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Increases in Language Input are Sustained among Mothers of Low SES: Evidence from a Randomized Controlled Trial

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SYNOPSIS

Objective. This randomized controlled trial examined whether the quantity and quality of maternal language input were increased through the 3Ts Home Visiting (3Ts-HV) intervention early in toddlerhood and whether increases in maternal language input were sustained over time among families of low SES, controlling for maternal education level, language skill, depressive symptoms, family adversity, child age, child language skills, and the length of recording. ***Design.*** 149 mother-toddler dyads of low SES were randomized to receive either the 3Ts-HV intervention (n = 76) or Healthy Lifestyle control (n = 73) curriculum from 14 to 20 months. Both quantity (tokens) and quality (lexical diversity, syntactic complexity, and use of complex sentences and *wh*-questions) of maternal language input were assessed at 14, 20, 26, 32, and 38 months. Hierarchical linear models were estimated to compare maternal language input between groups over time. Growth trajectories were modeled during the post-curriculum period alone, controlling for baseline maternal language input. ***Results.*** Intervention mothers had significantly larger increases in both quantity and quality of language input than Control mothers at 20 months. Intervention mothers' increases in both quantity and quality of language input were sustained at 26, 32, and 38 months. ***Conclusions.*** Language input can be promoted early in toddlerhood and sustained over time among families facing socioeconomic disadvantages. Fostering sustainable increases in maternal language behaviors with very young children among families of low SES is a critical first step in addressing early language input disparities.

INTRODUCTION

The social interactionist theory of language acquisition emphasizes that caregiver language input plays a critical role in shaping young children's language acquisition and development (Dickinson & McCabe, 1991). During the first few years of life, young children learn words and acquire language from interacting and/or communicating with their caregivers and other adults in their immediate environments (Leech, Salo, Rowe, & Cabrera, 2013; Rhyner, 2007). Receiving linguistic input from their caregivers and having access to

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rich language environments in the early years are essential for young children's vocabulary learning and language acquisition as well as their long-term development (Gilkerson et al., 2018). However, not all children have equal access to these assets, and differences often fall along socioeconomic lines.

Research has shown substantially high variabilities in the quantity and quality of caregiver language input within socioeconomic group (Gilkerson et al., 2017; Hirsh-Pasek et al., 2015; Weizman & Snow, 2001). Yet, compared with their affluent counterparts, caregivers with lower education levels and incomes are more likely to face challenges in enriching their children's language environments such that they use fewer words, less diverse vocabularies, and less complex language when talking with their children (Hart & Risley, 1995; Rowe, 2018). Education is indeed the most important SES indicator associated with caregiver use of language with their children (Hindman, Wasik, & Snell, 2016; Huttenlocher, Vasilyeva, Waterfall, Vevea, & Hedges, 2007). Caregivers with higher education levels, who are likely to be more proficient in their language skills, tend to talk more as well as use more diverse vocabulary and complex language with their children (Hoff, Burridge, Ribot, & Giguere, 2018; Rowe, 2018; Vernon-Feagans, Bratsch-Hines, Reynolds, & Willoughby, 2020). Likewise, young children facing socioeconomic disadvantages often do not have as ample language learning opportunities as their affluent peers. Caregivers from all SES backgrounds adjust the quantity and quality of their language input as a function of their children's age and language skills (Huttenlocher et al., 2007; Rowe, Pan, & Ayoub, 2005). Still, on average, young children in poverty often receive less support for language and literacy development and experience less diverse and less complex language environments compared with young children from families with higher incomes (Neuman, Kaefer, & Pinkham, 2018).

Multiple factors, including economic pressure, time constraints, and cultural norms, contribute to these differences in early language environments. Nevertheless, differences in the quantity and quality of caregiver language input create distinctly different social and learning experiences for children across different socioeconomic statuses (SES) early in life. Such inequality can set young children from low-SES backgrounds behind in vocabulary learning and language acquisition, which ultimately contributes to gaps in school readiness and educational opportunities (Gilkerson et al., 2018). Specifically, the negative impact of early language input disparities on infant language processing efficiency and vocabulary development has been identified as early as 18 months of age and becomes more pronounced by 24 months of age (Fernald, Marchman, & Weisleder, 2013). Other studies have demonstrated striking differences in young children's phonological awareness, vocabulary acquisition, oral language comprehension, and mastery of complex sentence structures across SES prior to school entry (Cunningham & Stanovich, 1997; Hart & Risley, 1995; Hoff, 2003; Vasilyeva, Waterfall, & Huttenlocher, 2008).

On average, caregivers of low SES fall behind their middle-class counterparts in measures of communicative input. Yet, within the low-SES population, substantially large variations in caregiver language input contribute to children's language and cognitive outcomes (Rowe, Leech, & Cabrera, 2017). Moreover, toddlers from low-SES backgrounds who receive more language input at 18 months are more efficient at processing words in real time and have larger expressive vocabularies at 24 months than their peers receiving fewer input (Hurtado, Marchman, & Fernald, 2008; Weisleder & Fernald, 2013). More importantly, caregiver language input remains strongly predictive of young children's later language abilities even when SES is controlled (Hart & Risley, 1995; Rowe, 2012; Weisleder & Fernald, 2013). Moreover, differences in the quantity and quality of language exposure fully or partially explain SES-related disparities in children's language skills (Hoff, 2003; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002). These findings have strong implications for interventions designed to increase the quantity and/or quality of caregiver language input among families of low SES in an effort to narrow disparities in children's language development and long-term outcomes.

Limitations of Interventions Promoting Caregiver Language Input for Young Children

To address disparities in early language milieus, a growing number of interventions have targeted caregivers with young children living in poverty. The theory of change behind language intervention research states the process in which inducing changes in caregiver language input will promote their children's language development. Child-directed language rather than overheard language facilitates young children's early vocabulary growth and language acquisition (Golinkoff, Hoff, Rowe, Tamis-LeMonda, & Hirsh-Pasek, 2019; Shneidman, Arroyo, Levine, & Goldin-Meadow, 2013; Weisleder & Fernald, 2013). Yet, less than half of interventions intended to change adults' communicative behaviors with children have actually assessed whether the target changes occurred in adults (Greenwood, Schnitz, Carta, Wallisch, & Irvin, 2020). Moreover, the majority of follow-up research questions have been focused on relatively short-term intervention impacts on children's outcomes (Greenwood et al., 2020).

The lack of follow-up data on caregiver measures prevents researchers from sufficiently examining the feasibility of promoting caregiver language input and from testing the sustainability of desirable changes among families from low-SES backgrounds. For instance, in a randomized controlled trial (RCT) with families from diverse SES backgrounds, McGillion, Pine, Herbert, and Matthews (2017) reported an increase in caregiver contingent talk with their 1-year-old children right after a 1-month intervention; however, no assessment was conducted over time to examine whether such an increase in

caregiver contingent talk was sustained. Likewise, Hadley et al. (2017), in a quasi-experiment, revealed an immediate increase in parental language input diversity with their toddlers after a brief intervention, without examining whether the increase was sustained over time. Notably, the generalizability of Hadley et al.'s (2017) findings was compromised due to a very small sample with unbalanced parental educational levels, limited ethnic diversity, and unknown SES. In an RCT with parents of low SES, Neville et al. (2013) showed immediate increases in parents' conversational turn-taking and language input diversity with their preschoolers after an 8-week intervention, without collecting follow-up data on the parents. In short, the lack of longitudinal data has limited the ability to examine the sustainability of intervention increases in caregiver language among families of low SES over time.

In addition to the above interventions, other more intensive interventions have been developed in hopes of impacting caregiver language behaviors over time. For example, the Play and Learning Strategies intervention, conducted across two developmental periods from infancy (PALS-I) to toddlerhood-preschool (PALS-II), was designed to promote responsive parenting among families with low incomes (Landry et al., 2012). Yet, findings of an RCT showed that maternal cognitive-linguistic supports, including language facilitation techniques and verbal prompting, were enhanced only up to 3 months after the PALS-II, without evidence to support the sustainability of maternal changes over time. The need for mothers to receive both the PALS-I and PALS-II interventions from infancy to toddlerhood-preschool to see significant short-term gains in maternal language behaviors was striking, revealing challenges of fostering sustainable changes in parental linguistic behaviors among families from low-SES backgrounds (Landry et al., 2012). Importantly, Landry et al. (2012) suggested that booster sessions might be necessary to support mothers to adapt to children's changing needs in later developmental periods in order to have sustainable changes in maternal language behaviors.

