Journal of Experimental Psychology: General

ISSN: 0096-3445

2024, Vol. 153, No. 11, 2849–2858
https://doi.org/10.1037/xge0001609

Infants and Toddlers in the United States With More Close Relationships Have Larger Vocabularies

Asana Okocha[1], Nicole Burke[2, 3], and Casey Lew-Williams[1]
[1] Department of Psychology, School of Public and International Affairs, Princeton University
[2] Department of Psychology, New York University
[3] Child Mind Institute

Young children learn language from their caregivers, family members, and friends. However, with few exceptions, contemporary developmental scientists have studied language input and language learning through the lens of the primary caregiver and the nuclear family, rather than the infants' broader communities. In many communities—and increasingly in the United States—nonnuclear family structures are common, and extended kin, fictive kin, and intergenerational relationships are relied upon for child care. Understanding children's relationships within kinship networks can allow for more inclusive depictions of children's social interactions and their language experiences. We drew upon methods used by researchers studying social networks to assess U.S. infants' and toddlers' network composition. Results showed that young children with a greater number of close relationships (but not those with larger networks overall) had larger vocabularies, after controlling for age and socioeconomic status. These findings suggest that distributed models of child-rearing are an influential factor in early language growth and call for increased attention to social networks for understanding children's developmental trajectories.

Public Significance Statement
This study suggests that the number of close relationships in infants' and toddlers' social networks is consequential for their language development. The findings extend prior research that has focused more narrowly on mother–child dyads. This study also shows that young children in lower income (vs. higher income) families tend to have more close relationships in their lives, which may offer unique forms of enrichment for their language development.

Keywords: family structure, social networks, vocabulary, socioeconomic status, child development

Young children learn language from their caregivers, family members, and friends, and it is well-documented that the quality and quantity of speech to children influences their cognitive development (Hirsh-Pasek et al., 2015; Rowe, 2012; Shneidman et al., 2013; Weisleder & Fernald, 2013). However, with few exceptions, contemporary developmental scientists have investigated and interpreted findings about language input and language learning through the lens of the primary caregiver and the nuclear family, rather than children's broader communities (e.g., Hart & Risley, 1995; Pan et al., 2005). In some cultures, this focus is reasonable. For example, a study with middle-class families from the United States showed that approximately two thirds of speech input comes from the mother (or primary caregiver) alone (Bergelson & Aslin, 2017). However, estimates of this sort are rarely inclusive of other family structures—particularly cases in which relationships between mother and child are somewhat less centralized due to the presence of other close caregivers or more interconnected familial networks (Sperry et al., 2019). Many families around the world do not rely solely on the nuclear family and instead practice more communal approaches to child-rearing. In the United States, for example, nonnuclear family structures are becoming increasingly common (Cross, 2018), and many

This article was published Online First June 24, 2024.
Tanja Charlotte Roembke served as action editor.
Asana Okocha https://orcid.org/0000-0002-4506-3430
Asana Okocha received funding from the National Science Foundation.
All supplemental materials and analyses can be found on the Open Science Framework at https://osf.io/eg8f9/?view_only=64a21a3db4d846b1ad9479110d22bf4a. Additional analyses include exploratory analyses by language background and by race/ethnicity. These data were previously presented as a poster at two conferences in 2022: the Boston University Conference on Language Development and the International Congress of Infant Studies.

Asana Okocha played a lead role in conceptualization, data curation, formal analysis, investigation, project administration, software, visualization, and writing–original draft and an equal role in funding acquisition, methodology, and writing–review and editing. Nicole Burke played a supporting role in conceptualization, formal analysis, and methodology and an equal role in writing–review and editing. Casey Lew-Williams played a lead role in resources, supervision, and writing–review and editing, a supporting role in methodology, and an equal role in conceptualization and funding acquisition.

Correspondence concerning this article should be addressed to Asana Okocha, Department of Psychology, School of Public and International Affairs, Princeton University, Peretsman Scully Hall, Princeton, NJ 08540, United States. Email: aokocha@princeton.edu

Americans rely on extended kin, fictive kin, and intergenerational relationships for child care (Jones, 2011). To date, relatively little research has investigated the impact of family structure on infants' language learning.

The nuclear family structure, which overwhelmingly characterizes the convenience samples near research institutions in the United States, prioritizes the relationship between one and two primary caregivers and the child. Conversely, extended kin systems, present in many international cultures and communities, as well as in some traditionally marginalized communities in the United States, have historically taken a relatively communal approach to child-rearing. Key characteristics of such a model include a de-emphasis of the two-parent household, the regular presence of many biological and nonbiological kin, distributed child care responsibilities among adults and siblings, and frequent intergenerational contact and care (Fapohunda & Todaro, 1988). As such, a child growing up in these contexts is likely to have close relationships with multiple caregivers, and existing research has called for greater emphasis on the potential impacts of multicaregiver settings (Jones, 2011; Sperry et al., 2019; Weber et al., 2017).

Research in anthropology and sociology has found that extended kin networks are more common in populations that have withstood extreme social and economic oppression, which threatens the nuclear family and encourages cross-family dependence (Brown, 2012; Madhavan & Gross, 2013). In the United States, for example, approximately half of all Black children live in a household with only one custodial parent present compared to roughly one quarter of non-Hispanic White children (U.S. Census Bureau, 2018). Yet, Black Americans show a higher likelihood of daily contact with extended family members, report offering more support to their families, and are more likely to have fictive-kin or nonbiological family relationships than non-Hispanic white individuals (Taylor et al., 2013). Differences in family and personal network structure are not solely based on race. Similarly, adults with lower socioeconomic status (SES) tend to have smaller overall networks, but a higher proportion of kin within their networks (Campbell et al., 1986; Carey & Markus, 2017).

Despite the pervasiveness of extended kin networks in the United States and internationally, most studies on language input and language learning have focused on relationships and interactions with the primary caregiver/s (e.g., Weber et al., 2017; Hart & Risley, 1995; Rowe, 2012). Examining caregiver input with a narrow conception of family structure may cause researchers to miss information that could be crucial to understanding language learning for children living in more communal caregiving settings, a highly common context for many children around the world.

Links between the social environment and children's language outcomes have been long studied, most prominently by Hart and Risley (1995), who documented a "30-million-word gap" in the number of words that children hear in low- versus high-SES households by age 4. That is, children from high-SES families are purported to hear many more words in the first years of life (on average, 45 million total) relative to children from low-SES families (on average, 13 million total), with consequences for children's vocabulary growth over time. These quantitative disparities documented by Hart and Risley have been called into question in multiple ways (see Prather et al., 2022, for commentary about the cognitive sciences in general), and recent research has indicated that the "gap" may be far smaller than originally reported (Gilkerson et al., 2017) or may be absent entirely (Sperry et al., 2020). This has raised questions about the importance of summarizing language input in purely quantified ways. Instead, a clear scientific trend emerging in recent years is the view that the *quality* of language input (defined differently across contexts and communities) is essential for understanding children's language growth (e.g., Casillas et al., 2020; Hirsh-Pasek et al., 2015; Pan et al., 2005). In particular, Sperry et al. (2019) found that accounting for speech from other adults and overheard speech in a child's environment eliminated the word gap. More broadly, studies differ in how much variation in language input they attribute to SES, with estimates ranging from 1% to 35% (Hoff, 2006). This inconsistency suggests that group-level demographics may not be a key cause of differences in children's language input or learning but instead that these differences may be related to other environmental factors that are linked to children's language experiences.

