Associations between Caregiver Stress and Language Outcomes in Infants with Autistic[1] and Non-Autistic Siblings

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[1]In accord with the current recommendations of autism researchers and autistic people, identity-first language will be used throughout this manuscript (see Bottema-Beutel et al., 2021 for further detail re: present guidance for use of terminology in referencing persons on the autism spectrum).

Abstract

Caregivers of autistic children present with high stress levels, which have been associated with poorer growth and outcomes in a number of developmental domains, including language, in autistic children. However, we did not previously know whether elevated caregiver stress was associated with language development in younger siblings of autistic children, who are at increased (approximately twenty-fold) likelihood of receiving a future diagnosis of autism and/or language impairment as compared to siblings of non-autistic children. The present study, therefore, explored whether and to what degree, as well as the putative mechanisms by which, caregiver stress was linked with later language outcomes of infant siblings of autistic and non-autistic children (Sibs-autism and Sibs-NA). Results of this study indicate that caregiver stress is indirectly related to later child language outcomes through caregiver linguistic input, across both Sibs-autism and Sibs-NA. Specifically, significant indirect effects suggest that caregivers with increased stress may speak less to their infants, resulting in reduced child language outcomes later in life for infants at both elevated and relatively lower, general population-level likelihood for a future diagnosis of autism. Clinical implications of the findings and future directions for research are discussed.

Associations between Caregiver Stress and Language Outcomes in Infants with Autistic and Non-Autistic Siblings

Autism is a neurodevelopmental condition characterized by differences in social communication, and by the presence of restricted, repetitive patterns of behavior, interests, or activities that impact an individual's ability to function in daily life (American Psychiatric Association, 2013). Features of autism typically emerge during the first few years of life and persist throughout the lifespan, potentially producing pervasive effects on the long-term outcomes of affected individuals (American Psychiatric Association, 2013). A large extant literature has shown, however, that the acquisition of language early in life is associated with increased social, educational, and vocational success for persons on the autism spectrum (e.g., Billstedt et al., 2005; Eaves & Ho, 2008).

The Role of the Caregiver in Language Development

Language development is shaped by a child's early language environment and experiences (e.g., Hart & Risley, 1995; Gilkerson et al., 2018; Golinkoff et al., 2019; Vihman, 2014). The transactional model of language development posits that language skills are built upon "dynamic interactions" between a child and their caregiver, wherein the caregiver scaffolds communication bids and shapes language development around the infant's experiences in their environment (e.g., Goldberg, 1977; Sameroff, 2009; see Woynaroski et al., 2014). Within this interactive process, as an infant gains language and communication skills, they are able to engage in communicative exchanges to a greater extent and can thereby influence their caregivers to respond in a manner that further facilitates the infant's development (Fogel & Lyra, 1997; Hoff, 2006). Thus, this model emphasizes the bidirectional and interdependent effects of the child and their caregivers in language acquisition (Sameroff, 2009; Tamis-LeMonda et al., 2014).

Given the importance of early language in long-term outcomes for autistic children, a growing body of research has focused on elucidating how caregiver input may impact language development in children on the autism spectrum (e.g., Bang & Nadig, 2015; Haebig et al., 2013). Researchers have shown, in a number of studies, that caregiver linguistic input is strongly associated with later vocabulary and broader spoken language skills of both autistic and neurotypical children (e.g., Choi et al., 2020b; McDuffie & Yoder, 2010; McGillion et al., 2017; Yoder et al., 2015; for review, see Heidlage et al., 2020).

Evidence that Caregiver Stress is Linked with Child Language

Caregivers of autistic children experience significantly more stress than caregivers of non-autistic children, with one study finding that over 80% of caregivers of children on the spectrum feel “stressed beyond their limits” (Bonis, 2016; Bitsika et al., 2013). The stress that these caregivers experience is, further, significantly increased in caregivers of autistic children compared to caregivers of children with other developmental disorders, such as Down syndrome (Bitsika & Sharpley, 2004; Bitsika et al., 2013; Estes et al., 2009; see Hayes & Watson, 2013 for a review). Caregiver stress has been linked with language outcomes in autistic children and children with developmental conditions other than autism (e.g., Blank et al., 2020; Quittner et al., 2010; Roberts; 2019; Sarant & Garrard, 2014). The impact of caregiver stress on child development may be the greatest in the early stages of life, when parents have concerns about their child’s development (e.g., Bonis et al., 2016; Karp et al., 2017) and when children are most malleable and experiencing large qualitative changes in language development (Shonkoff & Phillips, 2000).

Rationale for Focusing on Infant Siblings of Autistic Children

A primary challenge to testing the aforementioned, hypothesized relation between caregiver stress and children’s early language development is that, for some children, autism cannot be definitively diagnosed in the earliest stages of life (i.e., in infancy and toddlerhood; Ozonoff et al., 2015, 2018; Woolfenden et al., 2012). To overcome this challenge, many researchers prospectively follow infants known to be at increased likelihood for a future diagnosis of autism based on having an autistic older sibling (Sibs-autism). Approximately one in five of these infant siblings will go on to be diagnosed with autism (Messinger et al., 2015; Ozonoff et al., 2011). Additionally, Sibs-autism who are not diagnosed with the condition are more likely to present with a language disorder, display below-average developmental functioning, and/or present with subclinical autistic features (e.g., Charman et al., 2017; Landa et al., 2012; Messinger et al., 2013). To our knowledge, no study has yet explored the degree to which caregiver stress is associated with language in Sibs-autism, despite multiple studies pointing to parent stress as an unexplored variable in the language outcomes of this population (Wan et al., 2012; Yirmiya et al., 2006).