Furthermore, the Project Producing Infant/Mother Ethnic Readers (PRIMER), a 7-month intensive community-based intervention, was designed to foster home literacy environments among parents with low incomes. A 1-year follow-up RCT indicated that the initial gains in parental literacy behaviors were mostly not sustained, suggesting that booster sessions might be necessary to maintain parental behavioral changes (Cronan, Brooks, Kilpatrick, Bigatti, & Tally, 1996). Indeed, the length of the intervention, the types of techniques employed, and the use of booster sessions are thought to be critical elements of an intervention to produce sustainable changes in caregiver behaviors (Cronan et al., 1996; Ramey & Ramey, 1992).

The limitations in the language intervention literature speak to the need for further investigations on whether caregiver language input can be promoted through interventions early in life and whether the intervention changes in

caregiver language input can be sustained over time among families of low SES. Promoting caregiver language input in a sustainable manner is critical for addressing language input disparities in early childhood. Nonetheless, there have been well-documented challenges with participation and/or retention of families from low-SES backgrounds (e.g., Baucom et al., 2018; Robinson, Adair, Coffey, Harris, & Burnside, 2016). Caregiver characteristics, such as education level, depression, and family life stress, appear to be the most commonly reported barriers to caregivers' continued participation in research. Previous studies have revealed lower participation and/or retention rates among participants who have lower education levels, experience more depressive symptoms, or face more adverse family circumstances (Baucom et al., 2018; Gorman-Smith et al., 2002; Kersten-Alvarez, Hosman, Riksen-Walraven, Van Doesum, & Hoefnagels, 2010; Robinson et al., 2016). Missing data due to nonparticipation or attrition may compromise the validity of statistical inference and scientific conclusions (Robinson et al., 2016). To reduce bias due to missingness, the identified caregiver characteristics should be considered in understanding the sustainability of intervention impact on caregiver language input. To address the above limitations, the present study aimed to investigate whether maternal language input could be promoted among families of low SES through the 3Ts Home Visiting (3Ts-HV) intervention in a sustainable manner, controlling for the identified covariates. The 3Ts-HV intervention sought to foster caregiver child-directed language behaviors that nurture children's cognitive and language outcomes and promote school readiness and academic achievement.

Language Input in Promoting Young Children's Language Development

Between 14 and 30 months, children progress from producing one-word utterances to combining words to form sentences (Rowland, 2014). Children at this stage have to learn both the words and the way words are combined in order to acquire a language (Tomasello, 2003). The quantity and the quality of caregiver language input differentially contributes to children's language skills at different points of development (Rowe, 2012).

In the early stage of vocabulary acquisition, young children benefit from more frequent exposure to words (Rowe, 2012). Even in families from different SES backgrounds, children who receive more language input in the first year of life tend to accelerate in their vocabulary growth (Bornstein et al., 2020; Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). Also, the quantity of parental language input at 18 months predicts children's subsequent vocabulary skills (Rowe, 2012). Specific to low-SES households, infants who had more exposure to language input (i.e., higher input quantity) were more efficient in processing familiar words at 19 months. These infants in turn had larger expressive vocabularies by 24 months,

suggesting that their early language experiences with adults might have promoted their learning of new words (Weisleder & Fernald, 2013). Nonetheless, the quantity of caregiver language input alone is insufficient to account for variability in children's language development (Hirsh-Pasek et al., 2015). Language input quality in terms of diversity and complexity might be more potent than sheer quantity in predicting children's language outcomes (Hoff, 2003; Rowe et al., 2017).

Caregiver vocabulary diversity is a strong predictor of children's vocabulary and language development (Cristofaro & Tamis-LeMonda, 2012; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Vernon-Feagans et al., 2020). Parental use of diverse and sophisticated words at 30 months predicts children's vocabularies one year later, even after controlling for family SES, parental input quantity, and children's previous vocabulary skills (Rowe, 2012). Focusing on families living in high-poverty rural areas, one study revealed that maternal vocabulary diversity in the first three years positively predicted children's vocabulary and language skills in kindergarten at age 5 (Vernon-Feagans et al., 2020). In families from low-income backgrounds, maternal lexical diversity at 36 months promotes children's vocabulary and language skills, which in turn contributes to later school readiness (Cristofaro & Tamis-LeMonda, 2012). Likewise, maternal frequent use of sophisticated words during everyday activities at 60 months positively predicts children's vocabulary acquisition in kindergarten at age 5 and second grade at age 7 (Weizman & Snow, 2001).

Complexity of language input can be measured by the mean length of utterances (MLU) and the use of complex sentences. Longer utterances typically involve more diverse vocabularies, more content words, and more complex grammar than shorter utterances (e.g., Hoff, 2003). Compared to language input quantity and vocabulary diversity, MLU is the best predictor of child vocabulary at 24 months (Hoff & Naigles, 2002). Maternal MLU in the first three years positively predicts children's vocabulary and math skills in kindergarten at age 5 (Reynolds, Vernon-Feagans, Bratsch-Hines, & Baker, 2019; Vernon-Feagans et al., 2020).

Caregiver use of more complex utterance and a greater variety of syntactic structures in their spontaneous speech might promote children's expressive language and syntactic development (Huttenlocher et al., 2002, 2010). Multiclause (complex) sentences are constructed from simple sentences through recursive devices in which one clause is embedded in or conjoined with another. The structures of multiclause sentences provide linguistic tools that allow expression of complex thoughts including mental states, causal relations, and so forth (Huttenlocher et al., 2002). Preschoolers at 54 months show substantial individual differences in the comprehension and production of multiclause sentences, and such differences are associated with the proportion of multiclause sentences in parental speech, above and beyond family SES

(Huttenlocher et al., 2002). These preschoolers also showed greater syntactic growth when teachers provided more syntactically complex input, including more frequent use of multiclause sentences in their speech (Huttenlocher et al., 2002).

Complexity of language input can also be measured in terms of the types of questions caregivers use with their children. Specifically, *wh*-questions, referring to as questions framed with *what, when, where, which, why, who, whose*, or *how*, are often more linguistically and cognitively challenging for young children. Young children whose adult caregivers use more *wh*-questions when interacting with them have greater ability to comprehend and produce *wh*-questions on their own (Goodwin, Fein, & Naigles, 2015; Rowe et al., 2017), larger vocabularies and language skills (Cristofaro & Tamis-LeMonda, 2012; Leech et al., 2013; Rowe et al., 2017; Vernon-Feagans et al., 2020), and better verbal reasoning ability (Rowe et al., 2017). Caregiver use of *wh*-questions might be particularly helpful in fostering young children's vocabulary learning as these questions elicit more frequent and more syntactically complex verbal responses from children; vocabulary learning might in turn help promote verbal reasoning ability as children can use words to manipulate concepts and facilitate reasoning (Rowe et al., 2017). Caregiver use of *wh*-questions (especially the more complex "why" or "how" questions) might also directly foster young children's verbal reasoning ability as these questions challenge children to reason and provide verbal explanations (Frazier, Gelman, & Wellman, 2009).

Taken together, both quantity and quality of caregiver language input are critical in fostering young children's concurrent language acquisition as well as later academic skills and developmental outcomes. Bringing sustainable increases to the above five aspects of caregiver language input (i.e., language input quantity, lexical diversity, syntactic complexity, use of complex sentences, and use of *wh*-questions) early in life among families facing socioeconomic disadvantages is critical in narrowing early language input disparities.

The Present Study

Building on the language development and behavior change literature (Michie, Jochelson, Markham, & Bridle, 2009), the 3Ts-HV curriculum was a 6-month intervention designed to promote caregiver language inputs for young children living in low-SES households (see Table 1 for an overview). The "3Ts" – *Tune In, Talk More*, and *Take Turns* were the three key behavior change strategies for caregivers to enrich their child's language environments. Utilizing scaffolding, social learning and guided practice, quantitative linguistic feedback, and goal setting, home visitors supported caregivers in learning how to apply scientific knowledge and/or implement behavior changes in their

Table 1. Overview of the 3Ts-HV intervention curriculum.