The study by Hart and Risley preceded a sizable body of research that has attempted to describe the range of disparities that may shape children's early learning, spanning environmental, parental, and child-related factors (see Schwab & Lew-Williams, 2016). Research investigating environmental differences has focused on rates of child-directed speech (Shneidman & Goldin-Meadow, 2012) and environmental noise (McMillan & Saffran, 2016); research investigating parental characteristics has included maternal education and literacy skills (Pan et al., 2005) as well as parents' knowledge of child development (Rowe, 2008); and child-centered investigations have focused on numerous dimensions of individual differences, such as children's efficiency in real-time language processing (Weisleder & Fernald, 2013).

However, no published work has explicitly linked differences in family or network structure to children's language input and vocabulary development, although researchers have conducted culturally sensitive work examining language input across cultural contexts. A notable example comes from Casillas et al. (2020), in which researchers collected daylong recordings of 10 young Tseltal Mayan children (aged 2 and 3 years). Rates of child-directed speech were analyzed and related to children's language developmental milestones. Though child-directed speech from the primary caregiver(s) was somewhat lower compared to Western samples, children's language development (measured by babbling and first words) was on par with their age-matched Western peers. This finding highlights the importance of considering children's broader social environments, particularly sources of speech and language input beyond that of the primary caregiver, when assessing opportunities for language growth.

Extended kin contexts may uniquely support young children's word learning. As previously discussed, communities vary considerably in their emphasis on the mother–infant relationship and the degree to which one-on-one interactions between caregiver and child are expected and normalized (Lansford, 2022). Close relationships with a greater number of individuals, particularly with more adults, may support alternative pathways to early learning language. This idea is based on prior research emphasizing the benefits of familiarity with speakers in the language environment (e.g., Barker & Newman, 2004) as well as variation across talkers (e.g., Estes & Lew-Williams, 2015). It may be the case that multiple close relationships with adult caregivers and/or other children create an optimal learning environment with just the right amount of consistency and variability across talkers. Though mother–child

interactions are somewhat decentralized in such a model, young children raised in extended kinship contexts may readily learn language from other close adults and children in their lives, both through child-directed and overheard speech. This is further supported by laboratory-based work linking multiple-caregiver settings to an increased ability to attend to and learn from overheard speech in preschool children (Shneidman et al., 2009). These findings suggest that, across kin structures, there is heterogeneity in patterns of language input to children, as well as variability in children's ability to attend to and learn from various kinds of speech (see Ramírez-Esparza et al., 2017).

To better understand early language learning, it is necessary to consider the broad range of social partners that children interact with on a regular basis, which could enable an understanding of the real dimensionality of children's communicative experiences—well beyond the focus on SES in recent psychological science. An excellent framework in the social sciences that can consider how a child is embedded in their broader environment is a social network perspective. In the present study, we draw upon methods used by researchers studying social networks to assess infants' network compositions via social network analysis (SNA). SNA maps the position of individuals (or egos) in a broader structure of dyadic relationships with and between others, referred to as alters (Perry et al., 2018; see also Wasserman & Faust, 1994). Previous studies using SNA have examined relationships among older children and adolescents, linking social network characteristics to psychological and behavioral outcomes such as proliferation of social norms within schools (e.g., Paluck et al., 2016) and peer influences on consequential behaviors like adolescent smoking (e.g., Ennett et al., 2008). The majority of social network research in developmental science examines networks through a whole-network lens, typically making use of "closed" environments such as schools and exploring outcomes at the group level, as opposed to the individual level. Relatively less research has sought to understand development through an egocentric network approach, and very little work has explored infants' and toddlers' personal networks (Neal, 2020).

Using egocentric networks to explore how young children's social environments relate to their vocabulary development is a novel approach for capturing the nuances of early social interactions. As previously stated, relatively little work has used this approach in infancy and early childhood; however, initial work in this area has led to promising discoveries. A recent study by Burke et al. (2022) showed that infants' and young children's networks can be extracted through parent report and that aspects of the network, such as its size or the diversity of relationships within it, can be used to describe aspects of experience that developmental psychologists typically care about. For example, the study found that from infancy through age 5 there is a marked increase in network size. As children got older, their network size increased (Burke et al., 2022). Furthermore, the number of kin and peer relationships was assessed, as well as the emotional intensity of each relationship, referred to as strong versus weak ties in the network literature (Granovetter, 1973). As network size increased, the proportions of peer relationships, nonkin relationships, and weak ties all increased (Burke et al., 2022). While networks can be used to describe the nuances of children's early social interactions, there is also great potential for using these methods to better understand early language learning. Vocabulary size is a particularly relevant aspect of early communication, given that it is known to predict later life outcomes, at least in certain communities and cultures. How does variability in children's social networks relate to their vocabulary size? For example, is it more beneficial for vocabulary growth for children to have exposure to just one or two speakers (i.e., a strict nuclear family model), to many different speakers (i.e., a large social network with a high proportion of weak ties), or to a large number of close others (i.e., many strong ties in an extended family)? By assessing the number of relationships in children's social networks (overall network size) and the type of relationship (strong vs. weak ties), the present study begins to tease apart these possibilities.

By measuring the overall number of people (network size) and the intensity of each relationship (strong or weak tie), we can determine whether there is a relation between network properties and vocabulary size. Although our study was correlational in nature, making it difficult to infer causality, this investigation aimed to understand how speaker variability in children's social networks relates to their early language development.

The Present Study

The present investigation used social network methods as a means for exploring kinship dynamics with the goal of understanding variation in infants' and toddlers' vocabulary size. We analyzed relationships between young children's social network characteristics (with an emphasis on children's close relationships) and their vocabulary size within a diverse, U.S.-based sample. We emphasized a child-centered definition of kinship; rather than creating our own binary definition of kin, we considered all relationships as potentially influential for learning. In a preregistered study (https://aspredicted.org/vu2xx.pdf) using two parent-report surveys, our main hypothesis was that children would have larger vocabularies if they had more close relationships (referred to hereinafter as strong ties; Granovetter, 1973), driven by an optimal combination of familiarity and variability in young children's communicative interactions. There were three additional preregistered predictions: children with larger *overall* networks would also have larger vocabularies; the number of strong ties would be negatively correlated with SES (operationalized as yearly household income), such that lower SES children would have a greater number of strong ties (as explored by Campbell et al., 1986; Carey & Markus, 2017; Granovetter, 1973; McPherson et al., 2006); and overall social network size would increase with child age, replicating Burke et al. (2022). Together, the components of this investigation aimed to account for diverse and underrepresented kin structures, which have not been the focus of prior research on language learning. This focus is needed in order to better understand the natural complexity of language input to young children in their social environments and ultimately of within- and between-group differences in language growth.