Caregiver Linguistic Input as a Putative Mechanism By Which Caregiver Stress May Influence Language Outcomes

At present, the mechanisms by which caregiver stress is associated with early language development and outcomes are not well-understood. Researchers have suggested, however, that caregivers who experience stress may provide less linguistic input to their child early in life, possibly resulting in poorer child language outcomes (e.g., Berryhill, 2016; Wan et al., 2012; Yirmiya et al., 2006). Previously, there were limited options for measuring caregiver linguistic input in a child's everyday settings and, thus, for testing this hypothesis regarding how caregivers' psychological and linguistic factors may collectively influence child language outcomes. The advent of day-long recording technology such as the Language ENvironment Analysis (LENA) device and accompanying software has provided a potential solution to this problem. LENA allows researchers to quantify the amount of adult linguistic input occurring in the home environment without the presence of a researcher (Gilkerson et al., 2017). A rapidly-growing body of literature has linked caregiver linguistic input, as measured by LENA, to language development in typically-developing infants and children (e.g., Gilkerson et al., 2018; Leung et al., 2020; McGillion et al., 2017; Ramírez et al., 2020; Romeo et al., 2018).

LENA has additionally been used in research of autistic children, as well as in studies of infant siblings of autistic children (e.g., Seidl et al., 2018; Swanson et al., 2018, 2019; Warren et al., 2010; Woynaroski, 2014; Yoder et al., 2013). It has been demonstrated, for example, that adult word count (AWC), a quantitative estimate of caregiver linguistic input as measured by LENA, correlates with concurrent expressive language skill in autistic children (Warren et al., 2010). Another option for obtaining an automated index of adult input in autistic children, especially in light of the transactional model of development, is the Reciprocal Vocal Contingency (RVC) score. The RVC score, obtained using LENA data and extant software, quantifies interactions between child and parent based on three-event, bidirectional child-parent-child vocal exchanges and controls for the chance sequencings of these exchanges (Harbison et al., 2018). This index has been found to have high levels of stability and preliminary evidence of predictive validity in a sample of prelinguistic autistic children and in an independent sample of Sibs-autism (Feldman et al., 2021; Harbison et al., 2018). The AWC and RVC scores, therefore, are good automated options for testing caregiver linguistic input as a putative mechanism of theorized relations between caregiver stress and future language in Sibs-autism.

The Possibility That Associations of Interest May Differ for Infants at High Versus General-Population Level Likelihood for a Future Diagnosis of Autism

Notably, Sibs-autism may differ from infants at general population-level likelihood for autism (Sibs-NA, i.e., infant siblings of non-autistic children) in language development as early as 12 months of age (Bryson, 2007; Choi et al., 2020a, 2020b; Elison et al., 2013; Hazlett et al., 2017; Meera et al., 2020), regardless of the eventual presence or absence of an autism diagnosis. A growing body of literature has specifically found that caregiver-child interactions also differ between Sibs-autism and Sibs-NA, which may influence language development (e.g., Choi et al., 2020b; Haebig et al., 2013; Hirsh-Pasek et al., 2015; Leezenbaum et al., 2014; Yirmiya et al., 2006; Wan et al., 2013; but see Tager-Flusberg, 2016). Further, parents of Sibs-autism may present with greater levels of stress, given their child's increased likelihood for later autism diagnosis and differences in language development when compared to Sibs-NA (e.g., Karp et al., 2017; Tager-Flusberg, 2016). Thus, it is important to consider that hypothesized associations between caregiver stress and child language outcomes, through caregiver linguistic input, may differ for infants at higher versus relatively lower, general population-level likelihood of autism.

Purpose

The present study will explore the degree to which, and the mechanisms by which, caregiver stress influences later language outcomes of infant siblings at high and low likelihood for autism diagnosis. The specific research questions will include:

1. Are there between-group differences (Sibs-autism versus Sibs-NA) in the degree of stress that caregivers report experiencing?
2. Is caregiver stress negatively associated with later child language outcomes in Sibs-autism and Sibs-NA? Are these associations moderated by sibling group?
3. Does caregiver linguistic input mediate the aforementioned associations between caregiver stress and later child language outcomes in Sibs-autism and Sibs-NA? Are these associations moderated by sibling group?

Methods

Data for this study were drawn from a larger longitudinal correlational investigation, the **S**ensory **P**roject in **I**nfant/Toddler **S**iblings of Children with Autism (Project SPIS; PI Woynaroski). All procedures were approved by the Vanderbilt University Institutional Review Board.

Participants

Participants were 28 Sibs-autism and 22 Sibs-NA, recruited for Project SPIS. All infants were between 12-18 months (±30 days) at study entry and were living in a primarily English-speaking household. Infants were excluded from participation if they had adverse neurological history, a known genetic condition, and/or preterm birth (gestation < 37 weeks). To be included in the Sibs-autism group, infants were required to have at least one older sibling who was diagnosed with autism via a research-reliable administration of the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2012). To be included in the Sibs-NA group, participants were required to have only typically-developing older siblings as reported by parents and confirmed by screening below the threshold for autism risk on the Social Communication Questionnaire (Rutter et al., 2003), as well as to have no first-degree relatives with an autism diagnosis. All primary caregivers reported their highest level of education attained as a proxy for socioeconomic status (SES). See Table 1 for a detailed summary of participant characteristics.

Procedures

All infants were seen at two time points. At the first visit, all infants were between 12-18 months. The second visit occurred nine months later (i.e., when participants were 21-27 months).