Module 1: Introduction
Caregivers were introduced to the overarching themes and concepts throughout the 3Ts-HV curriculum. Foundational science regarding incremental theory of intelligence, brain plasticity in early childhood, critical period for language learning, and lasting impact of language input on children's brain, cognitive and language development was discussed.
Module 2: Talk More
Talk More strategies, designed to increase language input for young children in everyday life, were presented. Strategies included using descriptive language, labeling, singing songs, and talking about here/now, past/future, and thoughts/feelings.
Module 3: Tune In
Tune In strategies, designed to promote responsiveness to young children's communication initiatives, were presented. Strategies included reading young children's cues, talking about objects/actions in the child's current focus of attention, using child-directed speech, and adjusting to the child's level to make eye contact and/or share facial expressions.
Module 4: Take Turns
Take Turns strategies, designed to promote back-and-forth conversations with young children, were presented. Strategies included reading and responding to young children's cues, limiting technology use to increase the quality of caregiver-child interactions, and singing songs with children.
Module 5: Spread the Words
To further enrich young children's language environments and harness social capital, this module was designed to support caregivers to maximize language inputs from other adults in their children's lives. Caregivers were presented with strategies for sharing what they learned from the curriculum with other caregivers and family members surrounding their children.
Module 6: Executive Function
To foster young children's development of executive function and self-regulation skills, caregivers were presented with behavioral strategies for using talk to regulate child misbehaviors and/or tantrums. Behavior management strategies (such as recognizing own emotions and tone of voice, teaching children to describe feelings, think, and make choices, and reasoning and modeling self-regulation skills) were discussed and demonstrated.
Module 7: Directives
Caregivers were presented with behavioral strategies for reducing the use of directives (e.g., "No football in the house!"). The negative impact of directives on young children's language abilities and self-regulation skills was discussed. Caregivers were encouraged to use explanations to correct misbehaviors, foster cognitive thinking skills, and promote positive behaviors in young children (e.g., "Do not throw the football in the house because you might break something.").
Module 8: Encouragements
Caregivers were presented with behavioral strategies for using more encouragement or praise to promote positive behaviors, foster perseverance, and develop self-concept in young children. Differences between person-based and process-based encouragements were examined, explained, and exemplified, with an emphasis on praising children for efforts rather than results or abilities.
Module 9: Literacy
Book sharing as opposed to book reading with young children was introduced to engage children with books, encourage children's autonomy during book sharing, and foster positive experiences associated with books. Using the *3Ts* strategies during book sharing with children was explained and exemplified. Book sharing was presented as a way to foster young children's language and socioemotional skills, and short- and long-term interest in books.
Module 10: Oral Narratives
Oral narrative was introduced with an emphasis on caregivers telling stories to their young children and engaging their children to tell stories. Using the *3Ts* strategies during storytelling was explained and exemplified. Storytelling was shown as a way to foster young children's vocabulary learning, narrative skills, reading readiness, and understanding/self-regulation of emotion.
Module 11: Numbers
Young children's early math abilities such as understanding measurement, sorting, and patterns were discussed. Using the *3Ts* strategies to incorporate math and spatial language into everyday activities and conversations with young children were explained and exemplified. Incorporating math talk was presented with an emphasis on fostering young children's foundational understanding of mathematics and promoting their readiness for math learning upon school entry.
Module 12: Media Diet
Technology use was identified as a common obstacle of using the *3Ts* strategies, and a technology diet was recommended to caregivers. Caregivers learned about the negative impact of technology use on their ability to tune in to their children, the quality of caregiver-child interactions, and their children's cognitive and language development. Suggestions on how and when to limit technology use were presented, along with an emphasis on having one-on-one interactions with young children.

everyday lives with their child (Leung, Hernandez, & Suskind, 2020). Booster sessions might be a necessary component of an intervention to foster sustainable changes in caregiver language behaviors (Cronan et al., 1996; Landry et al., 2012). Thus, a series of four booster sessions was implemented over 18 months post curriculum to provide caregivers with continuous support and to refresh their learning (see Table 2 for an overview).

Empirical findings support the immediate efficacy of the 3Ts-HV intervention in enhancing caregiver knowledge, caregiver-child interaction quality, and linguistic exposure quantity in the context of low-SES households,

Table 2. Overview of the 3Ts-HV booster sessions.

	Booster 1	Booster 2	Booster 3	Booster 4
1. Introduction	Restate: (a) key concepts, e.g., early brain plasticity and lasting impact of early input on child development; (b) importance of caregiver role in enriching children's early language environments; and (c) functions of the 3Ts strategies			
2. Review of the *Talk More* strategies	Use more descriptions and action words	Don't just do it, talk your child through it	Take pronounces out of your vocabulary	Describe past and future, thoughts and feelings
3. Review of the *Tune In* strategies	Discuss how your child's clues had changed	Emphasize the use of child directed speech	Get your child to *tune in* to what you're doing	Get to the child's level
4. Review of the *Take Turns* Strategies	Identify your child's communication clues	Discuss how your conversations with your child had changed	Restate, "You are always *taking turns* by *tuning in* and *talking more*	Use singing as a way to *take* more *turns*
5. Revisiting discussion on the use of technology and the associated impact	Restate, "you cannot *tune in* to your child if you are *tuned in* to something else, so turn off technology"	(a) Restate, "young children do not learn from technology like they can learn from you"; (b) Review study about children who watch more TV know less words	(a) Revisit media diet; (b) Discuss how you changed the way of using technology at home in these past few months	Restate, "technology distracts you from using the 3Ts with your child"
6. Review of strategies using math talk		Use simple addition and subtraction	(a) Count, compare, and describe shapes/patterns; (b) Talk about position, directions, measurement, and sorting	(a) Show your child how you use math in daily life; (b) Use math talk to compare
7. Review of strategies promoting literacy	(a) Share book with child; (b) Allow child lead; (c) Use the 3Ts with child		During book share: (a) Describe past, future and thoughts and feelings; (b) Relate to child's life	(a) Keep books where child can reach them; (b) Go to the library; (c) Make up your own stories/ask questions
8. Revisiting other topics from curriculum	Give your child choices (Executive Function I)	(a) Minimize directives; (b) Focus on reasoning and explanations	(a) Show how you regulate yourself; (b) Watch your tone (Executive Function II)	(a) Use encouragement; (b) Emphasize using process-based praise; (c) Catch child being good

controlling for caregiver education level, language skills, and marital status (Leung et al., 2020). Compared with their Control counterparts immediately post intervention, Intervention caregivers were more knowledgeable about early childhood cognitive and language development. Intervention caregivers also utilized more praise, explanations, and open-ended questions while using less criticism, physical control, and intrusiveness than the Control caregivers when interacting with their child.

Moreover, the Language ENvironment Analysis (LENA; see further description in the Method section) technology was applied to estimate the linguistic exposure quantity available to the child. Intervention households were shown to have a greater amount of adult talk surrounding the child and a higher number of adult-child vocal exchanges than Control households (Leung et al., 2020). Nevertheless, these findings on linguistic exposure quantity focused on the overall language environment; this work did not specifically examine participating caregiver's language directed to the child. Thus, further investigation is needed to examine the 3Ts-HV intervention impact on the quantity and quality of child-directed language input among caregivers of low SES over time.

The present study expands previous work by examining five measures of maternal language input in the proximal context of the child. Through analyses of the language mothers use with their toddler during free play at home, the present study examines both quantity and quality of maternal language input. Quantity measures the number of words (Tokens), whereas quality measures lexical diversity (Types) and complexity (MLU, Complex Sentences, and *WH*-Questions). The present longitudinal study also extends previous work by following the mother-toddler dyads at 26, 32, and 38 months of age (i.e., 6, 12, and then 18 months after the intervention). Specifically, the present RCT examined whether: (1) the quantity and quality of maternal language input were increased through the 3Ts-HV intervention early in toddlerhood and (2) the intervention increases in maternal language input were sustained over time. As reviewed above, caregiver education level, language skill, child age, and child language skills have been associated with the quantity and quality of caregiver language input. Moreover, caregiver education level, depressive symptoms, and family adversity have been linked to nonparticipation or attrition. These six variables (maternal education level, language skill, depressive symptoms, family adversity, child age, and child language skills) were therefore considered as covariates in the present study. Based on findings of the 3Ts-HV intervention (Leung et al., 2020), we hypothesized that both quantity and quality of maternal language input would be promoted early in toddlerhood such that Intervention mothers would show larger increases in the five measures of maternal language input than Control mothers immediately after the intervention at 20 months of age. Given that evidence on intervention sustainability of behavior changes

remains limited in the language intervention literature, we explored whether increases in the five measures of maternal language input among Intervention mothers would be sustained over time at 26, 32, and 38 months.

METHOD

Participants

Participants were recruited through postings at child care centers, health clinics, local stores, public transportation, and community organizations serving low-SES populations in the Chicago metropolitan area between 2014 and 2017. Inclusion criteria required that primary caregivers had a toddler within the target age and born without significant cognitive or physical impairments, had legal custody of the child, spoke English as their primary language, and had a household income at or below 200% of the federal poverty line. Exclusion criteria were that caregivers were under 18 years old, received education beyond a 4-year college degree, did not live with the child, or did not spend at least two full days per week with the child. After obtaining written consent from the caregivers, 206 caregiver-toddler dyads were randomly assigned to either the 3Ts-HV intervention or Healthy Lifestyle control condition, using a matched pairs randomization procedure (King, Nielsen, Coberley, Pope, & Wells, 2011; see detailed description below). One hundred and fifty-six dyads (149 mothers, 4 other female relatives, and 3 fathers) completed at least one post-curriculum assessment. Only the 149 mother-toddler dyads (76 Intervention and 73 Control) were included in the analyses of the present study. Baseline sociodemographics of the samples appear in Table 3, and a CONSORT flow diagram is presented as Figure 1.