Method

Transparency and Openness

The data set utilized in this study is available on the Open Science Framework (OSF) at https://osf.io/eg8f9/?view_only=64a21a3db4d846b1ad9479110d22bf4a. The data citation is provided in the reference list. The code used for data analysis is freely available at the OSF (https://osf.io/eg8f9/?view_only=64a21a3db4d846b1ad9479

110d22bf4a; Okocha et al., 2023). All analyses were conducted in Rstudio Version 2022.07.1 (RStudio Team, 2022, ggplot (Wickham, 2016), and tidyverse (Wickham et al., 2019). Detailed descriptions of the analytic methods employed in this study are provided in the Method section. All materials and instruments used in data collection are described in the supplementary materials on the OSF and Method section. This study was preregistered on AsPredicted (https://aspredicted.org/vu2xx.pdf). No replication studies have been conducted.

Participants

Participants in our preregistered study were 369 English-speaking parents or legal guardians of infants and toddlers in the United States (infant age range = 12–37 months, $M = 24.8$ months; 189 caregivers identified their child's gender as girl and 177 as boy, and three preferred not to say). A power analysis based on pilot data from $N = 121$ participants showed that $N = 350$ parents or legal guardians would be needed to achieve sufficient power. Young children's race/ethnicity was intended to be approximately census-matched, although this was not perfect. A table of children's reported race/ethnicity is shown in Table 1. Annual household incomes ranged from <$25,000 to >$200,000, and 44.2% of participants had annual household incomes of less than $50,000. Finally, 313 respondents were the child's mother. We excluded 38 participants from the original sample due to parents' failure to pass a data quality check (discussed below). We excluded 20 additional participants who entered names of network members that were incomprehensible and likely inauthentic (e.g., "Hhhhhh"). Demographic data were collected using the following questions:

1. Please enter your child's birth date (formatted as yyyy/mm/dd).
2. What is your child's gender?
    a. Participants could select one of the following: Girl, Boy, Agender, Non-binary, I prefer another answer, I prefer not to say
3. What is your child's race/ethnicity? (Please select all that apply)
    a. Participants could select any of the following: Black or African American, White or European American, Asian or Asian American, Mixed/Biracial, Hispanic or Latino/a, Native American or Pacific Islander, Other, I prefer not to say
4. During a typical week, what language(s) does your child hear? Please only think about all the words your child has spoken directly to him or her (i.e., not TV or radio).
    a. My child hears English only
    b. My child hears English and one or more other languages
    c. My child does not hear English
5. Conditional: What language(s) other than English does your child hear?
    a. Free response box
6. What is your typical yearly household income?
    a. Scale from "$0" to "Greater than $200,000 per year"

Table 1
Children's Races/Ethnicities

Race/ethnicity	Count	Percentage
White	233	63
Black	32	9
Latinx	22	6
White and Hispanic or Latinx	20	5
Asian	16	4
Multiracial only (unspecified)	13	4
Black and White	8	2
White and Asian	5	1
Native or Pacific Islander	4	1
White and Native or Pacific Islander	4	1
Other	3	<1
Black and Hispanic or Latinx	2	<1
Prefer not to say	2	<1
Asian and Hispanic or Latinx	1	<1
Black and White, Hispanic or Latinx	1	<1
Black, White, Hispanic or Latinx and other	1	<1
Latinx and Native or Pacific Islander	1	<1
White and multiracial (unspecified)	1	<1

Survey

Using an online survey administered through Cint, we collected information about young children and the people they interact with regularly, including family and nonfamily (survey instrument and data have been made publicly available at https://osf.io/eg8f9/?view_only=64a21a3db4d846b1ad9479110d22bf4a). The content and wording of the questionnaire was adapted based on Burke et al. (2022). Participants provided first names of the people who their child interacted with regularly (at least once per week, in person or virtually). We first prompted parents to list the members of their child's household or households, and then we asked them about their child's sources of child care, such as daycare or preschool. Parents were asked to list the caretakers or teachers who regularly interacted with their child in those settings, as well as any children who stood out as a friend. We specifically asked parents about other children (under 18 years of age) who regularly interacted with their child, and we included those children in all analyses. Finally, we asked parents to list any adults or children who they had not listed previously. This methodology is supported by current best practices in social network research, which suggests that network surveys should organize information according to existing social structures (e.g., kinship roles) but should also provide opportunities for free recall of people and names (Scott & Carrington, 2014). In a subsequent section, we asked parents to supply relevant information about each reported individual. For each member of a child's network, participants reported gender, race/ethnicity, and age.

Each respondent (one parent or legal guardian) answered multiple questions meant to assess the strength of each relationship from the perspective of the infant, focusing on both observed behaviors (*Does your child show signs of missing this person when they are not around?*) and expected behaviors (*If this person arrived at your front door, would your child willingly go somewhere with him or her alone?*). Finally, respondents estimated the number of hours their

child typically spent with each individual in the child's network per week. Early termination of the survey questionnaire was automatically initiated if respondents indicated that they were not the child's parent or legal guardian or if the child's birth date was not within a previously determined range. We cross-checked the answer to two questions to determine whether participants were paying attention to the survey questions and reporting authentic information. The first question asked for the child's birth date and the last question asked for the child's age in years and months; we excluded responses from participants who entered dates or ages that differed by 4 months or more.

Following the network questionnaire, we administered the MacArthur–Bates Communicative Development Inventory Short Form III (MCDI) in order to estimate vocabulary size (Fenson et al., 2006). This tool provides a checklist of 100 lexical items and asks parents to indicate if their child produces each word (see Fenson et al., 2000). Finally, we asked parents to provide their own basic demographic information, including yearly household income, maternal education, race and ethnicity, and gender.

Results

Our main preregistered hypothesis was that social network characteristics would correlate with infants' and toddlers' vocabulary development, such that children with more strong ties would have larger vocabularies. Second, we predicted that vocabulary size would be positively correlated with overall network size. Third, we predicted that SES would shape network characteristics, such that lower SES participants would have a greater number of strong ties. Finally, we tested the confirmatory prediction that social network size would be positively correlated with infants' ages (Burke et al., 2022).

Number of Strong Ties (Close Relationships) Positively Associated With Young Children's Vocabulary Size

To evaluate whether the number of infants' and toddlers' strong ties was related to their productive vocabulary sizes (controlling for age and income), we first used a single measure of closeness. Network members for whom parents answered, "Yes, often" when asked, "Does your child show signs of missing this person when they are not around?" were counted as a strong tie within the target child's network. Using this measure of closeness, we found a significant, positive relationship between the number of strong ties and a child's MCDI score from a multiple linear regression model, $\beta = 0.16$, $p = .01$; $R^2 = .28$, $F(4, 364) = 36.02$, $p < .001$. We additionally tested a composite score representing the average of our first measure of closeness (Does your child show signs of missing this person when they are not around?) and an additional measure (*If this person showed up at your front door, would your child willingly go somewhere with them alone?*). There was a significant and positive relationship to MCDI scores, such that children with more strong ties had larger vocabularies, $\beta = .17$, $p = .008$; $R^2 = .28$, $F(4, 364) = 36.11$, $p < .001$ (Figure 1).