Measure of Caregiver Stress

Caregivers were asked to fill out the Parenting Stress Index Short Form, fourth edition (PSI) at the first time point of the study. In regard to questions pertaining to the caregiver-child relationship, caregivers were instructed to focus on their interactions with the infant participating in the present study. The PSI is a validated, 36-item caregiver report measure (Abidin, 1995; Haskett et al., 2006). From this measure, we derived the overall score, as well as five subscores previously shown to be valid in families with autistic children (i.e., general distress, parenting distress, rewards parent, child demanding, and difficult child; Zaidman-Zait et al., 2011), for use in analyses. The internal reliability of each subscore was good to excellent (Cronbach's α range = .81–.85).

Measures of Caregiver Linguistic Input

Participants were provided with two LENA recording devices and a specialized garment (i.e., vest) to wear during day-long recordings collected in children's everyday settings. Devices were worn for 16 hours, the maximum recording time for LENA processors, in the infant's home and community environments for two days (see Feldman et al., 2021 for more information). Parents were instructed to turn the device on when their child woke up in the morning and to leave the device on and in the garment pocket for the duration of the 16 hours. The audio data were transferred onto password-protected laboratory computers in a secure coding room upon return of the LENA devices. Recordings were analyzed using LENA Advanced Data EXtractor (ADEX) software to derive AWC scores and extant software to derive RVC scores (Harbison et al., 2018; Yoder et al., 2016). Each variable was averaged across the two recording days to increase stability, and thus potential predictive validity, of the scores (Feldman et al., 2021, Rushton et al., 1983).

Measures of Language Outcomes

To assess child language outcomes, the Mullen Scales of Early Learning (MSEL), the Vineland Adaptive Behavior Scales, second edition (VABS-2), and the MacArthur-Bates Communicative Development Inventories: Words and Sentences (MCDI) were collected at the second time point. The MSEL is a norm-referenced assessment that evaluates language, motor, and cognitive (visual reception) abilities (Mullen, 1995). The receptive and expressive language age equivalency scores were derived for use in analyses. The VABS-2 is a norm-referenced assessment that measures adaptive behavior in a number of domains, including communication, via a semi-structured interview (Sparrow et al., 2005). The receptive and expressive communication age equivalency scores were extracted from the measure for use in analyses. The MCDI is a parent-report measure of the words and sentences that a child can say (Fenson et al., 2007). The raw number of words spoken (i.e., expressive vocabulary) was extracted for use in analyses.

Analytic Plan

Prior to analyses, data were imported into R (R Core Team, 2020) to assess normality. Any variables that were not normally distributed (i.e., skew > |1| or kurtosis > |3|) were transformed, and missing data (ranging from 0-16% missingness across variables) were then imputed using the *missForest* package (Stekhoven & Bühlmann, 2012).

Aggregate receptive and expressive language scores were derived for each participant by averaging the relevant z-scores from the MSEL, VABS-2, and MCDI to increase the stability and, thus, the potential construct validity of the language outcomes (Rushton et al., 1983). Specifically, the expressive aggregate was the average of the z-scores for: (a) the age-equivalency score from the expressive language domain of the MSEL, (b) the age equivalency score for the expressive communication domain of the VABS-2, and (c) the expressive vocabulary raw score from the MCDI. The receptive aggregate was the average of the z-scores for: (a) the age-equivalency score from the receptive language domain of the MSEL, and (b) the age equivalency score from the receptive communication domain on the VABS-2 (Table 2).

To answer the first research question, independent samples t-tests were conducted to evaluate whether stress varied between caregivers of the Sibs-autism and Sibs-NA groups. To answer the second research question, a series of multiple regression models was carried out to evaluate associations between caregiver stress as indexed by the overall stress score and the subscores for general distress, parenting distress, rewards parent, child demanding, and difficult child on the PSI and later receptive and expressive language outcomes, as well as to test whether the associations of interest were moderated by sibling group.

To answer the third research question, mediation models were evaluated using the PROCESS macro (Hayes, 2017) in R to assess whether indices of caregiver linguistic input as measured by LENA (i.e., AWC and RVC) mediated associations between caregiver stress and later child receptive and expressive language. Sibling group was also evaluated as a moderator in these models to test whether the hypothesized indirect effects varied according to high versus low likelihood for a future autism diagnosis.

Results

Consideration of SES as a Covariate in Analyses

Our proxy index for SES (i.e., caregiver level of formal education) was not significantly associated with caregiver stress (rs ≤ |.15|, $p \geq .29$ across all indices of stress) or with child language outcomes; therefore, this variable was not controlled in subsequent statistical models.

Between-Group Differences in Caregiver Stress

Caregivers did not significantly differ by group, on average, on the overall raw score, t = 1.85, p = .070, Cohen's d = 0.51, or on the additional five subscores derived from the PSI. However, small to moderate effect sizes for between-group differences, in the anticipated direction, were observed for several indices of caregiver stress. See Table 3 for further detail.

Unconditional and Moderated Relations Between Caregiver Stress and Later Child Language Outcomes

In unconditional regression models carried out across sibling groups, associations between indices of caregiver stress and child language outcomes were statistically nonsignificant (all p > .2; see Table 4). Models testing moderated effects, however, revealed that some associations varied according to sibling group. Specifically, the relation between caregiver stress as indexed by the rewards parent subscore and both receptive and expressive language varied according to sibling group (p value for interaction effect in multiple regression model = .015, Cohen's f^2 = .14; and p = .047, Cohen's f^2 = .09, for receptive and expressive language, respectively; see Table 5). In both cases, positive associations were observed in the Sibs-NA group (i.e., more stress as indexed by this subscore was associated with higher child language; rs = .44 and .40 for receptive and expressive language, respectively) while correlations were null and/or trended in the opposite direction in the Sibs-autism group (rs = –.09 and –.28).