Design and Procedures

The present study was a double-blind, parallel group RCT. Research assessors collected data for all six assessments, whereas home visitors delivered all 12 curriculum modules and four booster sessions during separate visits at participant homes. Research assessors were blind to participant condition and performance, whereas home visitors were blind to observation and assessment data to minimize potential experimenter effects. Participants in the Control condition received an analogous curriculum to control for the potential attentional effect experienced by participants in the Intervention condition. Participants in both conditions filled out the same measures, completed the same study activities, and received the same compensation for their participation to minimize extraneous variability across conditions. They were never informed about the alternative curriculum to minimize subject expectancy effect.

Table 3. Baseline demographics of the intervention and control mother-toddler dyads[a].

	Intervention	Control
Sample size	76	73
Mother characteristics		
Age (*M, SD*)	29.21 (6.18)	28.29 (5.80)
Ethnicity		
European American, non-Hispanic	3 (.04)	5 (.07)
African American, non-Hispanic	59 (.78)	55 (.75)
Hispanic	3 (.04)	5 (.07)
Prefer not to answer or no response	11 (.14)	8 (.11)
Marital status		
Single	53 (.70)	52 (.71)
Married or civil union	14 (.18)	12 (.16)
Living with partner	8 (.11)	6 (.08)
Divorced or separated	1 (.01)	3 (.04)
Education level		
Some high school	5 (.07)	4 (.06)
High school graduate or GED completed	17 (.22)	18 (.25)
Postsecondary non-degree program	4 (.05)	3 (.04)
Some college credit but no degree	31 (.41)	27 (.37)
Two-year associate degree	8 (.11)	9 (.12)
Four-year bachelor's degree	11 (.14)	12 (.16)
Employed	35 (.46)	36 (.49)
LINK or WIC recipient	63 (.83)	65 (.89)
Medical card recipient	68 (.90)	62 (.85)
PPVT language skills (*M, SD*)	84.45 (13.20)	84.44 (14.60)
Family characteristics		
Housing		
No permanent home	2 (.03)	6 (.08)
Living with friends or relatives	27 (.36)	32 (.44)
Residing in a shelter	1 (.01)	0 (.00)
Family size (*M, SD*)	4.51 (1.76)	4.36 (1.33)
Child characteristics		
Age (*M, SD*)	1.18 (.11)	1.19 (.11)
Female	36 (.47)	35 (.48)
Enrolled in Early Head Start	9 (.12)	15 (.21)

LINK, Illinois Link program; WIC, Women, Infants and Children program; PPVT, Peabody Picture Vocabulary Test. [a]Frequency and proportion are reported in Table 3 except as otherwise noted.

The six research assessors and five home visitors were paraprofessionals who underwent rigorous training to collect data from or deliver curriculum to participants by following a standardized protocol. A professional trainer with five years of experience in adult/teacher education and professional development trained the home visitors. Such training involved direct coaching, reviewing videos of previous home visits, observing actual home visits, and delivering curriculum to a practice family, with feedback provided by the trainer at each stage. The trainer reviewed 10% of all home visits and booster sessions and provided home visitors with feedback/coaching throughout the study to ensure fidelity of implementation.

In the preliminary assessment, mothers received training on how to complete audio recordings with their toddler using the LENA digital device. They were asked to complete three full-day LENA recordings with their child during everyday activities at home in four weeks; each recording

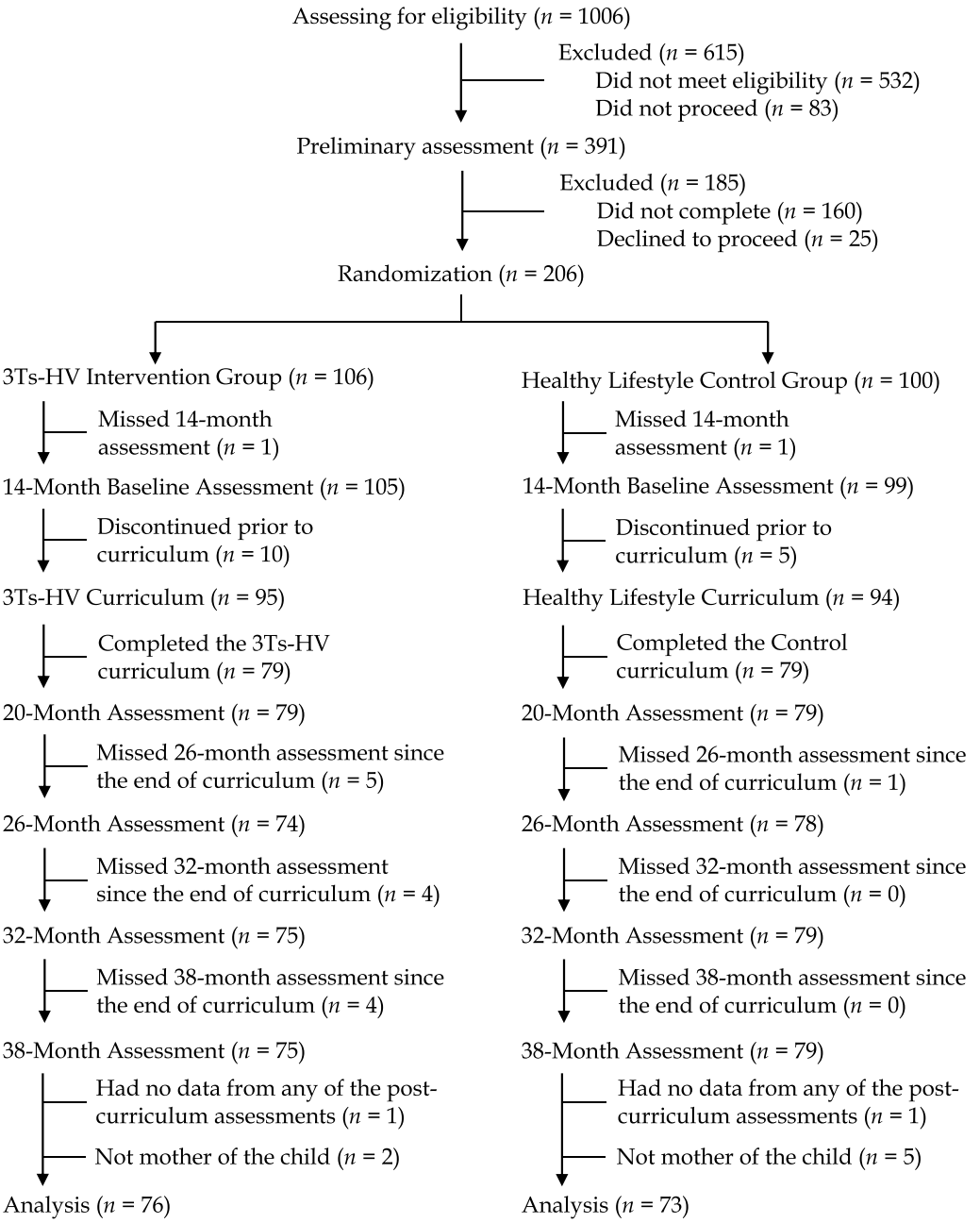

Figure 1. CONSORT flow diagram illustrating each stage of the randomized controlled trial.

had to be at least 8 hours long. Data from the three recordings were analyzed to generate an estimate of average adult-child conversational turn counts (CTC; Suskind et al., 2013), providing an initial measure of the quantity of linguistic inputs available to the child in the home environment. Using the LENA data, a matched pairs randomization procedure was

applied to ensure baseline equivalence on child age and CTC across conditions.

The baseline assessment was conducted on randomization at 14 months. Either the Intervention or Control curriculum was then implemented in a sequence of 12 modules on a bi-weekly basis. Post-curriculum assessments were conducted at 20, 26, 32, and 38 months. In each of these five assessments, the mother and toddler were asked to play as usual with a given set of age-appropriate toys in a designated area of their home; this 20-min free play was video-recorded. The first booster completed one month after the 20-month assessment, the second booster two weeks before the 26-month assessment, the third booster two weeks before the 32-month assessment, and the fourth booster two weeks before the 38-month assessment. This study was approved by the Biological Sciences Division Institutional Review Board at the University of Chicago Medicine (IRB#14-0895) and registered at clinicaltrials.gov (NCT02216032).

Intervention and Control Conditions

3Ts-HV Intervention Condition. Mothers in the Intervention condition received the 3Ts-HV curriculum. Curriculum sessions began with learning developmental science of early childhood (25 min). Scientific concepts were introduced in plain language and illustrated using animations. Through active discussions with the home visitor, the concepts were translated into actionable knowledge and/or applicable behavioral strategies. Specific behavioral strategies or parenting skills were then demonstrated through animations and video examples (10 min). Mothers learned how to apply the target strategy/skill with their child through guided practice, with feedback provided by the home visitor on strategy application or skill development.