Overall Network Size Does Not Predict Vocabulary Size

To address the specificity of the effect on vocabulary, we next compared infants' and toddlers' overall network sizes to their MCDI scores, again controlling for age and income. A multiple linear regression model did not reveal a significant relationship between total network size and MCDI score, $\beta = 0.08$, $p = .1$; $R^2 = .26$, $F(4, 364) = 33.22$, $p < .001$. These findings suggest that the number of strong ties in infants' and toddlers' social networks may be more influential in shaping vocabulary growth than the number of weaker ties or overall ties (see additional online materials at https://osf.io/eg8f9/?view_only=64a21a3db4d846b1ad9479110d22bf4a). But importantly, directionality could also be the reverse, where young children with better (vs. weaker) language skills develop more strong ties over time as a result of their communicative proficiency.

Income Predicts Number of Strong Ties, but Only When Adjusting for Household Size

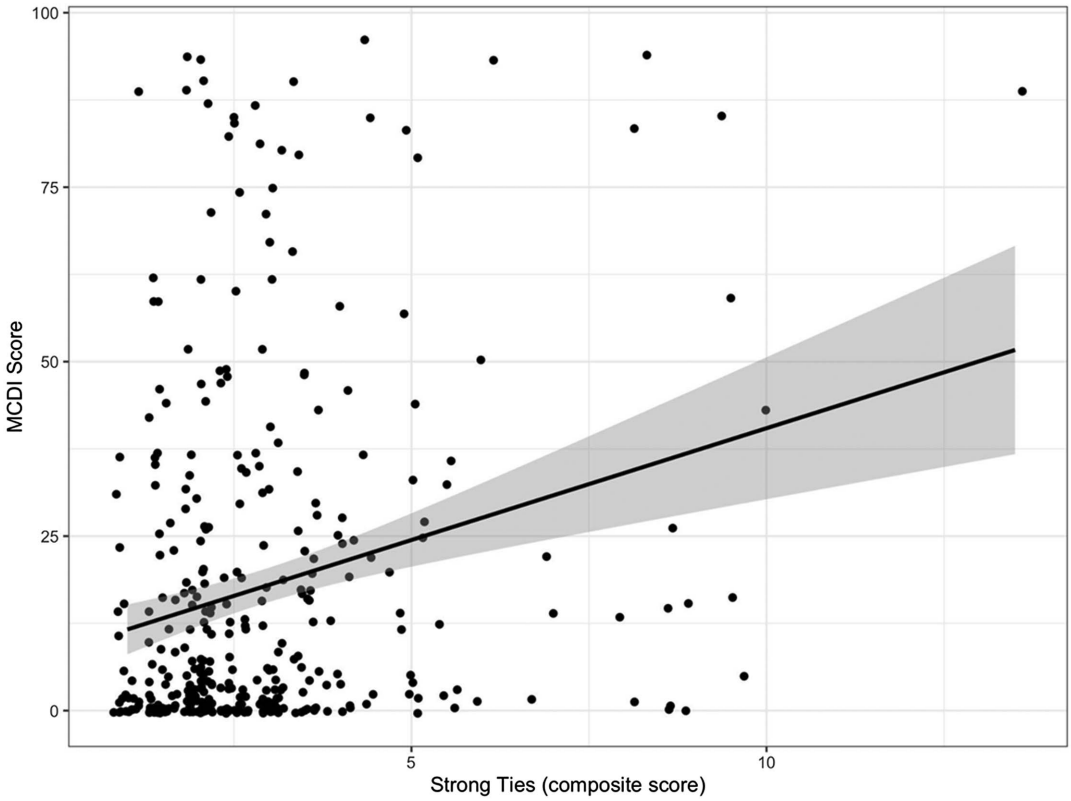
Our next preregistered prediction was that SES (operationalized as total yearly household income) would be negatively correlated with the number of strong ties. However, we did not find a significant relationship between yearly household income and strong ties through a multiple regression model ($\beta = 0.05$, $p = .27$, CI [−0.05, 0.16]). Similarly, there was no relationship between yearly household income and overall network size, $\beta = -.09$, $p = .1$; $R^2 = .014$, $F(2, 366) = 3.5$, $p = .03$.

As an exploratory follow-up, we tested a per person calculation of SES, given that overall yearly household income does not account for variation in standards of living across different family sizes. We divided yearly household income by the number of individuals in the household, exponentiated by 0.5, which accounts for the fact that household expenditures do not increase linearly as the number of individuals increases (see additional online materials at https://osf.io/eg8f9/?view_only=64a21a3db4d846b1ad9479110d22bf4a and Taylor et al., 2011, for more detailed explanations of this measure). Adjusted income showed a significant negative relationship with the number of strong ties, such that infants in lower SES households had more strong ties than those in higher SES households, $\beta = -0.17$, $p = .009$; $R^2 = .03$, $F(2, 366) = 5.82$, $p = .003$. This exploratory result suggests that *per capita* income is a potentially useful proxy for SES and may be a more fruitful way to define SES in future investigations (Figure 2).

Infants' and Toddlers' Overall Network Size and Number of Strong Ties Grow as They Age

Finally, replicating a finding from Burke et al. (2022), we found a significant positive relationship between child age and overall network size, $\beta = 0.1$, $p = .047$; $R^2 = .01$, $F(1, 367) = 4.17$, $p = .04$, suggesting that infants' social networks tend to grow larger as they age. Age also predicted the number of strong ties, $\beta = 0.13$, $p = .01$; $R^2 = .014$, $F(1, 367) = 6.36$, $p = .012$. A limitation from Burke et al. (2022) is that the sample skewed toward higher SES, meaning it was not possible to evaluate whether the relation between network size and child age varied by SES. Here, we conducted a linear regression with child age as the dependent variable and included network size and income as main effects, and the overall model was not significant, $F(2, 361) = 2.18$, $p = .11$, $R^2 = 0.01$. While we see no evidence that income relates to child age, we do see evidence that network size is correlated with child age, although these findings must be interpreted with caution.

Figure 1
Strong Ties Are Correlated With MCDI Score



Note. Shaded gray area indicates 95% confidence intervals. Correlation between children's number of strong ties (i.e., close relationships) and their vocabulary scores on the MCDI. MCDI = MacArthur–Bates Communicative Development Inventory.

