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The predictive role of caregiver's language richness in child development outcomes in rural China

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ABSTRACT

There is rich literature on the predictive role of the caregiver's language richness in child development outcomes during caregiver-child interaction. However, it is unclear whether this is true in rural China, where many young children are still not developing to their fullest potential. Our study supplements the current evidence in rural China by answering three questions. First, is the rural caregiver's language richness associated with child development outcomes? Second, do different child characteristics, caregiver characteristics, and household poverty status affect the relationship between caregiver language richness and early child development outcomes? Third, does the caregiver's language suitability moderate the association between language richness and child development outcomes? We observed and recorded 10-minute-long videos of 591 rural children aged 6–30 months and their primary caregiver dyads in a free toy play session and collected their social-demographic information. Trained coders coded videotaped interactions to obtain measurements of the caregiver's language richness and suitability. Children were assessed for cognitive, language, motor, and social-emotional development. A multivariate linear regression model adjusted for covariates was used to estimate the association between the caregiver's language richness and child development outcomes. Interaction terms were then added to the adjusted model to explore the moderating role of caregivers' language suitability, child characteristics, caregiver characteristics, and household poverty status. The caregiver's language richness is positively associated with the child's cognitive, language, motor, and social-emotional development. The association is more pronounced for children who are boys, in later toddlerhood, or from registered poverty households. In addition, we found that the caregiver's language suitability could enhance the association between language richness and child development outcomes.

1. Introduction

A growing body of evidence suggests that the early years of a child's life, especially the first three years, are critical for child development. Neuroscience research indicates that the brain develops most rapidly in the first years of life when neurons form new connections at an astounding rate (Nelson et al., 2000). Between four months before and up to 40 months after birth, the initial physiological structure of the brain forms and sets the foundation for further development (Grantham-Mcgregor et al., 2007). Many studies have also demonstrated that

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the average rate of return for human capital investment gradually decreases with age and is the highest in children aged 0–3 years old (Carneiro & Heckman, 2003; Heckman et al., 2013). Utilizing this critical yet short window of opportunity to promote early childhood development (ECD) is crucial in enhancing the quality of a child's future human capital.

Early experiences in life and the environment where a child grows have been shown to play a crucial role in ECD (Jirtle, 2008; Nafee et al., 2010; Szyf, 2009). Adversities in a child's early years, such as malnutrition, family violence, neglect, and so on, can seriously jeopardize brain development (Barnett, 1995; Mcewen & Morrison, 2013; Sharon E. Fox, 2010; Shonkoff & Garner, 2018; Shonkoff & Jack, 2016; Sinclair & Oberdoerffer, 2009). Conversely, a rich language environment and cognitive stimulation effectively promote children's growth and allow them to achieve their full developmental potential (Garca, Heckman, Leaf, & Prados, 2020; Shonkoff & Fisher, 2013; Winston & Chicot, 2016).

One of the most important factors in determining the quality of ECD is the caregiver's interaction with children, particularly through language. According to the social-pragmatic theory of language acquisition, language acquisition requires quality language input (Hoff & Naigles, 2002). Language acquisition occurs due to caregiver-child interactions that are repeated, predictable, and cooperative. When dealing with their children, caregivers unintentionally use a range of educational methods, including exaggerated intonations, higher pitches, contingent imitations, and the use of simplified vocabulary generated at a slower pace of articulation (Luchang Wang et al., 2021). Many studies have demonstrated that receiving rich language inputs from adult caregivers could help children develop language and cognitive abilities (Romeo et al., 2018; Rowe, 2012).

On the other hand, the various government policies aimed at improving the quality and standards of ECD services are yet to be put into practice. ECD's public financial investment has largely remained lacking in rural areas (Han & Cao, 2020). Many rural caregivers find it challenging to access scientific guidance for nurturing care, and their children's need for quality interaction is often overlooked (WHO, WORLD BANK, & ECDAN, 2018). There is an urgent need for empirical evidence to assist the Government of China in designing cost-effective ECD programs suitable to the rural context.