Based on the LENA recording completed in the prior week, the quantities of linguistic inputs available to the child in the home environment were presented in a form of easy-to-understand weekly reports to mothers, illustrating their progress throughout the intervention period (10 min; Suskind et al., 2015). In reviewing the individualized reports, the home visitor highlighted the mother's strengths, provided encouragement, and offered problem-solving suggestions to foster a sense of self-efficacy in the mother. Sessions ended with setting goals collaboratively with the home visitor (10 min) to provide mothers with an action plan along with achievable goals for applying the module knowledge and behavioral strategies into their daily routines in the following week. Mothers indicated where, when, and how the newly learned strategies, along with the 3Ts, could be employed in everyday contexts to increase language input for and communicative interactions with the child. Mothers also identified potential barriers that might impede them from incorporating the new strategies into daily routine and discussed possible solutions to

overcome the anticipated barriers. This goal setting activity helped mothers monitor progress, stay motivated, and develop awareness of language behaviors.

Booster sessions began with reviewing the key scientific concepts in child development and the applicable behavioral strategies presented throughout the curriculum. Concepts were illustrated using animations, and implementations of the 3Ts strategies during everyday routines were demonstrated using video examples (see Table 2). Based on the LENA recording from the prior week, quantitative linguistic feedback was provided to promote mother language behavior changes. Sessions ended with collaborative goal setting. Mothers received an age appropriate children's book at the end of each intervention and booster session.

Healthy Lifestyle Control Condition. Mothers in the Control condition received the Healthy Lifestyle curriculum (LoRe, Leung, Brenner, & Suskind, 2019), designed to promote caregiver knowledge and practices to develop a healthy lifestyle for their young children. Built on the American Academy of Pediatrics Bright Futures guidelines (Hagan, Shaw, & Duncan, 2017), this curriculum focused on pediatric nutritional needs, healthy eating behaviors, and physical activities for obesity prevention in early childhood. Practices that could be implemented in everyday life to maintain a healthy lifestyle for young children were introduced. Curriculum sessions began with a module viewing (15 mins), followed by a discussion about mothers' goals for developing a healthy lifestyle for the child (5 min). Mothers received one recipe for a healthy family meal on a budget, along with information about nutrition or dental hygiene at the end of every other curriculum session. In the booster sessions, mothers discussed how they had applied what they learned from the curriculum with their young children in daily routines. Mothers also indicated their plans for applying the learned practices in the next week and next month.

Assessment/Materials

Sociodemographics. Mothers reported their demographic information including ethnicity, relationship to the child, marital status, education level, employment status, LINK/WIC/medical card recipient, housing, family size, child gender, and Early Head Start enrollment at the 14-month baseline assessment. Education level was reported on a 6-point scale ranging from 1 (*some high school*) to 6 (*four-year bachelor's degree*).

Maternal Language Input. All maternal language input direct to the child during free play was transcribed using Datavyu (Version 1.3.7; Datavyu Team, 2014). Transcribers underwent rigorous training, and 9% of all recordings were double transcribed independently for 10 min that were randomly

selected for reliability (percentage of agreement on word = 81%; percentage of agreement on utterance = 88%). Any issues with transcription were discussed among transcribers until reaching agreement. The natural language processing library spaCy (version 3.1.3; Honnibal, 2016) in the Python programming language (Version 3.8.11; Van Rossum & Drake, 2009) was applied to analyze the transcripts in order to compute five measures of maternal language input.

Tokens. Token was a measure of maternal language input quantity. Tokens were calculated by counting the total number of words mothers spoke to their toddlers.

Types. Type was a measure of maternal language input lexical diversity. Types were calculated by counting the number of unique words (i.e., words that have different word roots) mothers used when talking with their toddlers. Inflectional variants of a given word were considered one type (e.g., "talk," "talks," "talking," "talked"). Words with irregular inflectional morphology were also considered one type (e.g., "tooth," "teeth").

Mean Length of Utterance. MLU was a measure of maternal language input syntactic complexity. An utterance was defined as any sequence of words preceded and followed by a pause, change in conversational turn, or change in intonational pattern. To calculate MLU, the total number of words was divided by the total number of utterances mothers produced when talking with their toddler.

Complex Sentences. Complex Sentence was a measure of maternal language input complexity. All utterances were classified as zero-clause utterances, simple sentences, or complex sentences. Zero-clause utterances did not contain a verb; they were not counted as sentences. Zero-clause utterances typically contained only a noun (e.g. "piggy"), a noun phrase or proper noun (e.g., "your piggy, Jenny"), a prepositional phrase (e.g., "in your room"), a preposition (e.g., "up"), or an interjection (e.g., "alright," "thank you"). Simple sentences contained one clause (e.g., "You eat apple?"), including: (1) utterances with a conjoined subject or object (e.g. "You and I play here now."); (2) utterances containing a single lexical verb combined with a modal auxiliary (e.g., "can," "must," "should"), a marginal modal (e.g., "used to," "have to"), or a quasi-modal (e.g., "going to," "to be able to"); (3) serial verb constructions (e.g. "go do it," "come get it") as the serial verbs occur together in a single verb phrase; and (4) tag questions (e.g., "You turned the page, *didn't you*?") because the tag was not counted as an additional predication. Complex sentences contained more than one clause (e.g., "I thought you like dog."), including: (1) utterance with infinitive forms of an additional verb (e.g., "You want to go home?"), gerund verb forms (e.g., "Start cleaning up the toys now"), or certain

verbs (specifically, "want," "let," "need," and "have') followed by a pronoun with another predication (e.g., "Let her do it.") and (2) coordinated clauses containing a single subject and more than one verb phrase (e.g., "I drunk tea and ate cookies."). Complex Sentences were calculated by counting its total number upon classification.

WH-Questions. *WH*-Questions, another measure of maternal language input complexity, were operationalized as utterances that began with "what," "when," "where," "which," "why," "who," "whose," or "how" and ended with a question mark. *WH*-Questions were defined as open-ended prompts for information and calculated by counting its total number.

Language Skills. Mothers' receptive vocabulary skills were assessed at the 14-month assessment using the Peabody Picture Vocabulary Test fourth edition (Dunn & Dunn, 2015). Their toddler's auditory comprehension skills were assessed using the Preschool Language Scale fifth edition (Zimmerman, Steiner, & Pond, 2011) at the 14, 20, 26, 32, and 38-month assessments.

Depressive Symptoms. Maternal depressive symptoms were assessed at the 14, 20, and 32-month assessments using the 10-item Center for Epidemiologic Studies Short Depression Scale (Andresen, Malmgren, Carter, & Patrick, 1994). Mothers rated each item about their feeling or behavior in the past week on a 4-point scale, ranging from 0 (*rarely or none of the time*) to 3 (all of the time). Two items were reverse coded. Mothers must respond to at least 8 items to receive a Depression score, which was a sum score of all 10 items. Cronbach's alpha for the current sample was .65.

Family Adversity. In each of the five assessments, mothers reported their experience of adverse family circumstance in the past 6 months by responding either "yes" or "no" to a checklist of 18 questions (Guss et al., 2016). These questions asked about stressors that happened to the family such as relationship instability (e.g., "Did you get divorced or separate from your partner, even though you may be back together now?"), illness (e.g., Have you or a member of your household had a serious illness?), mental health problems (e.g., "Have you or a member of your household had a significant depression, mental illness, or attempted suicide?"), financial difficulties (e.g., "Have circumstances this year made it extremely difficult to have enough to eat, get medical care, or keep you and your child(ren) safe?"), and violence or crime (e.g., "Have you or a member of your household been the victim of a violent crime?"). A Family Adversity score was calculated by counting the number of "yes" responses.

Analytic Plan

Preliminary Analyses. To examine whether the two conditions were balanced, chi-square tests, independent sample *t*-tests, and a one-way multivariate analysis of variance (MANOVA) were conducted in SPSS 27 to compare all study variables at baseline and the missing rate across conditions (Intervention vs. Control). There were slight variations in the average length of recording, ranging from 19.83 to 20.59 mins; length of recording was therefore considered another covariate. Together, maternal education level, language skills, depressive symptoms, family adversity, child age, child language skills, and length of recording were examined as covariates.

Hierarchical Linear Models. Hierarchical linear models (HLMs) were estimated to examine whether (1) the five measures of maternal language input were promoted through the 3Ts-HV intervention early in toddlerhood and (2) the intervention increases in maternal language input were sustained over time, controlling for the covariates. HLMs offer rigorous strategies to handle missing data and unequal time intervals between and within participant responses (Hedeker & Gibbons, 1997; Nich & Carroll, 1997). Five HLMs were estimated using the restricted maximum likelihood procedure. In each HLM, one measure of maternal language input was individually tested as the dependent variable.