Exploratory Analyses Between Vocabulary, Household Income, and Weak Ties

To augment the analysis outlined above, we tested several additional exploratory hypotheses. First, we explored the general relationship between SES and vocabulary. Next, we analyzed the role of *weak ties* in predicting children's vocabulary outcomes. From a multiple regression model, we found that there was no significant relationship between household income and MCDI (controlling for age) in our sample ($\beta = .04$, $p = .3$, CI [−.05, 0.13]). The adjusted measure of income also did not predict MCDI score (controlling for age; $\beta = 0.025$, $p = .57$ CI [−0.06, 0.1]). To evaluate the influence of weak ties on young children's vocabularies, we ran a multiple linear regression model including the total number of weak ties (total network size − number of strong ties), controlling for age and income. There was no significant relationship between weak ties and MCDI score ($\beta = 0.02$, $p = .6$, CI [−0.08, 0.12]). A feature of networks is that weak ties are often the source of growth in overall networks both for adults (Perry et al., 2018) and young children (Burke et al., 2022). This null result is perhaps not surprising given that *overall* network size did not predict vocabulary size and provides further evidence that it is children's contact with their strong ties that is beneficial for their vocabulary growth.

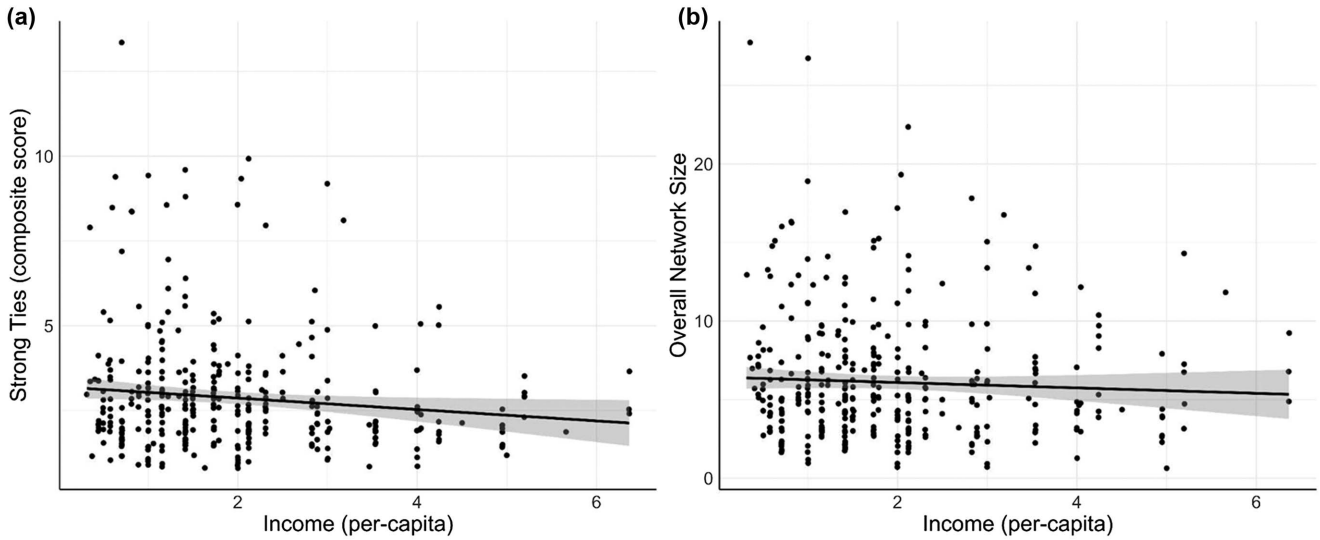
Discussion

This study examined links between children's social relationships and their vocabulary skills using a roughly representative sample of parents of young children in the United States. In an online survey, parents reported about the individuals in the child's life, rated the strength of those relationships, and completed a 100-item vocabulary questionnaire. We found that children with more strong ties (i.e., close relationships) had larger vocabularies, after controlling for age and SES. Furthermore, we found that neither overall network size nor the number of weak ties predicted vocabulary, suggesting that close relationships are a particularly relevant factor for vocabulary development. We also found that per capita income was negatively correlated with the number of strong ties for children in our sample. Finally, we found that overall social network size and strong ties increased with child age, supporting a previous finding in the literature (Burke et al., 2022).

Although this study is the first to explicitly link social network characteristics to vocabulary size, we cannot make conclusions regarding directionality. That is, we cannot rule out the possibility that language skills influence the number of close relationships in a child's life. It is possible that a child with advanced language skills would be better able to maintain a high number of close relationships

Figure 2

Correlations Between per Capita Income and Network Characteristics



Note. Shaded gray area indicates 95% confidence intervals. Per capita income significantly predicted strong ties, and infants in lower income households had more strong ties. There was no significant relationship between per capita income and overall network size.

in their life. However, previous findings in psychology and neuroscience support the idea that social network characteristics shape language abilities rather than the reverse. First, research with macaque monkeys has shown that living in larger social groups causes changes in brain development and function (Sallet et al., 2011). Though human research is limited in its ability to make such causal claims based on social characteristics, a similar link has been identified between adult humans' social network sizes and the size of specific brain regions (Bickart et al., 2011). Although these findings are not directly related to variation in young children's learning, laboratory-based research has made strides in linking children's social contexts to their ability to learn from various types of language input. For example, in a behavioral study with preschool-aged children, a greater amount of time spent around multiple adults at home predicted young children's ability to attend to and learn from overheard speech in the lab (Shneidman et al., 2009). This study does not rule out the possibility that children seek out larger social networks if they are better at learning from overheard speech, but the authors argue that this possibility is unlikely because young children have little control over the number of adults present at a given moment in their lives. Instead, external factors such as family and household size, parenting decisions, SES, and geography are likely to be more influential in shaping a child's daily exposure to adults.

Our study revealed differences between strong versus weak ties in predicting children's vocabulary. Why might this difference be meaningful? Prior social network research with adults has suggested that there may be benefits of having weak ties within a social network, particularly in their usefulness for accruing social capital and gaining access to opportunity (Granovetter, 1973). Scholars have also argued that social inequality is exacerbated by unequal distributions of weak ties between racial and class groups (Campbell et al., 1986; DiMaggio & Filiz, 2012), and social interventions have targeted weak ties for improving economic and social outcomes (e.g., Vasilaky & Leonard, 2018). Interestingly, some scholars argue that closer networks (those with more strong ties) produce redundancy in contact and thus are less useful for accessing novel and potentially useful resources, which exacerbates existing inequality (Granovetter, 1973; see Carey & Markus, 2017, for a notable exception). The results of our study support an alternative viewpoint by proposing that many strong ties within a social network may support young children's language growth.

Although our study did not address potential mechanisms underlying the effect of strong ties on children's vocabularies, we cautiously propose that having numerous strong ties may engender unique cognitive benefits for young children, which ultimately supports their language growth. In particular, many strong ties may introduce optimal amounts of both *redundant* and *diverse* language into a child's language environment. This hypothesis is supported by existing work examining the effects of redundancy, familiarity, and variability on learning.