Indirect Effects of Caregiver Stress on Child Language Outcomes Via Caregiver Linguistic Input

To assess whether caregiver stress was indirectly related to child language outcomes, through caregiver linguistic input, a series of mediation analyses was conducted. Models were constructed to assess the relations between PSI scores (independent variables) and receptive/expressive language outcomes (i.e., receptive and expressive language aggregate scores; dependent variables) via AWC and RVC (putative mediators).

Mediation Models with Overall PSI Score as Independent Variable

The first series of mediation models employed the overall PSI score as the independent variable. These models revealed that caregiver linguistic input as indexed by AWC significantly mediated the relations (a) between caregiver stress as indexed by the overall PSI score and expressive language (95% CI = [–0.0128, –0.0004]) and (b) between caregiver stress as indexed by the overall PSI score and receptive language (95% CI = [–0.0161, –0.0009]). The indirect effect of caregiver stress on children’s receptive/expressive language through caregiver linguistic input was complete in both models, meaning that the direct effect of caregiver stress on later receptive and expressive language was not statistically significant when controlling for AWC. RVC did not significantly mediate the relations between the PSI overall raw score and receptive or expressive language (receptive language 95% CI = [–0.0124, 0.0019], expressive language 95% CI = [–0.0083, 0.0038]).

Mediation Models Evaluating Additional PSI Scores as Independent Variables

We ran additional analyses to evaluate whether relations between other indices of caregiver stress derived from the PSI and later child language outcomes were significantly mediated by AWC or RVC. Several models that evaluated AWC as the putative mediator were significant. Specifically, the model assessing the indirect effect of the parenting distress subscore on receptive language, the model assessing the indirect effect of the rewards parent subscore on receptive and expressive language, and the models assessing the indirect effect of the child demanding subscore on receptive and expressive language all yielded confidence intervals for the indirect effect that did not include zero (see Table 6 for a summary of relevant statistics; see Appendix A for additional mediation analyses that were run in post hoc analyses using alternative LENA variables). Figure 2 depicts results of a representative mediation model, and Figure 3 depicts scatterplots for representative relations comprising indirect effects of caregiver stress on later child language via caregiver linguistic input. The direction of effects was similar across all significant indirect effects, such that increased caregiver stress was associated with reduced caregiver linguistic input, which covaried with lower child language at outcome assessment, controlling for caregiver stress as measured at study entry.

Moderated Mediation Models

A series of moderated mediation models was subsequently run to assess whether any of the seven significant mediation models (see Table 6) were moderated by sibling group (i.e., Sibs-autism versus Sibs-NA). None of the significant indirect effects involving the PSI overall raw score (i.e., PSI as the independent variable, receptive/expressive language as dependent variables, AWC as the mediator) were moderated by sibling group (receptive language 95% CI for the conditional indirect effect = [–0.0201, 0.0127], expressive language 95% CI for the conditional indirect effect = [–0.0280, 0.0090]). The relation between the PSI child demanding subscore and expressive language, as mediated by AWC, however, was moderated by sibling group (95% CI for the conditional indirect effect = [-0.2863, -0.0108]), such that the indirect effect was significantly stronger in Sibs-NA versus Sibs-autism.

Discussion

This study sought to evaluate hypothesized associations between caregiver stress, caregiver linguistic input, and later language outcomes in younger siblings of autistic and non-autistic children (i.e., Sibs-autism and Sibs-NA). Our results suggest that caregivers of Sibs-autism and Sibs-NA may not differ on mean levels of reported stress and that direct effects between caregiver stress and later child language outcomes are limited. However, findings indicate that several aspects of caregiver stress may indirectly influence later child language outcomes, not only in infants at elevated familial likelihood for a future diagnosis of autism, but also in infants at relatively lower, general-population level likelihood for the condition.

Caregiver Linguistic Input Mediates Associations between Caregiver Stress and Language Outcomes

Mediation analyses indicated that caregiver stress influenced later child receptive and expressive language indirectly through caregiver linguistic input as indexed by Adult Word Count (AWC). These indirect effects were complete, meaning that direct effects of caregiver stress on later child language were non-significant, controlling for AWC. In most significant mediation models, the indirect effect of caregiver stress on future child language via caregiver linguistic input as indexed by AWC did not vary according to sibling group. This finding supports prior work demonstrating that caregiver linguistic input is a salient factor for language learning in all infants (e.g., Bang & Nadig, 2015; Choi et al., 2020b; Hirsh-Pasek et al., 2015; Hoff, 2006; Gilkerson et al., 2018; Rowe, 2012), and furthers our understanding of how caregiver stress may influence later language outcomes in young children (Swanson et al., 2019).

Caregiver Stress Does Not Differ by Sibling Group

To our knowledge, this is the first study to explore caregiver stress in infant siblings of autistic children. Caregivers of Sibs-autism did not report experiencing significantly more stress than caregivers of Sibs-NA, a result that is seemingly inconsistent with previous work in caregivers of autistic children (Bitsika et al., 2013; Bonis, 2016; for review, see Hayes & Watson, 2013). Notably, several effect sizes for between-group differences that did not surpass the threshold for statistical significance were small to moderate in magnitude, and the present study was underpowered to detect such effects. Thus, additional studies employing larger sample sizes are necessary to ascertain, with a higher level of confidence, whether caregivers of Sibs-autism are predisposed to high stress.