To estimate the magnitude of the initial and the sustained intervention impact at each assessment, growth trajectories were modeled during the post-curriculum period alone, controlling for the maternal language input at baseline. Repeated assessments (20, 26, 32, and 38 months) were nested within participants; the time variable was at Level l. Given that the actual lengths of time between assessments vary from family to family, time was specified as the actual number of months between assessments to achieve the most accurate estimates possible. The Intervention variable (Intervention = 1; Control = 0) was at Level 2, accounting for the impact of the 3Ts-HV Intervention curriculum relative to the Control curriculum. Baseline measure of maternal language input and the identified covariates were entered into the models. As maternal depressive symptoms were assessed at three out of the five assessments, it was examined as a covariate only in supplementary analyses.

To examine whether the intervention impact was sustained over time, individual trajectories of each maternal language input measure were modeled as linear growth models including both an intercept at 20-month assessment (immediately post intervention) and a linear component representing the relation with time in each trajectory (Raudenbush & Bryk, 2002). The estimates for Intervention examined whether the Intervention and the Control mothers differed from each other in their language input measures immediately post intervention at 20-month assessment. The estimates for Time

examined whether the Control mothers showed changes in their language input measures over time. The estimates for Intervention*Time interaction examined whether the intervention impact (i.e., the differences between the Intervention and the Control mothers) on language input measures changed over time. The models included a random intercept (u_0), a random slope (u_1), and time-level random effects (e). To provide further support for the sustained intervention impact on all five measures of maternal language input, we estimated five additional HLMs with the intercept being re-centered at 38 months (the last time point). All HLMs were estimated using Stata 16.

RESULTS

Preliminary Analyses

Mothers in the two conditions, on average, did not differ in terms of the missing rate and all study variables at baseline.

Hierarchical Linear Models

The estimates for all HLMs are reported in Table 4. The significant positive effects of Intervention on all five measures of maternal language input indicated that Intervention mothers had higher counts than Control mothers on Tokens, $\beta = .89$, $p < .001$, Types, $\beta = .65$, $p < .001$, MLU, $\beta = .46$, $p < .001$, Complex Sentences, $\beta = .75$, $p < .001$, and *WH*-Questions, $\beta = .31$, $p = .005$, immediately after the intervention period. The standardized beta coefficients for Intervention effects indicated that compared with Control mothers, Intervention mothers had a significant .89 standard deviation (*SD*) increase in Tokens, .65 *SD* increase in Types, .46 *SD* increase in MLU, .75 *SD* increase in Complex Sentences, and .31 *SD* increase in *WH*-Questions at 20-month assessment. In support of our hypothesis, both quantity and quality of maternal language input were promoted early in toddlerhood at age 20 months. In contrast, the non-significant effects of Time on all five measures of maternal language input indicated that Control mothers had no changes in Tokens, $\beta = .02$, $p = .28$, Types, $\beta = .01$, $p = .60$, MLU, $\beta = .02$, $p = .42$, Complex Sentences, $\beta = .02$, $p = .36$, and *WH*-Questions, $\beta = -.002$, $p = .94$, over time from 20 through 38 months.

There was a significant negative Intervention*Time interaction effect on Tokens, $\beta = -.02$, $p = .02$, showing that the intervention increase in Tokens was slightly reduced over time. The standardized beta coefficients for the Intervention*Time interaction indicated that there was a .02 *SD* decrease for every additional month for the control group. However, Intervention mothers still had a significantly higher count than Control mothers on Tokens over time, from 20 through 38 months. The non-significant Intervention*Time

Table 4. Hierarchical linear models examining five measures of language input between intervention and control mothers over time.

	Maternal Language Input														
	Tokens			Types			MLU			Complex Sentences			*WH*-Questions		
	B	(*SE*)	*β*	*B*	(*SE*)	*β*	*B*	(*SE*)	*β*	*B*	(*SE*)	*β*	*B*	(*SE*)	*β*
Fixed effects															
Intervention	429.53***	56.71	.89***	45.82***	8.42	.65***	.30***	.08	.46***	13.11***	2.44	.75***	7.02**	2.72	.31**
Time (as months)	12.60	9.01	.03	1.15	1.37	.02	.01	.01	.02	.45	.38	.03	−.23	.46	−.01
Intervention*Time	−8.30*	3.26	−.02*	−.97	.50	−.01	−.00	.00	−.01	−.27	.14	−.02	−.05	.20	−.00
Covariates															
Mother education level [a]															
High school graduate	−105.56	104.46	−.22	−9.77	15.87	−.14	−.15	.14	−.23	−4.55	4.54	−.26	−1.61	5.32	−.10
Postsecondary	−112.05	144.51	−.23	−3.29	22.07	−.05	−.16	.20	−.23	−6.04	5.96	−.34	3.11	7.41	.11
Some college credit	−132.58	100.91	−.27	−6.89	15.35	−.09	−.13	.13	−.20	−5.07	4.08	−.29	.42	5.14	−.01
Associate degree	−148.69	118.92	−.31	−18.69	18.10	−.26	−.16	.16	−.23	−10.36	4.76	−.59	10.92	6.09	.47
Bachelor's degree	59.17	116.33	.12	25.69	17.71	.36	.03	.16	.05	−.12	4.75	−.01	14.45*	5.94	.63*
Mother language skills	.99	1.87	.00	.11	.29	.00	.00	.00	.00	−.00	.07	−.00	.08	.10	.00
Child age [b]	−6.79	8.84	−.01	1.02	1.31	.02	.02	.01	.03	−.19	.36	−.01	.61	.45	.02
Child language skills [b]	1.10	1.12	.00	.17	.17	.00	.01**	.00	.01**	.05	.04	.00	.19**	.06	.01**
Length of recording [b]	60.16***	7.54	.12***	7.53***	1.16	.11***	.01	.01	.02	1.36***	.31	.08***	2.25***	.42	.10***
Family adversity	−9.35	7.32	−.02	−2.43	1.12	−.03	−.01	.01	−.02	−.15	.29	−.01	−.46	.40	−.02
Baseline PCDS [c]	.65***	.07	.52***	.52***	.06	.47***	.45***	.07	.39***	.67***	.08	.50***	.51***	.14	.19***
Intercept	−764.32***	291.83	−2.71***	−93.55**	44.47	−3.13***	.47	.44	−2.23***	−13.79*	12.04	−1.63*	−68.59***	15.44	−4.05***
Variance component															
Intercept variance (u_0)	72072.70	12484.40	.31	1495.98	296.09	.30	.12	.02	.28	141.61	25.09	.47	135.76	32.31	.26
Slope variance (u_1)	81.53	51.35	.00	1.72	1.21	.00	.00	.00	.00	.15	.09	.00	.47	.18	.00
Covariance	−634.10	651.23	−.00	−3.68	14.96	−.00	.00	.00	.00	−1.99	1.17	−.01	.78	1.85	.00
Time variance (e)	53135.45	4490.97	.22	1272.16	107.51	.26	.13	.00	.31	89.43	7.67	.29	165.70	14.01	.32
Observations		570			570			570			564			570	
Sample size		148			148			148			147			148	

Supplementary Hierarchical Linear Models with Maternal Depressive Symptoms Examined as an Additional Covariate

	Maternal Language Input														
	Tokens			Types			MLU			Complex Sentences			*WH*-Questions		
	B	(*SE*)	*β*	*B*	(*SE*)	*B*	(*SE*)	*β*	*B*	(*SE*)	*B*	(*SE*)	*β*	*B*	(*SE*)
Intervention	437.63***	55.77	.91***	48.11***	8.49	.69***	.36***	.09	.55***	14.28***	2.42	.82***	7.05**	2.59	.31**
Time (as months)	15.25	9.71	.03	1.05	1.41	.01	.02	.01	.03	.55	.42	.03	.37	.49	.02
Intervention*Time	−9.87	5.05	−.02	−1.31	.73	−.02	−.01	.01	−.01	−.35	.22	−.02	−.19	.28	−.01
Covariates included		Yes			Yes			Yes			Yes			Yes	
Observations [d]		289			289			289			287			289	
Sample size		148			148			148			147			148	