On the one hand, strong ties within a network create *speaker redundancy*, which may be useful for helping children detect the sounds, words, and sentences that are important in their environment. When learning new words, children must direct their attention to relevant information and decrease attention to irrelevant information (Axelsson et al., 2012), and existing evidence shows that contextual redundancy aids young children's initial word learning and retention (Axelsson & Horst, 2014; Horst, 2013; Horst et al., 2011; Sénéchal & Cornell, 1993). This raises the question of how exposure to new words may differ when hearing speech from strong versus weak ties. For a highly familiar speaker (i.e., a strong tie), a new word may be easier to process and parse and easier to map to an object or event. The child's mental representation may become increasingly robust as they hear the word from additional familiar speakers. But, for an unfamiliar speaker (such as a weak tie in a

child's social network), the child may not as readily encode or understand the word. Existing work supports this idea. For example, Barker and Newman (2004) showed that talker familiarity enhanced infants' ability to process a speech stream against background noise. Over time, exposure to speech from multiple familiar speakers may help young children find and learn from the speech that matters most, and our data suggest that speech from many unfamiliar speakers (i.e., weak ties) may not carry this same benefit for word learning. Future investigations should examine the relationship between the number of strong ties within a child's network and the proportion of speech from familiar versus unfamiliar speakers in naturalistic settings.

While familiar speakers are certainly helpful for word learning, having multiple strong ties within a social network is also likely to introduce a certain amount of meaningful speaker variability, that is, neither too much nor too little variability. There is a wealth of existing evidence showing that variability of stimuli shapes learning, sometimes for better and sometimes for worse (e.g., Gómez, 2002; Rost & McMurray, 2009; Singh, 2008; Thiessen, 2011). In research on language learning, some findings indicate that speaker variability hinders children's and adults' word learning, due to the added acoustic complexity of hearing many different voices (Creel & Bregman, 2011; Jusczyk et al., 1992; Mullennix et al., 1989).

However, other work has shown that speaker variability helps infants learn phonological categories (Rost & McMurray, 2009) and may support the identification and encoding of the invariant properties within an utterance (Houston & Jusczyk, 2000). Research by Estes and Lew-Williams (2015) may help reconcile this apparent contradiction. In a controlled experiment with infants, exposure to a speech stream with low speaker variability (two speakers) derailed word segmentation ability, while exposure to a stream with higher speaker variability (eight speakers) aided segmentation. This difference is not easy to map onto definitions of strong versus weak ties, but it may be the case that having *more than two* recurring speakers is beneficial for learning-related challenges in language. In the natural world, a traditional nuclear family context may often produce situations similar to experimental conditions with low speaker variability, while an extended kin context, defined here as having numerous strong ties, might produce more learning opportunities resembling conditions with high speaker variability.

Limitations

There were various aspects of the design and context that limit our ability to make general conclusions about children's home contexts and language development. First, proxy reporting in survey methods is biased by the experience of the person filling out the survey (Blair et al., 2004; Epley, 2008). Parents may be limited in their ability to accurately recall the individuals in their child's life or assess their child's behaviors in relation to others. However, we do have some initial evidence that our survey did not introduce overwhelming bias into the results. Comparing our results to those of Burke et al. (2022) reveals a similar relation between child age and social network size. Second, this study was limited in its ability to make causal claims regarding children's close relationships and their vocabulary sizes. Our study sought to shed light on the potential benefits of multicaregiver settings, but due to its observational nature, we cannot eliminate the possibility that children with larger vocabularies develop more strong ties due to communicative prowess or self-selection. Third, though we were interested in understanding the ways in which children's language development varies in relation to their relationships, we did not collect naturalistic recordings of children's daily interactions. Thus, we cannot examine how the many people in a child's life contribute to patterns of language input and children's vocabulary growth—an exciting direction for future research. There may, for example, be ways in which weaker ties influence language development that we were not able to capture in our survey-based approach. That is, weaker ties are unlikely to be irrelevant to young children's language learning, and future research should examine how children's infrequent communications with certain network members may supplement their learning from stronger ties. Fourth, although this study recruited a diverse sample of participating families, we did not have the ability to explore geographic or cultural variation in social network size or composition.

Constraints on Generality

Critically, all of the participants within our sample resided in the United States, and White and Hispanic/Latino participants were underrepresented. This limits our ability to make claims about infants and toddlers residing in nations and communities beyond the United States, where extended kin networks are sometimes more common (Brown, 2012; Madhavan & Gross, 2013). Future investigations should explore cross-community variability in young children's social network size and composition as it relates to their language growth over time. This study is also limited in its ability to make claims about children living in multilingual communities, as our sample did not contain adequate power to make comparisons between linguistic groups. Descriptive statistics and preliminary language analyses are included in the additional online materials at https://osf.io/eg8f9/?view_only=64a21a3db4d846b1ad9479110d22bf4a.

Conclusion

Many researchers have highlighted the need for a more contextualized understanding of language input in order to understand children's development and learning (e.g., Casillas et al., 2020; Sperry et al., 2020), and this study makes a similar call to action. Considering family and network structure in investigations of young children's home language environments offers promising explanatory power for uncovering within- and across-group heterogeneity in language outcomes.

References

Axelsson, E. L., Churchley, K., & Horst, J. S. (2012). The right thing at the right time: Why ostensive naming facilitates word learning. *Frontiers in Psychology*, *3*, Article 88. https://doi.org/10.3389/fpsyg.2012.00088

Axelsson, E. L., & Horst, J. S. (2014). Contextual repetition facilitates word learning via fast mapping. *Acta Psychologica*, *152*(95), 95–99. https://doi.org/10.1016/j.actpsy.2014.08.002

Barker, B. A., & Newman, R. S. (2004). Listen to your mother! The role of talker familiarity in infant streaming. *Cognition*, *94*(2), B45–B53. https://doi.org/10.1016/j.cognition.2004.06.001

Bergelson, E., & Aslin, R. N. (2017). Nature and origins of the lexicon in 6-mo-olds. *Proceedings of the National Academy of Sciences of the United*

States of America, *114*(49), 12916–12921. https://doi.org/10.1073/pnas.1712966114

Bickart, K. C., Wright, C. I., Dautoff, R. J., Dickerson, B. C., & Barrett, L. F. (2011). Amygdala volume and social network size in humans. *Nature Neuroscience*, *14*(2), 163–164. https://doi.org/10.1038/nn.2724

Blair, J., Menon, G., & Bickart, B. (2004). Measurement effects in self vs. Proxy response to survey questions: An information processing perspective. In P. P. Biemer, R. M. Groves, L. E. Lyberg, N. A. Mathiowetz, & S. Sudman (Eds.), *Measurement errors in surveys* (pp. 145–166). Wiley. https://doi.org/10.1002/9781118150382

Brown, S. L. (2012). Poverty status and the effects of family structure on child well-being. In R. King & V. Maholmes (Eds.), *The Oxford handbook of poverty and child development* (pp. 54–67). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199769100.013.0003

Burke, N., Brezack, N., & Woodward, A. (2022). Children's social networks in developmental psychology: A network approach to capture and describe early social environments. *Frontiers in Psychology*, *13*, Article 1009422. https://doi.org/10.3389/fpsyg.2022.1009422

