ($d_z = 0.53, p = .021$). Thus, in the intervention group, the probability of maternal multimodal responsiveness at Time 1 was about the same, given either infant communicative or exploratory behavior, but at Time 2, the probability of maternal multimodal responsiveness was higher given infant communicative behavior than given infant exploratory behavior.

Discussion

This study documents the effect of an intervention focused on overall maternal sensitivity on maternal verbal responsiveness to infants' behaviors. Our results show positive impacts of the intervention on mothers' multimodal verbal responsiveness in a sample of Brazilian families from low-income contexts, who are not typically studied in developmental research. Intervention effects persisted over short-term and long-term follow-up visits. Other parenting interventions have been shown to impact overall maternal sensitivity and child language competence, including families from low SES households (Brady, Warren, & Sterling, 2009; Garcia et al., 2019; Leigh, Nievar, & Nathans, 2011). Here, we expand on such work by documenting effects of an intervention on mothers' verbal responsiveness specifically.

What mechanisms might explain the intervention's effect on maternal multimodal verbal responsiveness? First, visits focused broadly on social contingency, non-intrusiveness, turn-taking, and the use of diverse vocabulary when engaging with infants, all of which may have led to heightened verbal responsiveness by mothers. The coupling of video feedback with live modeling and discussion of social contingency may have conveyed to mothers the importance of acknowledging infants' activities and interests. Additional discussions about intrusiveness communicated to mothers that non-responsive interactions might interrupt or restrict infants' activities. Moreover, the intervention's focus on turn-taking during play and other activities (e.g., singing or talking to the infant) and guidance on the importance of using words while interacting with infants may have heightened mothers' multimodal verbal responsiveness. Second, live modeling strategies may have provided mothers with feasible examples of how to couple responsive verbalizations with behavioral actions to create joint attention episodes that build on infants' ongoing activity (Suarez-Rivera et al., 2018).

Third, the program may have led to changes in mothers' general perceptions about and interpretations of infant behaviors. The short video feedback sessions addressed key tenets of maternal sensitivity (Author reference) and may have improved mothers' awareness of the communicative nature of infant behavior, thus instilling an understanding of ways to support infant learning in the moment. Many of the behaviors discussed during sessions centered on infants' communicative attempts during video recordings (e.g., vocalizations, smiles, gestures, etc.). Mothers had the chance to observe and discuss how their preverbal infants communicate and react when mothers were and were not responsive. Thus, the use of video feedback was a powerful strategy, an approach to early interventions that is supported by studies (Balldin, Fisher, & Wirtberg, 2018; Cates, Weisleder, & Mendelsohn, 2016). Videos provide mothers with opportunities to watch their infants' reactions to sensitive and non-sensitive (intrusive) behaviors and reflect on their own styles of interacting. Shared reflection may have prompted mothers to incorporate verbal responsiveness into their behaviors during communicative exchanges with their infants at home.

The greater proportions in maternal multimodal verbal responsiveness in the intervention group compared to the comparison group were sustained from Time 1 to Time 2. Mothers in the intervention group became progressively more likely to augment language with physical cues over the course of their infants' second year. This trend was even stronger when infants displayed communicative behaviors at Time 2. Around 18 months of age, infants communicate their desires and interests with clearer and perhaps more overt behaviors and vocalizations than they had before. Such communication may have further fostered multimodal verbal responsiveness in the intervention group given that mothers were better able to interpret and respond to infants' communicative attempts. Mothers in the intervention were prone to coordinating verbal and non-verbal responses to children's clear communicative attempts to fully engage their infants in play and exploration. Thus, infants' language skills contribute to reciprocal interactions by eliciting mothers' acknowledgment and encouragement of autonomy (Whipple, Bernier, & Mageau, 2011). Notably, mothers in the intervention group showed lower proportions of non-verbal maternal responses than did mothers in the comparison group, which further confirms the intervention's effects on verbal dimensions of sensitivity. Surprisingly, we did not see an intervention effect on mothers' unimodal verbal responsiveness. The play context may have encouraged mothers to be more likely to pair language with other forms of communication, partially explaining why the intervention improved multimodal, but not unimodal, responsiveness.

Infant communicative behaviors were more frequent in the intervention group than in the comparison group at follow-up observations, suggesting the indirect benefits of MSP on early infant language development. The positive impact on infant communication, which was not a direct target of the intervention, aligns with prior research. In one study, an intervention aimed at parents' sensitivity toward their 12- to 15-month-olds resulted in more utterances by infants at a 6-month follow-up compared to infants in a comparison group (Garcia et al., 2019). In the current study, the greater use of multimodal verbal responsiveness by mothers in the intervention group may have facilitated infants' development of communicative behaviors. When mothers follow their infant's lead by coupling their speech with manual actions, they facilitate infants' mapping of words to their real-world referents (Suarez-Rivera et al., 2018).

Infant communicative behaviors and maternal verbal multimodal responsiveness increased from 11 (Time 1) to 18 months (Time 2) in both intervention and comparison groups, lending support to the transactional perspective on child development (Bornstein, Hendricks, Haynes, & Painter, 2007). At 18 months, children have more verbal skills and may be more competent conversational partners (Kuchirko, Tafuro, & Tamis LeMonda, 2018) than at 11 months, when their communicative repertoires are largely limited to gestures and other nonverbal communications (Rowe, Özçalışkan, & Goldin-Meadow, 2008). Infants' growing communicative skills likely elicited increased talk by mothers, including greater unimodal and multimodal verbal responsiveness. Conversely, maternal multimodal redirection decreased from 11 to 18 months in both groups. It may be easier for mothers to ignore or not recognize the communicative interests of younger, less skilled infants than infants who more competently signal their interests and intentions.

This study is not without limitations. The small sample size limited statistical power in our analyses. Future investigations should observe mother-infant interactions across lengthier periods of time in a larger sample, which would increase the number of target interactive

sequences available for analysis and thus allow the calculation of other sequential analysis coefficients such as adjusted residuals and effect sizes for individual dyads (Bakeman & Quera, 2011). Coefficients such as Yule's Q, which reflects the magnitude of the temporal association between infant communicative behavior and maternal multimodal verbal responsiveness, may capture a dyad's reciprocal engagement and relate to child language skills. This methodological approach could greatly contribute to understanding associations between real-time mother-child interactions and children's language development. Lengthier observations, using either video or audio-recording, would capture a variety of mother-infant activites and communicative exchanges, thus enabling researchers to examine a more representative snapshot of dyads' daily interactions than a short structure task can afford (Bergelson, Amatuni, Dailey, Koorathota, & Tor, 2019; Tamis-LeMonda, Custode, Kuchirko, Escobar, & Lo, 2019; Tamis-LeMonda, Kuchirko, Luo, Escobar, & Bornstein, 2017). Another limitation is the absence of data on the interventionists' fidelity to the model.

In sum, an intervention focused on overall maternal sensitivity spurred heightened maternal verbal multimodal responsiveness by encouraging mothers to acknowledge and follow their infants' lead and avoid being intrusive. Moreover, intervention effects continued months later, and showed indirect effects on infants' communicative behaviors. Interventions that target core tenets of sensitivity may benefit children's early language development and yield cascading effects on multiple domains of infant development.

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Data availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to information that could compromise the privacy of research participants.

Declaration of Competing Interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appdev.2021.101313.

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