Additional Hierarchical Linear Models with Intercept Re-centered at 38 Months

	Maternal Language Input														
	Tokens			Types			MLU			Complex Sentences			*WH*-Questions		
	B	(*SE*)	*β*	*B*	(*SE*)	*B*	(*SE*)	*β*	*B*	(*SE*)	*B*	(*SE*)	*β*	*B*	(*SE*)
Intervention	280.07***	58.14	.58***	28.44***	9.17	.41***	.23**	.09	.36**	8.25***	2.35	.47***	7.97*	3.56	.35*
Time (as months)	12.61	9.01	.02	1.14	1.36	.02	.01	.01	.02	.44	.38	.03	.23	.47	.01
Intervention*Time	−8.30*	3.26	−.02*	−.97	.50	−.01	−.01	.00	−.01	−.27*	.14	−.02*	.05	.20	.00
Covariates included [e]		Yes			Yes			Yes			Yes			Yes	
Observations		570			570			570			564			570	
Sample size		148			148			148			147			148	

MLU, Mean Length of Utterance; *B*, Estimated Coefficient; *SE*, Standard Error; *β*, Standardized Estimated Coefficient (Effect Size). To examine possible quadratic/cubic effects of time, five post hoc HLMs adding Time^2, Intervention*Time^2 interaction, Time^3, and Intervention*Time^3 interaction were estimated (available upon request). None of these were statistically significant. [a]Mother education level was examined as a categorical variable, with "some high school" as the reference group. [b]Depending on the assessment time point of the maternal language input measures examined in the models, child age, child language skills, and length of recording at the corresponding assessment period were entered into the models as covariates. [c]Depending on the outcome variable in the model, the corresponding measure of maternal language input at baseline was entered as covariates. [d]Observations were reduced because maternal depressive symptoms were assessed only at the 14, 20, and 32-month assessments, not 26 and 38-month assessments. [e]Covariates included maternal education level, language skill, child age, child language skills, family adversity, length of recording, and baseline maternal language input. * $p < .05$. ** $p < .01$. *** $p < .001$.

interaction effects on the other four measures of maternal language input indicated that the intervention increases in Types, $\beta = -.01$, $p = .06$, MLU, $\beta = -.01$, $p = .45$, Complex Sentences, $\beta = -.01$, $p = .10$, and *WH*-Questions, $\beta = .0004$, $p = .96$, were sustained throughout the 18-month post-intervention period, from 20 to 38 months.

Results of the additional HLMs with the intercept re-centered at age 38 months further supported sustained intervention effects on all five measures of maternal language input 18 months post intervention. Just as at age 20 months, Intervention mothers had higher counts than Control mothers on Tokens, $\beta = .58$, $p < .001$, Types, $\beta = .41$, $p < .001$, MLU, $\beta = .36$, $p < .01$, Complex Sentences, $\beta = .47$, $p < .001$, and *WH*-Questions, $\beta = .35$, $p < .05$, at age 38 months. The standardized beta coefficients for the Intervention effects indicated that, compared with Control mothers, Intervention mothers had a significant .58 *SD* increase in Tokens, .41 *SD* increase in Types, .36 *SD* increase in MLU, .47 *SD* increase in Complex Sentences, and .35 *SD* increase in *WH*-Questions 18 months later. Trajectories of change in all five measures of maternal language input from 14 to 38 months are plotted for Intervention and Control mothers separately in Figure 2.

DISCUSSION

Significance of the Present Study

The present study examines whether maternal language input can be promoted early in toddlerhood in a sustainable manner among families facing socioeconomic disadvantages. Testing this research question with a longitudinal randomized controlled trial is a strength. Observing the language mothers use when interacting with their young children at home throughout toddlerhood allows us to obtain rigorous objective measures of maternal language input (Tamis-LeMonda, Kuchirko, Luo, Escobar, & Bornstein, 2017) and to compare the quantity and quality of maternal language input between the Control and Intervention groups over time.

The present study contributes to the literature by revealing that mothers' education levels and language skills are not fixed barriers to enhancing the quantity and quality of their language input for young children in a sustainable manner. Caregivers with higher education levels are likely to provide greater language input for their children early in life, suggesting that these caregivers tend to better understand the importance of early environments in fostering young children's development (Hindman et al., 2016; Huttenlocher et al., 2007). Likewise, caregivers with more proficient language skills often provide high-quality language input when talking with their young children, likely because these caregivers are more capable of using diverse vocabularies, sophisticated words, and complex sentences in their speech (Hoff et al.,

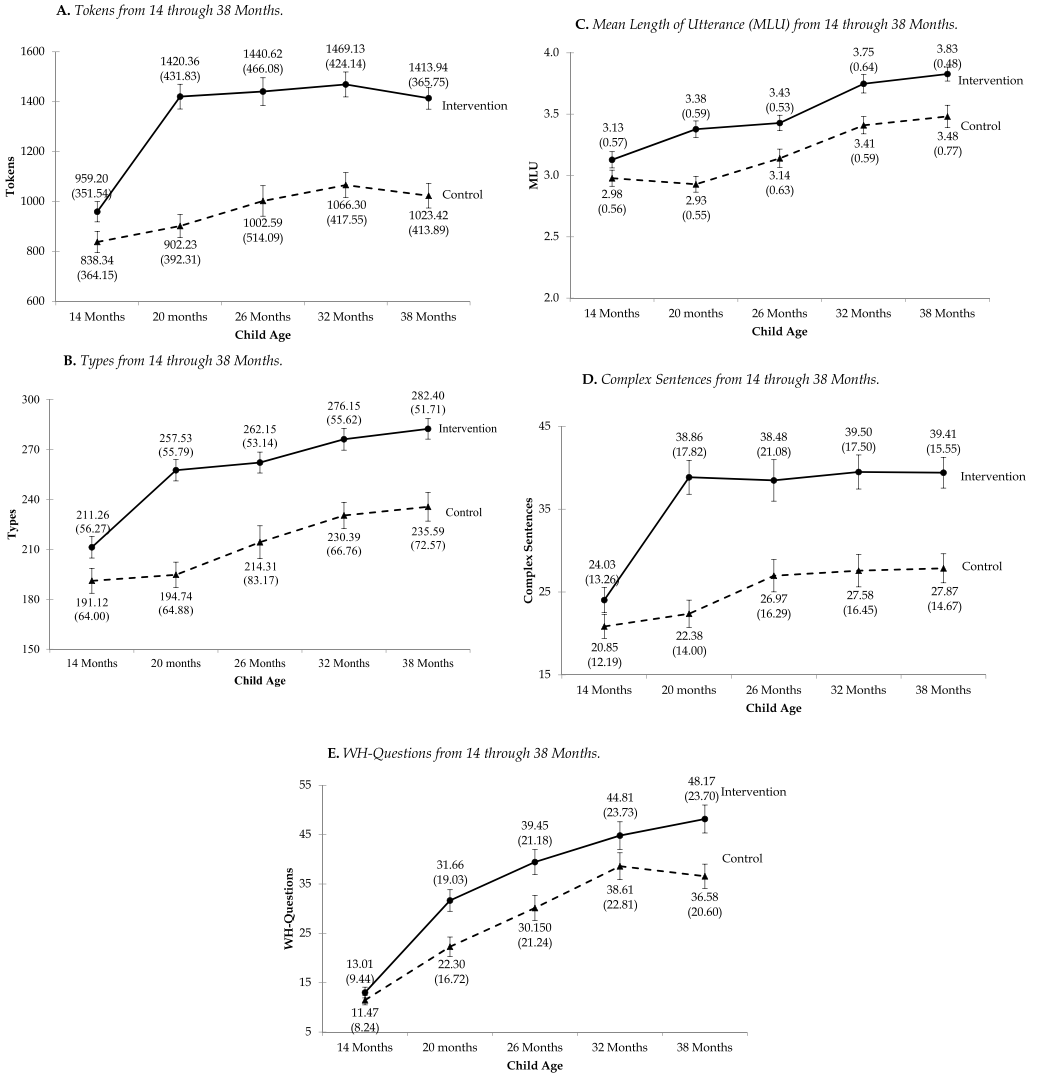

Figure 2. Means and standard deviations of the five maternal language input measures. (a) Tokens from 14 through 38 months. (b) Types from 14 through 38 months. (c) Mean Length of Utterance (MLU) from 14 through 38 months. (d) Complex sentences from 14 through 38 months. (e) WH-questions from 14 through 38 months.

2018; Rowe, 2018; Vernon-Feagans et al., 2020). Limited educational attainment and language skills have been discussed as two major barriers to caregivers of low SES in enriching the language environments for their young children (e.g., Rowe, 2018). However, the present findings reveal that supporting mothers with evidence-based knowledge and strategies to foster an optimal language environment for their young children's development is one strategy to overcome the identified barriers in order to narrow early language input disparities.

The present findings provide empirical evidence that both quantity and quality of maternal language input for young children are malleable among families of low SES. The five different aspects of maternal language input can be enhanced in a sustainable manner through the 3Ts-HV intervention during toddlerhood to enrich the language milieus of young children facing socioeconomic disadvantages. Findings are discussed in light of implications for the study of early childhood language intervention and future directions.