1.1. Caregivers' language richness and child development outcomes

Language richness refers to the quantity and diversity of vocabulary and linguistic structures used by caregivers during interactions with children (Huttenlocher et al., 2010; Rowe, 2012). One important aspect of caregiver language richness is the amount of talk directed at the child, known as "child-directed speech" (CDS). CDS is characterized by simplified syntax, exaggerated intonation, and repetitive phrases, and is thought to facilitate language learning by providing children with a rich linguistic environment that is tailored to their current language abilities (Wang, et al., 2021).

Caregiver language richness has been shown to play a crucial role in shaping children's language development outcomes. Previous studies have consistently demonstrated a positive association between caregivers' language richness and children's language development, including vocabulary size, syntax acquisition, and verbal fluency. Caregivers who engage in frequent, varied, and interactive language interactions create an enriched linguistic environment, fostering children's language growth (Hoff & Naigles, 2002).

Moreover, caregiver language richness has also been linked to positive outcomes in other areas of child development, such as improved executive functioning skills, increased empathy and social competence, and higher academic achievement (Hoff, 2003; Huttenlocher et al., 2010). For example, a study by Huttenlocher et al. (2010) found that children's vocabulary growth was positively associated with the quantity and quality of maternal language input they received.

1.2. Caregivers' language richness, suitability, and child development outcomes

Language suitability refers to caregivers' ability to tailor their language to the developmental needs and abilities of the child, including clear and simplified speech, appropriate pacing, and responsive feedback. Language suitability acts as a moderator by shaping the quality of caregiver-child interactions, ensuring that the language input is accessible and beneficial to the child (Rowe, 2012). Caregivers who possess high language richness but lack language suitability may overwhelm children with complex language structures or fail to provide appropriate support and scaffolding, hindering optimal language development. Conversely, caregivers who exhibit both language richness and suitability create an optimal language environment, where children receive linguistically rich input adapted to their developmental abilities, thereby facilitating language learning and overall language proficiency (Rowe, 2012).

The moderating effect of language suitability can be explained by its impact on the quality of caregiver-child interactions. Caregivers who employ suitable language strategies, such as clear and simplified speech, pacing, and responsive feedback, enhance children's comprehension, engagement, and socio-emotional well-being (Tamis-LeMonda, Bornstein, & Baumwell, 2001; Weisleder & Fernald, 2013). Language suitability acts as a facilitator, enabling children to effectively process and internalize the rich language input provided by caregivers. It ensures that children receive language input that aligns with their developmental abilities, leading to enhanced language acquisition and fluency.

1.3. Caregivers' language richness and child, caregiver, and household characteristics

In addition to the verbal contact between the caregiver and the child, a variety of factors have been shown to impact the quality and quantity of language input from caregivers, which in turn affects children's language development and overall well-being. One important factor is the socioeconomic status (SES) of the household. For example, low family economic circumstances and living situations may cause caregivers to engage passively and negatively in caregiver-child interactions, which could influence young children's language development. Noble et al. (2005) found that SES was found to predict 24% of the variance in receptive vocabulary abilities, 24% of the variance in phonological awareness, but only 5% of the variance in receptive grammar skills.

Caregivers' language richness may also be influenced by factors such as gender, age, birthweight, etc. Gender differences in caregiver language richness have been observed in some studies, with mothers providing more language input than fathers in some cases (Leaper, 2002; Pancsofar & Vernon-Feagans, 2006). Age has also been found to be a factor influencing caregiver language richness, with older caregivers providing more enriched language input to children than younger caregivers (Hart & Risley, 1995). Birthweight has also been linked to caregiver language richness, with lower birthweight infants receiving less rich language input from their caregivers (Mendelsohn et al., 2005).

Caregivers' own education level has also been found to influence the richness of language input provided to children, even after controlling for socio-economic status (Hoff, 2003; Rowe, 2012). For example, a study by Rowe (2012) found that caregivers with higher levels of education provided more diverse vocabulary and richer syntax to their children, even when income and other demographic factors were taken into account.

1.4. Present study

Considering the importance of caregiver-child interaction, particularly the role of the caregiver's language, and the need to support the design of effective ECD interventions in rural China, this paper aims to explores three questions in the context of rural China. First, is the rural

caregiver's language richness associated with child development outcomes? Second, do different child characteristics, caregiver characteristics, and household poverty status affect the relationship between caregiver language richness and early child development outcomes? Third, does the caregiver's language suitability moderate the association between language richness and child development outcomes?