Clinical Implications

The present results suggest that it may be important to intervene when caregivers of infants at high and low likelihood for autism are experiencing elevated stress, in order to mitigate potential indirect influences of such stress on child language acquisition. Fortunately, there are practices and interventions known to reduce caregiver stress. For example, in a review of stress in caregivers of autistic children, Bonis (2016) found that caregiver-led support groups were effective in remediating the stress that caregivers experience. Additionally, caregivers who utilized respite services reported lower stress levels. Weitlauf et al. (2020) recently demonstrated, in the context of a randomized controlled trial, that mindfulness-based stress reduction provided in tandem with a parent-implemented naturalistic developmental behavioral intervention (NDBI) may reduce caregiver stress relative to receiving training in the use of NDBI strategies alone. Thus, there are a number of potential approaches that display promise for reducing stress in caregivers of infants and young children.

Limitations and Future Directions

This study provides novel insights into the mechanisms by which caregiver stress may influence child language outcomes but has several limitations. First, our measurement of two constructs at the same time-point is less than optimal. Although we found support for associations between caregiver stress and concurrent caregiver linguistic input, additional work is needed to determine whether higher levels of caregiver stress precede and predict reduced caregiver linguistic input. A study design wherein caregiver linguistic input is measured at a later timepoint, rather than concurrently, would establish temporal precedence for all constructs comprising theorized mediation relations and thereby increase our confidence in the indirect effects observed.

Additionally, the present study did not consider which infants in the Sibs-autism group went on to be diagnosed with autism. Our team is continuing to follow the participants in the present study longitudinally, with a plan to evaluate whether associations between caregiver stress, caregiver linguistic input, and later child language outcomes do vary according to diagnostic outcome, versus simply familial likelihood for a future autism diagnosis.

Finally, there is ongoing discussion regarding the factor structure of the PSI and whether or not it is a valid measure for a population that is not neurotypical. Though we used five subscores of the PSI as validated by Zaidman-Zait et al. (2011) in our analyses, to our knowledge no one has previously studied the factor structure of the PSI in caregivers of Sibs-autism. Thus, subsequent psychometric studies are necessary in order to determine how we might best measure caregiver stress in infant siblings of autistic and non-autistic children in future research.

Conclusion

The findings of the present study advance our understanding of the links between caregiver stress, caregiver linguistic input, and later language outcomes in infant siblings of autistic and non-autistic children. Our results indicate that caregiver stress may indirectly influence child language outcomes through its influence on caregiver linguistic input not only in infants at high likelihood for a future diagnosis of autism, but also in infants at general-population level likelihood for the condition. Additional research is, therefore, necessary to understand how we can best support caregivers and optimize the early language learning environment for infants at high and low likelihood for autism.

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Tables

Table 1

Participant Demographics By Sibling Group

	Sibs-autism (*n* = 28) *M* (*SD*) Min-Max	Sibs-NA (*n* = 22) *M* (*SD*) Min-Max
Age in Months at Time 1	13.71 (1.84) 11-18	14.05 (2.13) 11-18
Percent Male	53.6%	50.0%
MSEL Early Learning Composite*	89.36 (13.07) 70-118	91.57 (12.14) 84-121
	n	*n*
Race	28 White (28)	20 White 1 Black/African-American 1 Multiple
Ethnicity	1 Hispanic/Latino 27 Not Hispanic/Latino	1 Hispanic/Latino 21 Not Hispanic/Latino
Primary Caregiver's Highest Level of Education	2 High School Diploma or GED 10 College/Technical (1-2 Yrs) 8 College/Technical (3-4 Yrs) 5 Graduate/Professional School (1-2 Yrs) 3 Graduate/Professional School (3+ Yrs)	3 College/Technical (1-2 Yrs) 7 College/Technical (3-4 Yrs) 5 Graduate/Professional School (1-2 Yrs) 7 Graduate/Professional School (3+ Yrs)

Note. MSEL = Mullen Scales of Early Learning (Mullen, 1995).
*Groups differed at $p < .001$

Table 2

Summary of Key Study Constructs, Measures, and Variables According to Research Question

Construct	Measure/s	Variable(s)	Role Per Research Question	Measurement Period
Sibling Group	Demographic form, parent report, ADOS, SCQ	Infant sibling of (a) autistic child/ren, as confirmed with the ADOS, or (b) only non-autistic, neurotypical child/ren, as confirmed via score below threshold for autism concern (i.e., score of 15) on the SCQ	IV (RQ 1), Moderator (RQ 2,3)	Time 1
Caregiver Stress	PSI	(a) overall PSI raw score (b) general distress subscore (c) parenting distress subscore (d) rewards parent subscore (e) child demanding subscore (f) difficult child subscore	DV (RQ 1), Predictor (RQ 2, 3)	Time 1
Caregiver Linguistic Input	LENA	Average of scores across two recordings for: (a) Adult Word Count (b) Reciprocal Vocal Contingency score	Mediator (RQ 3)	Time 1
Later Receptive Language	MSEL VABS	Average of z scores for Time 2: (a) MSEL receptive age equivalency (b) VABS receptive age equivalency	DV (RQ 2,3)	Time 2
Later Expressive Language	MSEL VABS MCDI	Average of z scores for Time 2: (a) MSEL expressive age equivalency (b) VABS expressive age equivalency (c) # words “child says” on MCDI	DV (RQ 2,3)	Time 2

Note. RQ = research question; DV = dependent variable; IV = independent variable; ADOS = Autism Diagnostic Observation Schedule, Second Edition; SCQ = Social Communication Questionnaire; PSI = Parenting Stress Index Short Form, Fourth Edition; LENA = Language ENvironment Analysis; MSEL = Mullen Scales of Early Learning; VABS = Vineland Adaptive Behavior Scales, Second Edition; MCDI = MacArthur Communicative Development Inventories, Words and Sentences.