Campbell, K. E., Marsden, P. V., & Hurlbert, J. S. (1986). Social resources and socioeconomic status. *Social Networks*, *8*(1), 97–117. https://doi.org/10.1016/S0378-8733(86)80017-X

Carey, R. M., & Markus, H. R. (2017). Social class shapes the form and function of relationships and selves. *Current Opinion in Psychology*, *18*, 123–130. https://doi.org/10.1016/j.copsyc.2017.08.031

Casillas, M., Brown, P., & Levinson, S. C. (2020). Early language experience in a tseltal Mayan village. *Child Development*, *91*(5), 1819–1835. https://doi.org/10.1111/cdev.13349

Creel, S. C., & Bregman, M. R. (2011). How talker identity relates to language processing. *Language and Linguistics Compass*, *5*(5), 190–204. https://doi.org/10.1111/j.1749-818X.2011.00276.x

Cross, C. J. (2018). Extended family households among children in the United States: Differences by race/ethnicity and socio-economic status. *Population Studies*, *72*(2), 235–251. https://doi.org/10.1080/00324728.2018.1468476

DiMaggio, P., & Filiz, G. (2012). Network effects and social inequality. *Annual Review of Sociology*, *38*(1), 93–118. https://doi.org/10.1146/annurev.soc.012809.102545

Ennett, S. T., Foshee, V. A., Bauman, K. E., Hussong, A., Cai, L., Reyes, H. L. M., Faris, R., Hipp, J., & Durant, R. (2008). The social ecology of adolescent alcohol misuse. *Child Development*, *79*(6), 1777–1791. https://doi.org/10.1111/j.1467-8624.2008.01225.x

Epley, N. (2008). Solving the (real) other minds problem. *Social and Personality Psychology Compass*, *2*(3), 1455–1474. https://doi.org/10.1111/j.1751-9004.2008.00115.x

Estes, K. G., & Lew-Williams, C. (2015). Listening through voices: Infant statistical word segmentation across multiple speakers. *Developmental Psychology*, *51*(11), 1517–1528. https://doi.org/10.1037/a0039725

Fapohunda, E. R., & Todaro, M. P. (1988). Family structure, implicit contracts, and the demand for children in Southern Nigeria. *Population and Development Review*, *14*(4), 571–594. https://doi.org/10.2307/1973625

Fenson, L., Marchman, V. A., Thal, D. J., Dale, P. S., Reznick, J. S., & Bates, E. (2006). *MacArthur-Bates Communicative Development Inventories, second edition (CDIs)* [Database record]. APA PsycTests. https://doi.org/10.1037/t11538-000

Fenson, L., Pethick, S., Renda, C., Cox, J. L., Dale, P. S., & Reznick, J. S. (2000). Short-form versions of the MacArthur Communicative Development Inventories. *Applied Psycholinguistics*, *21*(1), 95–115. https://doi.org/10.1017/S0142716400001053

Gilkerson, J., Richards, J. A., Warren, S. F., Montgomery, J. K., Greenwood, C. R., Kimbrough Oller, D., Hansen, J. H. L., & Paul, T. D. (2017). Mapping the early language environment using all-day recordings and automated analysis. *American Journal of Speech-Language Pathology*, *26*(2), 248–265. https://doi.org/10.1044/2016_AJSLP-15-0169

Gómez, R. L. (2002). Variability and detection of invariant structure. *Psychological Science*, *13*(5), 431–436. https://doi.org/10.1111/1467-9280.00476

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, *78*(6), 1360–1380. https://doi.org/10.1086/225469

Hart, B., & Risley, T. R. (1995). *Meaningful differences in the everyday experience of young American children*. Paul H Brookes Publishing. https://doi.org/10.1093/jpepsy/24.1.85

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., Yust, P. K. S., & Suma, K. (2015). The contribution of early communication quality to low-income children's language success. *Psychological Science*, *26*(7), 1071–1083. https://doi.org/10.1177/0956797615581493

Hoff, E. (2006). How social contexts support and shape language development. *Developmental Review*, *26*(1), 55–88. https://doi.org/10.1016/j.dr.2005.11.002

Horst, J. S. (2013). Context and repetition in word learning. *Frontiers in Psychology*, *4*, Article 149. https://doi.org/10.3389/fpsyg.2013.00149

Horst, J. S., Parsons, K. L., & Bryan, N. M. (2011). Get the story straight: Contextual repetition promotes word learning from storybooks. *Frontiers in Psychology*, *2*, Article 17. https://doi.org/10.3389/fpsyg.2011.00017

Houston, D. M., & Jusczyk, P. W. (2000). The role of talker-specific information in word segmentation by infants. *Journal of Experimental Psychology: Human Perception and Performance*, *26*(5), 1570–1582. https://doi.org/10.1037/0096-1523.26.5.1570

Jones, D. J. (2011). Coparenting in extended kinship systems: African American, Hispanic, Asian heritage, and Native American families (K. M. Lindahl, Ed.). In J. P. McHale & K. M. Lindahl (Eds.), *Coparenting: A conceptual and clinical examination of family systems* (pp. 61–79). American Psychological Association. https://doi.org/10.1037/12328-003

Jusczyk, P. W., Pisoni, D. B., & Mullennix, J. (1992). Some consequences of stimulus variability on speech processing by 2-month-old infants. *Cognition*, *43*(3), 253–291. https://doi.org/10.1016/0010-0277(92)90014-9

Lansford, J. E. (2022). Annual research review: Cross-Cultural similarities and differences in parenting. *Journal of Child Psychology and Psychiatry*, *63*, 466–479. https://doi.org/10.1111/jcpp.13539

Madhavan, S., & Gross, M. (2013). Kin in daily routines: Time use and childrearing in rural South Africa. *Journal of Comparative Family Studies*, *44*(2), 175–191. https://doi.org/10.3138/jcfs.44.2.175

McMillan, B. T. M., & Saffran, J. R. (2016). Learning in complex environments: The effects of background speech on early word learning. *Child Development*, *87*(6), 1841–1855. https://doi.org/10.1111/cdev.12559

McPherson, M., Smith-Lovin, L., & Brashears, M. E. (2006). Social isolation in America: Changes in core discussion networks over two decades. *American Sociological Review*, *71*(3), 353–375. https://doi.org/10.1177/000312240607100301

Mullennix, J. W., Pisoni, D. B., & Martin, C. S. (1989). Some effects of talker variability on spoken word recognition. *The Journal of the Acoustical Society of America*, *85*(1), 365–378. https://doi.org/10.1121/1.397688

Neal, J. W. (2020). A systematic review of social network methods in high impact developmental psychology journals. *Social Development*, *29*(4), 923–944. https://doi.org/10.1111/sode.12442

Okocha, A. U., Lew-Williams, C., & Burke, N. (2023). *Infants and toddlers in the United States with more close relationships have larger vocabularies*. https://osf.io/eg8f9/?view_only=64a21a3db4d846b1ad9479110d22bf4a