To achieve this aim, we observed and recorded 10-minute-long videos of 591 rural children aged 6–30 months and their primary caregiver dyads in a free toy play session and collected their social-demographic information. We collected data on caregiver's language richness and suitability, children's cognitive, language, motor, and social-emotional development, and social-demographic information.

The results of this study have important implications for policymakers and practitioners designing interventions for the most vulnerable children in rural China. By understanding the impact of caregiver's language on child development outcomes and the potential moderating effects in the relationship, we can design interventions that promote caregivers' language inputs and improve early development outcomes for children in rural areas.

2. Methodology

2.1. Sampling

Our study was conducted in the summer of 2018 in a county of Jiangxi Province. The county was still a nationally designated poverty county at that time and was lifted out of such status at the end of 2019. The county's GDP per capita was 15,835 yuan, roughly at the average level of all poverty counties in China in 2018. Therefore, our study site can be considered representative of the economic development level of resource-limited areas in rural China. Fig. 1.

We obtained a list of all townships in the sample county from the local regulatory authority. A total of three townships consisting of 27 administrative villages or 167 natural villages were randomly chosen. We obtained the list of registered births from the local family planning official for each selected township. All 616 children aged 6–30 months at the survey and their primary caregivers were selected as our study sample. The caregiver who takes the most responsibility for the child's daily care was identified as the primary caregiver. Of these 616 children, 25 were excluded for not completing the interview or test on child development outcomes. Our final sample, therefore, included 591 children and their primary caregivers. 253 of them are mothers of the sample children, and the rest of 338 are caregivers other than mothers (for instance, grandmothers or fathers). The average age of the sample caregivers was 42.61 years old, and the average educational attainment was 5.84 years of schooling.

2.2. Data Collection

We obtained ethical approval in June 2018 (No. IRB00001052-17056). We conducted home visits accompanied by local government officials. Upon arrival at each household, the purpose of the study was explained to the child's primary caregiver, and written informed consent was obtained. Those illiterate caregivers who understand Chinese may have the consent read to them and put their thumbprint on the subject signature line using inkpad that was prepared by the research team.

2.3. Child development outcomes measurement

To obtain measurements for child development outcomes, the enumerators administered the Bayley Scales of Infant Development III (BSID-III), the Infant Behaviour Questionnaire-Revised Edition (IBQ-R), and the Early Childhood Behaviour Questionnaire Very Short Form (ECBQ-VSF) for each eligible child in the household.

We measured each child's cognitive, language, and motor development using the BSID-III cognitive, language, and motor scales. The BSID-III scale targets children aged between 0–42 months and proved to be a gold-standard scale in assessing the developmental functioning of infants and young children. Previous studies have formally translated the BSID-III scale into Chinese (Xu, Liu, Zhou, & Li, 2011). Back translation and customization have been conducted to ensure that the translation is suitable for the Chinese context (Lei Wang et al., 2019; Xu et al., 2011; Yang & Liu, 2016). It took 0.5 to 1.5 hours to complete the evaluation, the exact time of operation depends on the child's age in months.

Enumerators administered each item in the BSID-III scale by interacting with the child using a set of standardized toys in the presence of a caregiver; however, the caregiver was not allowed to help the child. The cognitive scale assessed play skills, information processing (attention to novelty, habituation, memory, and problem-solving), counting, and number skills (Bayley, 2006a, 2006b; Robertson, 2010). The language scale assessed children's comprehension and expression skills (Bayley, 2006a, 2006b). The motor scale assessed gross and fine motor skills (Bayley, 2006a, 2006b). The raw score for each of the three scales was calculated as the number of items completed by the child (Bayley, 2006a, 2006b). This was then transformed into a composite score following the BSID-III guidelines. Higher scale scores correspond to better child development. The composite scores were

Table 1
Definition of caregiver's language richness scale during interaction.

Language richness score		Example
0	The caregiver did not make any description of the object.	-
1	The caregiver mentioned the name of the object.	"This is an apple."
2	The caregiver described the characteristics or features of the object, such as color, size, and shape.	"This red apple is so big."
3	The caregiver described the properties and functions or properties of the object.	"A small spoon could be used to scoop out the soup."