Table 3

Comparison of Caregiver Stress by Sibling Group

Variable	*t*	*p*	Cohen's *d*
PSI Overall Raw Score	1.85	.070	0.51
PSI General Distress	1.83	.073	0.51
PSI Parenting Distress	0.98	.331	0.27
PSI Rewards Parent	1.82	.073	0.50
PSI Child Demanding	0.79	.433	0.22
PSI Difficult Child	1.54	.130	0.42

Note. PSI = Parenting Stress Index Short Form, Fourth Edition (Abidin, 1995). Subscores were derived using guidelines from Zaidman-Zait et al. (2011).

Table 4

Unconditional Associations Between Caregiver Stress and Later Child Language

PSI Factor	Expressive Language	Receptive Language
Overall Raw Score	0.02	–0.12
General Distress	0.05	0.01
Parenting Distress	0.11	0.03
Rewards Parent	–0.02	–0.15
Child Demanding	–0.04	–0.19
Difficult Child	–0.03	–0.17

Note. PSI = Parenting Stress Index Short Form, Fourth Edition (Abidin, 1995). Subscores were derived using guidelines from Zaidman-Zait et al. (2011). Expressive language = aggregates generated from the Mullen Scales of Early Learning (MSEL), Vineland Adaptive Behavior Scales, Second Edition (VABS) and MacArthur Communicative Development Inventories, Words and Sentences (MCDI). Receptive language = aggregates generated from the MSEL and VABS (see Table 2 for more information on aggregate generation).
All statistical tests were non-significant (*p*s > .2).

Table 5

Results of Multiple Regression Models Assessing Whether Associations between Caregiver Stress and Later Language are Moderated by Sibling Group

	Expressive Language				Receptive Language			
PSI Factor	$\beta_{interaction}$	Cohen's f^2	$r_{Sibs\text{-}autism}$	$r_{Sibs\text{-}NA}$	$\beta_{interaction}$	Cohen's f^2	$r_{Sibs\text{-}autism}$	$r_{Sibs\text{-}NA}$
Overall Raw Score	0.67	.04	.02	.34	0.67	.05	–.14	.29
General Distress	0.13	.00	.22	.19	0.19	.01	.12	.26
Parenting Distress	0.63	.06	.04	.41	0.43	.03	.00	.33
Rewards Parent	0.87*	.09	–.09	.40	1.04*	.14	–.28	.44*
Child Demanding	0.35	.02	–.11	.16	0.17	.01	–.21	–.05
Difficult Child	0.57	.04	–.07	.29	0.58	.05	–.23	.23

Note. PSI = Parenting Stress Index Short Form, Fourth Edition (Abidin, 1995). Subscores were derived using guidelines from Zaidman-Zait et al. (2011). Expressive language = aggregates generated from the Mullen Scales of Early Learning (MSEL), Vineland Adaptive Behavior Scales, Second Edition (VABS) and MacArthur Communicative Development Inventories, Words and Sentences (MCDI). Receptive language = aggregates generated from the MSEL and VABS (see Table 2 for more information on aggregate generation). $\beta_{interaction}$ = Standardized beta for the interaction term (i.e., group * PSI factor) from multiple regression models with the language aggregate as the dependent variable and group and PSI factor as additional regressors. Cohen's f^2 = effect size for the interaction term in multiple regression models; thresholds of .02, .15, and .35 reflect small, moderate, and large effects, respectively. *$p < .05$, ** $p < .01$, ***$p < .001$.