Promoting Language Input among Mothers of Low SES

Language experiences in the first three years of life provide a foundation for children's development. Both quantity and quality of language input directed to children in early childhood have been shown to accelerate their vocabulary and language skills (e.g., Hoff & Naigles, 2002; Huttenlocher et al., 2010; Weisleder & Fernald, 2013), which ultimately contribute to school readiness and academic performance later (Cristofaro & Tamis-LeMonda, 2012; Reynolds et al., 2019; Vernon-Feagans et al., 2020). In an attempt to narrow early language input disparities, the present findings with the Intervention group demonstrate the potential of inducing increases in maternal language input during early toddlerhood to enrich the language environments for young children from low-SES backgrounds.

Through the 3Ts-HV curriculum, Intervention mothers learned about brain plasticity in early childhood, the critical period for language learning, and the lasting impact of early language input on children's brain, cognitive, and language development (Leung et al., 2020). Given their enhanced knowledge of early childhood cognitive and language development, Intervention mothers would be motivated to provide linguistic and cognitive stimulation for their children at a very early age. In support of this argument, Intervention mothers learned to talk more frequently and use more diverse vocabularies, longer utterances, and more complex sentences and *wh*-questions when interacting with their toddlers as early as 20 months of age, around the time when most toddlers better understand the speech directed to them. These findings have implications for addressing early language input disparities by showing that maternal language input in families of low SES can be promoted through intervention very early in a child's life.

To our knowledge, evidence supporting the sustainability of intervention impact on caregiver language behaviors with young children from low-SES backgrounds is still limited. Previous studies with families of low SES have mostly reported short-term intervention impacts on caregiver language input for young children (Hadley et al., 2017; Landry et al., 2012; McGillion et al., 2017). Findings of the present study contribute to the language intervention literature by providing empirical evidence that increases in maternal language input can be sustained among families facing socioeconomic disadvantages

over time. Specifically, the Intervention mothers continued to provide their young children with an elevated vocabulary diversity, syntactic complexity, use of complex sentences, and use of *wh*-questions without showing significant declines 18 months after the initial post-intervention increases.

Moreover, the Intervention mothers talked more with their young children through 12 months after the intervention, but showed a decrease in their elevated language input quantity toward the end of toddlerhood. These mothers might have focused more on increasing the quality rather than quantity of their language input as their young children entered the preschool age period. Nonetheless, the Intervention mothers had a higher input quantity than their Control counterparts throughout the 18 months post intervention, indicating that these mothers increased their language inputs for their young children more than what they would have typically done in the early preschool period.

Sustainability of the Intervention Increases in Maternal Language Input

Several mechanisms might have facilitated the sustainability of the intervention increases in maternal language input over time. Understanding the science behind their language behavior changes might have motivated Intervention mothers to continue to foster an enriched language environment for their children throughout early childhood. Research with families of low SES consistently shows that caregivers who better understand early cognitive and language development are more likely to provide cognitive stimulation and linguistic inputs for their young children (e.g., Leung & Suskind, 2020; List, Pernaudet, & Suskind, 2021). In the present study, the Intervention mothers learned about the developmental science of early childhood and the long-term impact of early language environments on children's development. These mothers might have internalized their role as their young children's first teacher and recognized the critical importance of their language inputs in fostering their young children's brain, cognitive, and language development. Hence, they might have been motivated to maintain the increased quantity and quality of language inputs for their young children through early preschool age.

Moreover, incorporating target behavioral strategies and parenting skills into everyday lives might have helped Intervention mothers maintain language behavior changes with their young children over time. During the 6-month curriculum, scientific concepts were translated into actionable knowledge and applicable behavioral strategies for Intervention mothers. Through guided practices with concrete feedback on strategy application and skill development, Intervention mothers learned to implement the target behavioral strategies and parenting skills to provide high-quantity and high-quality language stimulation for their young children. As Intervention

mothers effectively incorporated the target strategies and skills into their daily routines and interactions with their young children, they were likely to maintain the increased quantity and quality of their child-directed speech over time.

Implementing booster sessions post curriculum might have been a critical element facilitating the sustainability of the intervention increases in maternal language behaviors. Previous language intervention studies have suggested that booster sessions might be necessary to maintain the caregiver language behavior changes over time (Cronan et al., 1996; Landry et al., 2012). In the present study, a series of four boosters was implemented over 18 months after the end of the curriculum to maintain increases in maternal language input. The brief review and discussion included in the booster sessions might have refreshed Intervention mothers' learning of the curriculum materials and reinforced their application of the target behavioral strategies. Additionally, the feedback and collaborative goal setting included in the booster sessions might have also kept Intervention mothers motivated to continue to enrich the language environment of their young children. Booster sessions likely provided necessary supports for Intervention mothers to maintain increases in their child-directed speech through early preschool age.

Limitations and Future Directions

Some limitations of the present study should be noted. The present study observed maternal language input through 18 months after the intervention to examine the sustainability of increases in maternal language input from toddlerhood through early preschool. However, four booster sessions were also implemented during this period of 18 months. The present findings might not simply show the intervention impact, but rather the impact of the boosters on facilitating the maintenance of the intervention impact on maternal language behavior changes. Nevertheless, the present findings demonstrate the importance of providing mothers who face socioeconomic disadvantages with continuous support to enhance their child-directed speech early in life and to enrich their young children's language milieus.

The present study also did not consider the potential long-term intervention impact on children's outcomes. One common goal of language intervention research is to enhance young children's developmental outcomes by promoting caregiver communicative behaviors directed to the children (Greenwood et al., 2020). Our larger study is following the mother-child dyads over five years through children's kindergarten entry. Utilizing longitudinal data on mothers' language behaviors and children's cognitive and language development, future studies will examine how intervention increases in maternal language input in early childhood contribute to young children's language learning, cognitive functioning, and developmental trajectory.

Moreover, missing data might have limited a full evaluation of the long-term intervention impact on maternal language behaviors. To provide rigorous strategies to handle missing data, the HLMs were applied as the analytic procedure, and potential covariates of missingness were taken into account. Indeed, the extant literature documents the unique challenges researchers face in engaging families from socioeconomically disadvantaged backgrounds in longitudinal intervention research (Greenwood et al., 2020). Time constraints, conflicting priorities, multiple life stressors, and/or frequent changes in contact information may have contributed to the difficulties with participant retention in this population. Identifying more proactive retention strategies and sustainable implementation approaches to engage families is critical for future studies in addressing SES-related early language disparities.

The present study focused on language input of the target mother without considering the language input provided by other adult caregivers of the child. Yet, relying on family members for caregiving is common among families with limited economic resources (McWayne, Mattis, & Li, 2020). Other adult caregivers therefore play an important role in shaping the early language environments of the child. Recognizing these diverse caregiving networks, the 3Ts-HV intervention is designed to encourage mothers to maximize language inputs from other adults in their children's lives. Mothers were presented with strategies for sharing what they learned from the curriculum with other caregivers and family members surrounding their children. To better capture the language milieus of young children from low-SES backgrounds, future studies should consider the potential positive spillover effect on promoting the quantity and quality of child-directed speech of other adult caregivers of the children.

To address early language input disparities, the 3Ts-HV intervention is designed to support mothers of low SES with evidence-based knowledge and strategies to enrich the language environment of their young children. However, mothers who do not have access to robust social and economic resources often encounter a variety of challenges and difficulties that negatively impact the quantity and quality of their language input (Schwab & Lew-Williams, 2016). For example, some mothers of low SES are prone to experiencing chronic stress due to food insecurity, housing instability, and/or neighborhood safety; their ability to be physically, emotionally, and cognitively present for their children may be therefore compromised. Hence, future intervention research addressing language disparities should take SES-related stressors and challenges into consideration.

IMPLICATIONS FOR PRACTICE, APPLICATION, AND POLICY

Findings of the present study can help inform community agents, practitioners, and policy stakeholders who work with caregivers of young children experiencing socioeconomic

disadvantages in an effort to narrow early language input disparities. Caregivers from low-SES backgrounds may likely encounter various challenges in enriching the early language milieus for their young children. Translating developmental science into actionable knowledge and incorporating behavioral strategies into everyday activities are essential components in supporting these caregivers. Importantly, providing these caregivers with continuous support significantly enhances their child-directed language input in a sustainable manner throughout early childhood. Together, the present study sheds lights on the critical approach in addressing early learning disparities.

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Ethical Principles

The authors affirm having followed professional ethical guidelines in preparing this work. These guidelines include obtaining informed consent from human participants, maintaining ethical treatment and respect for the rights of human or animal participants, and ensuring the privacy of participants and their data, such as ensuring that individual participants cannot be identified in reported results or from publicly available original or archival data.

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