Table 2
Definition of caregiver's language suitability during interaction.

Language suitability dimension		Kappa coefficient
Pacing speed	The caregiver's pacing speed is appropriate for the child to follow, or less than two words per second.	0.820

age-standardized with a normative mean score of 100 (Bayley, 2006b; Bos, 2013; Li et al., 2009; Lowe, Erickson, Schrader, & Duncan, 2012; Serenius et al., 2013), thereby allowing comparisons among different age groups.

The IBQ-R assessed the social-emotional development of each child for children aged 6–12 months (Rothbart et al., 2001) and the ECBQ-VSF for those aged 13–36 months (Putnam et al., 2006). Numerous studies have verified the applicability of both scales in Asian countries (Rothbart et al., 2001; Sukigara et al., 2015). IBQ-R and ECBQ-VSF are based on the caregiver's responses to a series of questions measuring children's sociality in three aspects: problem behavior, response to emergencies, and self-regulation. Each question asked the caregiver to rate the frequency of a specific behavior on a 7-point scale (1=Never; 7=Always). The IBQ-R contained 36 questions with an internal validity of 0.75 (Eva Vonderlin, Anna Ropeter, & Sabina Pauen, 2012). The ECBQ-VSF included 37 questions with an internal validity of 0.65, slightly lower than that of the original long-form (0.78), but still above the general acceptance level of 0.6 (Nunnally & Bernstein, 1978; Potměšilová & Potměšil, 2019). Each scale took 0.5 hours to complete on average.

The score for each question of both the IBQ-R and ECBQ-VSF was calculated as the frequency given by the caregiver (1=Never; 7=Always) divided by 7. As there were five modules in each scale, the final score was computed by summing the scores of all individual items and dividing them by 5. The scores calculated from the two scales were used to measure social-emotional development for sample children.

2.4. Language assessment

The caregiver's language use was assessed through a 10-minute video recording of a toy play session. Before recordings began, enumerators addressed questions and concerns from the caregiver regarding the video recording procedures and then provided a set of "kitchen toys" that the research team prepared for caregiver-child interaction with the caregiver. Given that the presence of instructions could potentially induce a change of behavior of the subject (Kazdin, 1982), the caregiver was instructed to use the toys to play with the child as usual in an uncontrolled natural environment (usually in the children's home) without any certain tasks. During the video recording process, family members not involved with the study were instructed to stay away. If there was more than one eligible child, the enumerator asked the caregiver to play with the children in different rooms, creating separate recordings for each child.

We coded the video clips to extract useful information on measuring the caregiver's language richness and suitability. To facilitate the process of video coding, a manual including a list of codes, definitions of each code, and instructions for coding was developed. A total of four university graduate students were trained with the coding manual. The coders remained constantly alert while watching the video to capture the flow of activities of the caregiver and the child, which often involved replaying the video multiple times.

Using the following steps, we constructed the language richness score from the video clips. Each video was first segmented into interaction turns. The cut-off point is either an interactive segment's start or end. An interactive segment starts from the point where one party exhibits a signal of interaction, verbal or non-verbal. The segment ends when the child and the caregiver begin to play independently for more than ten seconds, which becomes a non-interactive segment's starting point. The coders recorded the durations of all interactive and non-interactive segments. For each segment, the caregiver's language richness was rated on a 5-point scale to capture the intensity of language richness. Zero point refers to the fact that the caregiver did not make any description of the object. One point is that the caregiver mentioned the object's name. Two points refer to the caregiver describing the object's characteristics or features, such as color, size, and shape. Three points refer to the fact that the caregiver describes the properties and functions of the object. Four points refer to the caregiver describing the properties, functions, and how to realize the object's function. The definition and an example for each scale level are reported in Table 1. For a non-interactive segment, the caregiver automatically received a score of 0. After acquiring the rated scores for all video segments, the language richness score of each caregiver was calculated as the weighted average of all segment scores, in which the weight was equal to the duration of each segment divided by ten (the time length of video recording of toy play session).