Table 6

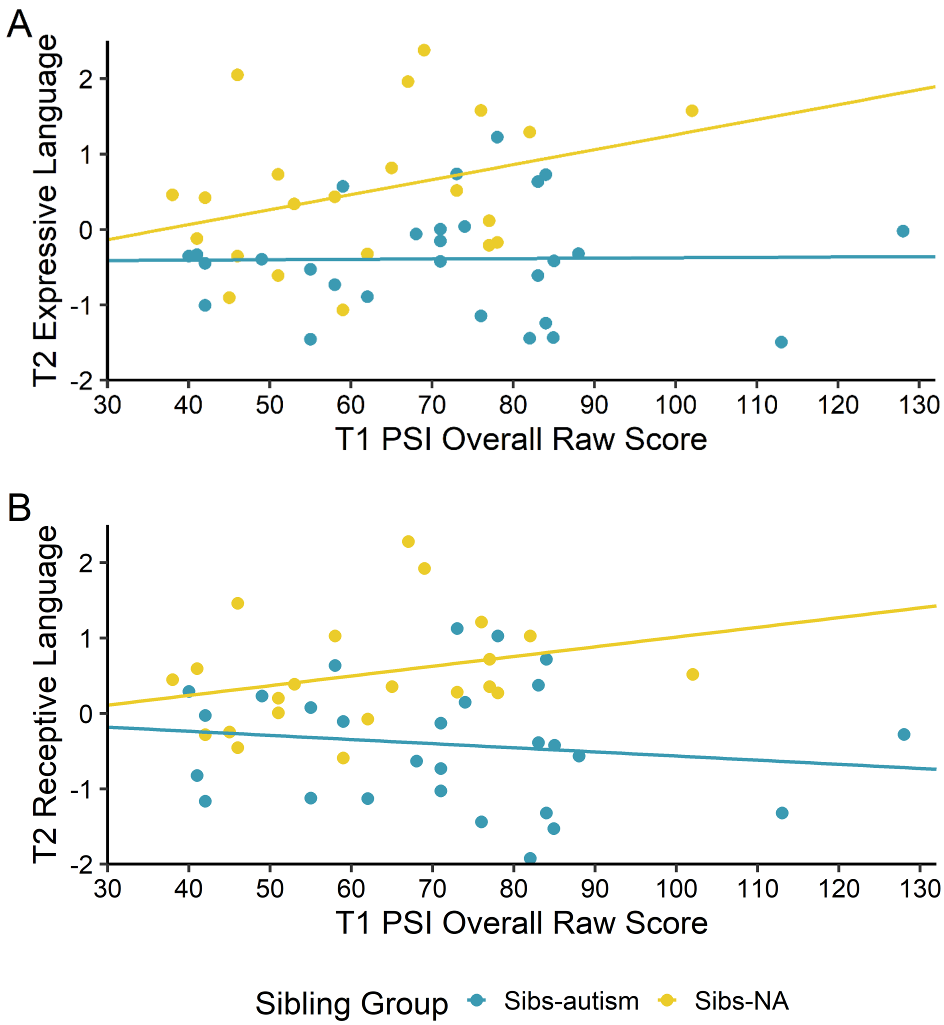
95% Confidence Intervals for Mediation Models Assessing the Indirect Effect of Caregiver Stress on Later Child Language as Mediated by Adult Word Count (AWC)

PSI Factor	Expressive Language 95% CI for Indirect Effect	Receptive Language 95% CI for Indirect Effect
Overall Raw Score	**–0.01, –0.00**	**–0.01, –0.00**
General Distress	–0.03, 0.01	–0.04, 0.02
Parenting Distress	–0.07, 0.00	**–0.07, –0.00**
Rewards Parent	**–0.06, –0.01**	**–0.08, –0.01**
Child Demanding	**–0.08, –0.01**	**–0.10, –0.02**
Difficult Child	–0.04, 0.00	–0.05, 0.05

Note. Bolded values indicate 95% confidence intervals for the indirect effect that do not cross zero (i.e., significant mediation models). PSI = Parenting Stress Index Short Form, Fourth Edition (Abidin, 1995). Scores were derived using guidelines from Zaidman-Zait et al. (2011). Expressive language = aggregates generated from the Mullen Scales of Early Learning (MSEL), Vineland Adaptive Behavior Scales, Second Edition (VABS) and MacArthur Communicative Development Inventories, Words and Sentences (MCDI). Receptive language = aggregates generated from the MSEL and VABS (see Table 2 for more information on aggregate generation).

Figure 1

Associations Between Caregiver Stress and Future Child Language According to Sibling Group

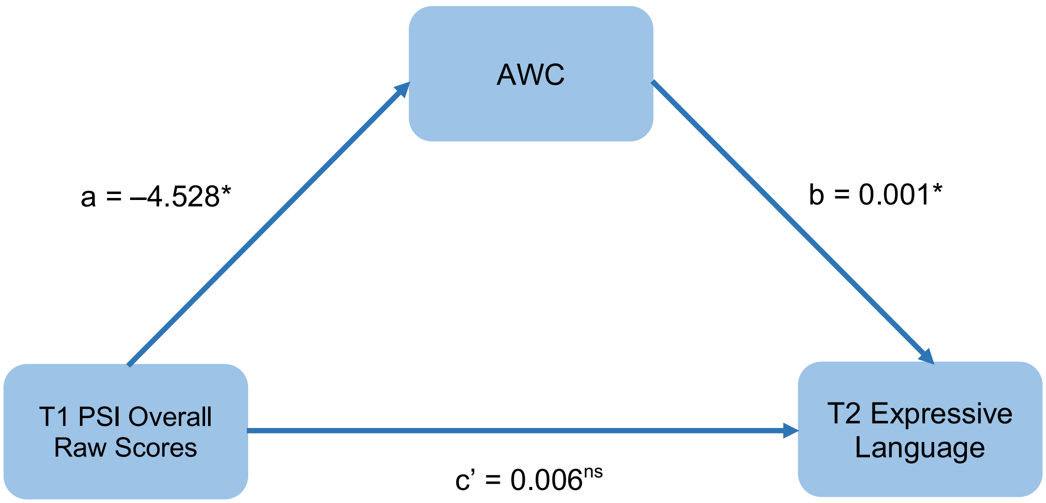


Note. Figures depict associations between caregiver stress as indexed by the overall score from the PSI at Time 1 and child (a) expressive language and (b) receptive language at Time 2 as moderated by sibling group. Associations were null or trending negative in the Sibs-autism group (represented by blue dots) but trending positive and only significant in the Sibs-NA group (represented by yellow dots), making these conditional relations difficult to interpret. Expressive language = aggregates generated from the Mullen Scales of Early Learning (MSEL), Vineland Adaptive Behavior Scales, Second Edition (VABS) and MacArthur Communicative Development

Inventories, Words and Sentences (MCDI). Receptive language = aggregates generated from the MSEL and VABS (see Table 2 for more information on aggregate generation).