Paluck, E. L., Shepherd, H., & Aronow, P. M. (2016). Changing climates of conflict: A social network experiment in 56 schools. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(3), 566–571. https://doi.org/10.1073/pnas.1514483113

Pan, B. A., Rowe, M. L., Singer, J. D., & Snow, C. E. (2005). Maternal correlates of growth in toddler vocabulary production in low-income families. *Child Development*, *76*(4), 763–782. https://doi.org/10.1111/1467-8624.00498-i1

Perry, B., Pescosolido, B., & Borgatti, S. (2018). *Egocentric network analysis: Foundations, methods, and models (structural analysis in the social sciences)*. Cambridge University Press. https://doi.org/10.1017/9781316443255

Prather, R. W., Benitez, V. L., Brooks, L. K., Dancy, C. L., Dilworth-Bart, J., Dutra, N. B., Faison, M. O., Figueroa, M., Holden, L. R., Johnson, C., Medrano, J., Miller-Cotto, D., Matthews, P. G., Manly, J. J., & Thomas, A. K. (2022). What can cognitive science do for people? *Cognitive Science*, *46*(6), Article e13167. https://doi.org/10.1111/cogs.13167

Ramírez-Esparza, N., García-Sierra, A., & Kuhl, P. K. (2017). Look who's talking NOW! Parentese speech, social context, and language development across time. *Frontiers in Psychology*, *8*, 1008. https://doi.org/10.3389/fpsyg.2017.01008

Rost, G. C., & McMurray, B. (2009). Speaker variability augments phonological processing in early word learning. *Developmental Science*, *12*(2), 339–349. https://doi.org/10.1111/j.1467-7687.2008.00786.x

Rowe, M. L. (2008). Child-directed speech: Relation to socioeconomic status, knowledge of child development and child vocabulary skill. *Journal of Child Language*, *35*(1), 185–205. https://doi.org/10.1017/S0305000907008343

Rowe, M. L. (2012). A longitudinal investigation of the role of quantity and quality of child-directed speech in vocabulary development. *Child Development*, *83*(5), 1762–1774. https://doi.org/10.1111/j.1467-8624.2012.01805.x

RStudio Team. (2022). *RStudio: Integrated development for R*. RStudio, PBC. https://www.rstudio.com/

Sallet, J., Mars, R. B., Noonan, M. P., Andersson, J. L., O'Reilly, J. X., Jbabdi, S., Croxson, P. L., Jenkinson, M., Miller, K. L., & Rushworth, M. F. S. (2011). Social network size affects neural circuits in macaques. *Science*, *334*(6056), 697–700. https://doi.org/10.1126/science.1210027

Schwab, J. F., & Lew-Williams, C. (2016). Language learning, socioeconomic status, and child-directed speech. *Wiley Interdisciplinary Reviews: Cognitive Science*, *7*(4), 264–275. https://doi.org/10.1002/wcs.1393

Scott, J., & Carrington, P. J. (2014). *The SAGE handbook of social network analysis*. Sage Publications. https://doi.org/10.4135/9781446294413

Sénéchal, M., & Cornell, E. H. (1993). Vocabulary acquisition through shared reading experiences. *Reading Research Quarterly*, *28*(4), 360–374. https://doi.org/10.2307/747933

Shneidman, L. A., Arroyo, M. E., Levine, S. C., & Goldin-Meadow, S. (2013). What counts as effective input for word learning? *Journal of Child Language*, *40*(3), 672–686. https://doi.org/10.1017/S0305000912000141

Shneidman, L. A., Buresh, J. S., Shimpi, P. M., Knight-Schwarz, J., & Woodward, A. L. (2009). Social experience, social attention and word learning in an overhearing paradigm. *Language Learning and Development*, *5*(4), 266–281. https://doi.org/10.1080/15475440903001115

Shneidman, L. A., & Goldin-Meadow, S. (2012). Language input and acquisition in a Mayan village: How important is directed speech? *Developmental Science*, *15*(5), 659–673. https://doi.org/10.1111/j.1467-7687.2012.01168.x

Singh, L. (2008). Influences of high and low variability on infant word recognition. *Cognition*, *106*(2), 833–870. https://doi.org/10.1016/j.cognition.2007.05.002

Sperry, D. E., Miller, P. J., & Sperry, L. L. (2020). Hazardous intersections: Crossing disciplinary lines in developmental psychology. *European Journal of Social Theory*, *23*(1), 93–112. https://doi.org/10.1177/1368431018812465

Sperry, D. E., Sperry, L. L., & Miller, P. J. (2019). Reexamining the verbal environments of children from different socioeconomic backgrounds. *Child Development*, *90*(4), 1303–1318. https://doi.org/10.1111/cdev.13072

Taylor, P., Kocchar, R., Cohn, D., Passel, J., Velasco, G., Motel, S., & Patten, E. (2011). *Fighting poverty in a bad economy, Americans move in with their relatives*. Pew Social and Demographic Trends. https://www.pewresearch.org/social-trends/2011/10/03/fighting-poverty-in-a-bad-economy-americans-move-in-with-relatives/#:~:text=Without%20public%20debate%20or%20fanfare,generational%20households%20in%20modern%20history

Taylor, R. J., Chatters, L. M., Woodward, A. T., & Brown, E. (2013). Racial and ethnic differences in extended family, friendship, fictive kin and congregational informal support networks. *Family Relations*, *62*(4), 609–624. https://doi.org/10.1111/fare.12030

Thiessen, E. D. (2011). When variability matters more than meaning: The effect of lexical forms on use of phonemic contrasts. *Developmental Psychology*, *47*(5), 1448–1458. https://doi.org/10.1037/a0024439

U.S. Census Bureau. (2018). *2018 American community survey 1-year estimates*. https://www.census.gov/data.html

Vasilaky, K. N., & Leonard, K. L. (2018). As good as the networks they keep? Improving outcomes through weak ties in rural Uganda. *Economic Development and Cultural Change*, *66*(4), 755–792. https://doi.org/10.1086/697430

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications*. Cambridge University Press. https://doi.org/10.1017/CBO9780511815478

Weber, A., Fernald, A., & Diop, Y. (2017). When cultural norms discourage talking to babies: Effectiveness of a parenting program in rural Senegal. *Child Development*, *88*(5), 1513–1526. https://doi.org/10.1111/cdev.12882

Weisleder, A., & Fernald, A. (2013). Talking to children matters: Early language experience strengthens processing and builds vocabulary. *Psychological Science*, *24*(11), 2143–2152. https://doi.org/10.1177/0956797613488145

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag. https://ggplot2.tidyverse.org

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T. L., Miller, E., Bache, S. M., Müller, K., Ooms, J., Robinson, D., Seidel, D. P., Spinu, V., & Yutani, H. (2019). "Welcome to the tidyverse." *Journal of Open Source Software*, *4*(43), 1686. https://doi.org/10.21105/joss.01686

Received February 15, 2023
Revision received April 2, 2024
Accepted April 6, 2024 ■