The language suitability of each caregiver was captured in three dimensions: pacing speed, tone, and volume. The definition of each dimension of suitability is presented in Table 2. For each video clip segment, the suitability (Yes=1 and No=0) of the caregiver's language was rated in each dimension. For a non-interactive segment, the caregiver automatically received a score of 0. The language suitability score of each caregiver was then calculated in the same way as the language richness score by taking the weighted average of all segment scores, using the duration of each segment divided by ten as its weight.

The research team made our own coding system by referring to the coding categories and rules of the Neuropsychomotor Video Analysis of Adult and Child interaction (NVA). NVA is a tool for the structured observation, evaluation, and categorization of videotaped interactions between the caregiver and the child in the first three years of life; the caregiver can also be interpreted as an educator, therapist, or teacher. The NVA coding's structure enables the observer to evaluate the actions of caregiver-child dyads independently while always relating them to one another (Moioli et al., 2014).

Coders were trained and certified collectively to use the NVA methodology. After passing the external training, coders are also required to attend an internal training organized by the research team for our own coding system. This external training course was taken place online from September 5th to 28th 2020, and was taught by professor Margherita Moioli, author of NVA coding system, neuropsychomotor therapist from the University of Milan.

Coding standards will be restated and unified when inter-coder reliability is below 50%. Before the formal coding, six coders were paired to code 5% of the video clips that were randomly selected from our sample to measure the inter-coder reliability. After the completion of coding, the Kappa coefficient for the language richness score was computed to be 0.873 and between 0.802–0.834 for three language suitability indicators. The Cronbach's alpha coefficient, which is usually used to measure internal consistency, was computed to be 0.856 for the language richness score and between 0.789–0.815 for three language suitability indicators, suggesting good consistency across different coders (Nunnally & Bernstein, 1978).

Table 3
Summary statistics of key variables.

Variable	Mean ± S. D / No. (%)	Min	Max
A. Child Development Outcomes			
Cognitive score	97.17 ± 13.71	55	145
Language score	88.71 ± 15.85	47	153
Motor score	99.83± 16.76	46	154
Social-emotional score	4.36 ± 0.53	1.75	6.33
B. Caregiver's language richness during interaction			
Language richness score	1.17 ± 1.15	0	4
C. Caregiver's language suitability during interaction			
Suitability score on pacing speed	0.72 ± 0.38	0	1
Suitability score on tone	0.28 ± 0.39	0	1
Suitability score on volume	0.22 ± 0.37	0	1
D. Child characteristics			
Gender			
Boy	301 (50.93)		
Girl	290 (49.07)		
Age in months	17.60 ±6.61	6	30
Low birth weight			
Yes	33 (5.58)		
No	558 (94.42)		
E. Caregiver characteristics			
Mother as caregiver			
Yes	253 (42.81)		
No	338 (57.19)		
Age in years	42.61 ± 14.63	8	79
Education in years	5.84 ± 4.32	0	16
F. Household characteristics			

2.5. Social demographic information

A face-to-face interview was conducted with the child's primary caregiver to obtain social and demographic information, including the gender of the child, their age, whether the child was born with low birth weight, the age of the primary caregiver, the education level of the primary caregiver, whether the child's mother is the primary caregiver, and whether the child lives in a registered poverty household.

2.6. Statistical models

Statistical analysis was performed using Stata 15.0. Linear regression models were fitted to estimate the association between the caregiver's language richness and child development outcomes. The dependent variables are the child's cognitive, language, and motor scores as measured by the BSID-III scale and social-emotional score as measured by the IBQ-R/ECBQ-VSF. The independent variable of interest is the caregiver's language richness score.

The unadjusted model is as follows:

$$Y_i = \beta_0 + \beta_1 Richness_i + \varepsilon_i \quad (1)$$

where Y_i denotes the development outcomes of child i, including the cognitive, language, motor, and social-emotional scores. $Richness_i$ is the language richness score of the caregiver. ε_i is the error term, clustered at the village level.