Figure 2

Representative Mediation Relation Between Caregiver Stress and Child Language via Caregiver Linguistic Input

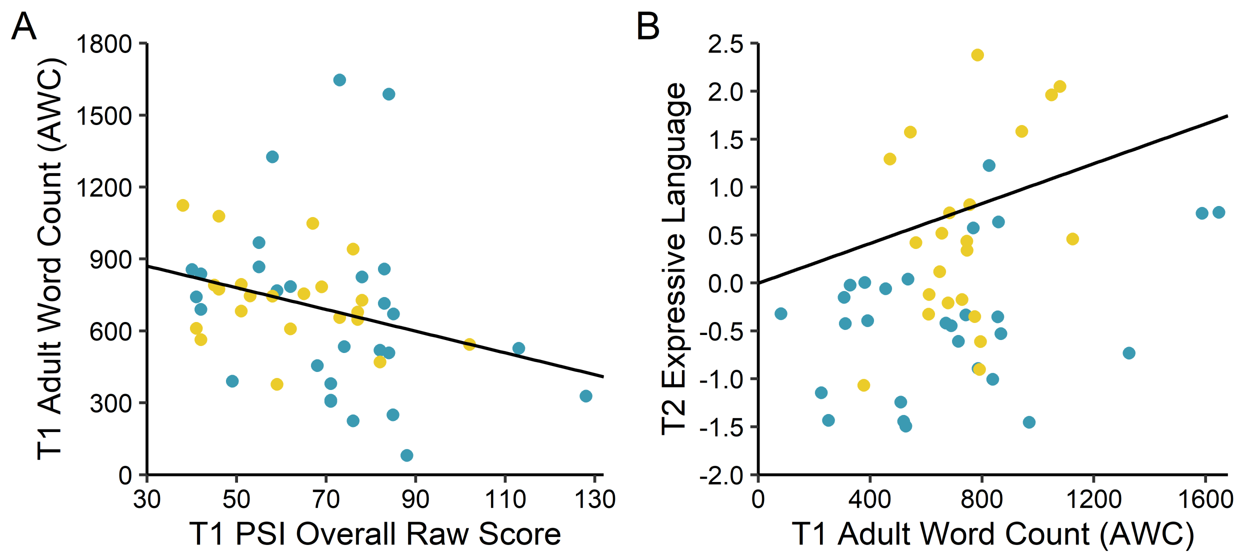


Note. Figure depicts a representative mediation relation. T1 = Time 1 (12-18 mos), PSI = Parenting Stress Index Short Form, Fourth Edition (Abidin, 1995), T2 = Time 2 (21-27 mos), a = the relation between caregiver stress and caregiver linguistic input as indexed by Adult Word Count (AWC), b = the relation between AWC and later child expressive language, controlling for caregiver stress, c’ = the direct effect of parent stress on later expressive communication, controlling for AWC. Note that c’ is non-significant, meaning that the association between parent stress and later child expressive communication is completely mediated by AWC. This indirect effect is not moderated by sibling group. All values are unstandardized coefficients.

**p* < .05, ns = non-significant result.

Figure 3

Representative Scatterplots for Paths Comprising the Mediation Relation Between Caregiver Stress and Child Language via Caregiver Linguistic Input



Note. Figure depicts scatterplots for paths comprising one significant mediation relation across infant siblings of autistic and non-autistic children (represented by blue and gold dots, respectively). T1 = Time 1 (12-18 mos), PSI = Parenting Stress Index Short Form, Fourth Edition (Abidin, 1995), T2 = Time 2 (21-27 mos), A = the relation between caregiver stress as indexed by the overall raw score from the PSI and caregiver linguistic input as indexed by Adult Word Count (AWC), B = the relation between AWC and later child expressive language. All significant mediation models comprised paths in the anticipated direction, such that increased caregiver stress was associated with reduced caregiver linguistic input, and reduced caregiver linguistic input covaried with lower child language levels.

Appendix A

Additional mediation analyses were run wherein only the Adult Word Count (AWC) for the primary caregiver (i.e., the caregiver who filled out the Parenting Stress Index Short Form, Fourth Edition [PSI]) was used as the mediator by extracting the relevant Male Adult Near (MAN) and Female Adult Near (FAN) estimated adult word counts for each participant (MAN $n = 2$). We found significant indirect effects such that the linguistic input of the primary caregivers significantly mediated the relations between the rewards parent and child demanding scores, respectively, and receptive language (rewards parent 95% CI = [-0.0629, -0.0041], child demanding 95% CI = [-0.0718, -0.0088]). The indirect effect between caregiver stress and receptive language was complete in both models, meaning that the direct effect of caregiver stress on later receptive and expressive language was non-significant when controlling for primary caregiver AWC.

There are a few factors that may have contributed to the lack of significant findings for several models when the putative mediator was the AWC for the sex matching the primary caregiver. First, given that only two fathers were reported as the primary caregiver in this sample (1 Sibs-autism, 1 Sibs-NA), there may not be enough diversity in caregivers for this distinction to be meaningful. Second, the LENA recordings indicated that female speakers in the environment talked significantly more than male speakers, $t(44) = 9.35$, $p < .001$, $M_{diff} = 327.0$ words/hour. Closer inspection of the data shows that there were, further, more female than male adult words produced near the child for one of the two infants in the dataset whose father served as the primary caregiver. It is possible that this family may not have recorded truly representative days or that linguistic input for this child comes predominantly from the mother or other adult females despite the fact that the father is considered the primary caregiver. Finally, by parsing the adult word count by primary caregiver's sex, we may have altered the stability of our variables and, thus, our ability to detect effects of interest (see Feldman et al., in prep).