The adjusted model incorporates a set of covariates to improve the estimation precision:

$$Y_i = \beta_0 + \beta_1 Richness_i + \beta_2 CHILD_i + \beta_3 CAREGIVER_i + \beta_4 hh\_poor_i + \delta_i \quad (2)$$

In Model (2), $CHILD_i$ is a vector of child characteristics including gender, age (in months), and whether the child has a low birth weight. $CAREGIVER_i$ is a vector of caregiver characteristics, including whether the caregiver is the mother (Yes=1), age (in years), and education (in years). hh_poor_i represents whether the household is a registered poverty household (Yes=1).

To explore the moderating effects in the association between the caregiver's language richness and child development outcomes, we then introduce interaction terms to the adjusted model:

$$Y_i = \beta_0 + \beta_1 Richness_i + \beta_2 CHILD_i + \beta_3 CAREGIVER_i + \beta_4 hh\_poor_i + \beta_5 Richness_i * CHARAC_t + \beta_6 SUIT_i + \beta_7 Richness_i * SUIT_i + \epsilon_i \quad (3)$$

In Model (3), $Richness_i * CHARAC_t$ is an interaction term between the caregiver's language richness score and the variables of interest, including child characteristics, caregiver characteristics, and household poverty status. And $Richness_i * SUIT_i$ is an interaction term between the caregiver's language richness score and each of the language suitability scores. For $Richness_i * CHARAC_t$ and $Richness_i * SUIT_i$, each interaction term was added to the model one at a time.

3. Results

3.1. Summary statistics

The summary statistics for key variables of children and caregivers are presented in Table 3. The average cognitive, language and motor scores of children in the sample were 97.17, 88.71, and 99.83, respectively. These were all lower than the mean scores of the BSID-III scale's reference population (Bos, 2013; Lowe et al., 2012; Serenius et al., 2013), with the least difference seen in the motor score. The average social-emotional score was 4.36, lower than the mean norm score (Putnam et al., 2006). The average language richness score for 591 caregivers was 1.17, with a standard deviation of 1.15.

Just over half (51%) of the sample children were male with an average age of 17 months, and very few (6%) were reported to have had a low birth weight. For less than half (43%) of children, their mother was the primary caregiver. In addition, 13% of children were from registered poverty households and received the minimum livelihood guarantee (Dibao) from the Government. Caregivers were on average 43 years old and had received six years of education, roughly primary-school level in China.

We further conducted a series of two-sample t-tests on child development scores, comparing them to different child, caregiver, and household characteristics; the results are reported in Table 4. Girls scored significantly higher than boys in all development outcomes (Rows 1a–1c, Columns 1–4). Children younger than 18 months scored significantly higher in cognitive development (Rows 2a–2c, Column 1), while children with low birth weight scored significantly lower in the cognitive, language, and motor scales (Rows 3a–3c, Columns 1–3). Children whose mother was the primary caregiver scored significantly higher in all development outcomes (Rows 4a–4c, Columns 1–4), while those whose caregiver was older than 45 scored significantly lower on the social-emotional scale (Rows 5a–5c, Column 4). Children from registered poverty households scored significantly lower on the cognitive scale (Rows 7a–7c, Column 1).

We explored the correlation between the caregiver's language richness, suitablity and child development outcomes and presented them in Table 5. The verbal expression richness of the caregiver is significantly correlated with the young child's language, motor, and social emotion. Language tone suitability is significantly correlated with the young child's language and social emotion. Language pacing speed and volume suitability are significantly correlated with the cognition and language of the young child.

3.2. Multivariate regression analysis

Adjusted regression results on the association between the caregiver's language richness and child development outcomes are presented in Table 6. The variance inflation factors (VIFs) are below 2.2 for all variables and less than the critical value (Ramsey, 1969), indicating there is no multicollinearity in our model. A one-point increase in the

Table 4
Comparison of child development outcomes by characteristics of interest (Mean ±S.D).

	Cognition (1)	Language (2)	Motor (3)	Social emotion (4)
A. Child				
(1) Gender				
(1a) male	96.61 ±13.82	87.13 ±15.28	98.65 ±15.80	4.32±0.57
(1b) female	97.76 ±13.60	90.34 ±16.28	101.06 ±17.65	4.40±0.50
(1c) P value	0.01	<0.01	0.01	0.03
(2) Age (in months)				
(2a) >18	95.42 ±12.61	90.54 ±14.79	102.33 ±14.77	4.35±0.58
(2b) ≤18	98.86 ±14.51	86.96 ±16.63	97.44 ±18.18	4.37±0.48
(2c) P value	<0.01	0.99	0.99	0.34
(3) Low birth weight				
(3a) Yes	88.64 ±16.26	81.03 ±13.59	94.30 ±17.71	4.37±0.46
(3b) No	97.68 ±13.39	89.16 ±15.86	100.16 ±16.66	4.36±0.54
(3c) P value	<0.01	<0.01	0.03	0.55
B. Caregiver				
(4) Mother as caregiver				
(4a) Yes	97.35 ±13.82	89.29 ±15.77	101.07 ±17.03	4.38±0.49
(4b) No	97.04 ±13.59	88.26 ±15.96	98.91 ±16.52	4.33±0.56
(4c) P value	0.01	0.02	0.02	0.03
(5) Age (in years)				
(5a) >45	96.58 ±13.88	88.69 ±15.73	100.12 ±17.03	4.31±0.56
(5b) ≤45	97.91 ±13.49	88.76 ±16.02	99.48 ±16.46	4.39±0.51
(5c) P value	0.12	0.67	0.28	0.06
(6) Education (in years)				
(6a) ≤ 9	95.45 ±14.17	87.38 ±15.24	98.80 ±16.85	4.34±0.52
(6b) > 9	97.90 ±13.46	89.27 ±16.08	100.27 ±16.73	4.38±0.54
(6c) P value	0.65	0.68	0.33	0.45
C. Household				
(7) Registered poverty household				
(7a) Yes	96.87 ±13.62	88.65 ±16.12	97.64 ±16.86	4.35±0.54

caregiver's language richness score is associated with an increase of 0.07 points in language score ($p < 0.05$), 0.07 points in motor score ($p < 0.05$), and 0.09 points in social-emotional score ($p < 0.05$). All coefficients are statistically significant after controlling for child, caregiver, and household characteristics.

Table 6 also revealed significant sub-group differences in child development outcomes. Compared with girls, boys scored lower in language (β= -0.12, $p < 0.01$) and motor (standardized β= -0.09, $p < 0.05$) scales. Low birth weight was negatively correlated with cognitive (β= -0.03, $p < 0.01$) and language (β= -0.02, $p < 0.01$) scores. Children whose mother was their primary caregiver scored better on cognitive scales (β= 0.15, $p < 0.05$). Additionally, we found that the education level of the primary caregiver was positively associated with development scores in social-emotion (β= 0.48, $p < 0.05$). Child age was positively correlated with both motor (β= 0.42, $p < 0.05$) development.

Moderating effects in the association between the caregiver's language richness and child development outcomes are presented in Table 7. We find that the language richness of the caregiver interacts with the child's gender, age, and poverty status in predicting child development outcomes. Specifically, compared with girls, an increase of one point in the caregiver's language richness score is associated with an increase of 0.001 ($p < 0.05$) and 0.001 ($p < 0.05$) points in cognitive and language scores for boys, respectively. In addition, for a one-month increase in the age of the child, a one-point increase in the caregiver's language richness score should bring an extra 0.02 ($p < 0.01$) points for motor score. Furthermore, a child from registered poverty household benefits more from the caregiver's language richness in cognitive and language development, with extra increases of 0.43 ($p < 0.05$) and 0.74 ($p < 0.05$) points, respectively.

Table 7 also presents the moderating role of the caregiver's language suitability in the association between language richness and child development outcomes. We find that among caregivers whose language inputs were more suitable, the association of language richness is significantly more substantial for the cognitive (β= 0.02, $p < 0.05$) and language (β= 0.04, $p < 0.05$) scores of the child. We further distinguished the moderating effects of the different subscales of language suitability, and the results are presented in Appendix A1. Pacing speed, tone and volume suitability were found to enhance the association between language richness and child development outcomes. For those caregivers whose language pacing speed was more suitable, the association of language richness is significantly more substantial for the cognitive (β= 0.02, $p < 0.05$) and language (β= 0.04, $p < 0.05$) scores of the child. For a one-point increase in the caregiver's language richness, a child whose caregiver talks more affectionately and warmly should expect an extra 0.01 ($p < 0.05$) point increase in language score and a 0.09 ($p < 0.05$) point increase in social-emotional score. Even larger gains are seen among caregivers who talk with a more suitable volume, with an expected extra 0.01 ($p < 0.05$) points for cognitive score and 0.04 ($p < 0.05$) points for language score. No statistically significant moderating role of any language suitability is found for child motor score.

4. Discussion

Our results indicate that caregiver's language richness while interacting with a child plays a supporting role in virtually language, motor, and social-emotional development of young children. The statistically significant coefficient of caregiver's language richness for child's development aligns with the well-established view that caregiver's language plays a vital role in the formation and development of a child abilities. For example, Hoff and Naigles (2002)found that the amount and quality of language input from caregivers during early childhood were strongly linked to children's later language development. Similarly, Rowe and Snow (2019) showed that children who were exposed to more varied and complex language input from their caregivers during their first three years of life had larger vocabularies and stronger language skills by age three. Our results, together with previous research, highlight the crucial role that caregivers can play in promoting early language development in children and underscore the importance of promoting language-rich interactions between caregivers and children from an early age.

Our results of the reduced form model indicate that the language richness of caregivers has a less significant impact on child cognitive development. Cognitive development of children may be more prone to be affected by a range of factors, and failure to consider the effect of these factors may interfere with the results. The coefficient of caregiver's language richness for child's cognitive development becomes statistically significant after adding the interaction terms, the estimated relationship became clearer and the value of R-square became higher.

We also find that the caregiver's language richness improves for boys, children in later toddlerhood, and those from registered poverty households. Despite the results from our t-test that boys' language and motor development is less advanced than girls', boys seem to benefit more from the stimulation of caregiver's language richness in cognitive,

Table 5
Zero-order correlation of all critical variables.

	Cognition	Language	Motor	Social emotion	Verbal expression richness	Pacing speed suitability	Tone suitability	Volume suitability	Gender of child (male=1)	Age of child in months	Low birth weight (yes=1)	Mom as caregiver (yes=1)	Age of caregiver in years	Education of caregiver in years
Language	0.48*													
Motor	0.54	0.47												
Social emotion	-0.02	0.04	-0.01											
Verbal expression richness	0.01	0.06*	0.11*	0.10*										
Pacing speed suitability	0.04*	0.04*	0.01	0.01	0.07*									
Tone suitability	0.01	0.01*	0.04	0.06*	0.41**	0.03								
Volume suitability	0.02*	0.01*	0.02	0.05	0.17	0.16**	0.57**							
Gender of child (male=1)	-0.08	-0.09*	-0.09*	-0.06	0.01	0.01	0.02	0.00						
Age of child in months	-0.05	0.08*	0.25*	0.00	0.20**	-0.05	0.03	0.05	0.01					
Low birth weight (yes=1)	-0.14**	-0.15**	-0.03*	0.00	0.01	0.02	0.03	0.06	-0.06	0.06				
Mom as caregiver (yes=1)	0.03*	0.02	0.10	0.08	0.01	0.08	0.04	0.03	0.04	-0.18	0.08			
Age of caregiver in years	-0.05	-0.05	0.04	0.07	-0.02	-0.10*	0.00	-0.04	0.03	0.18	-0.01	-0.60*		
Education of caregiver in years	0.08*	0.08	0.04	0.00*	0.05	0.04	0.02	0.00	0.01	-0.11	0.03	0.41*	-0.68*	
Registered poverty household (yes=1)	-0.06*	-0.02	-0.04	-0.02	-0.03	-0.04	-0.03	0.01	0.00	0.04	0.01	-0.05	0.07	-0.06

*p<0.05; **p<0.01.

Table 6
The effect of the caregiver's language richness on development scores of the child.

	Cognition				Language				Motor				Social emotion			
	B	SE	β	p-value	B	SE	β	p-value	B	SE	β	p-value	B	SE	β	p-value
(1) Language richness	0.95	0.45	0.08	0.06	1.12	0.47	0.07	p<0.05	1.20	0.26	0.07	p<0.05	0.05	0.02	0.09	p<0.05
(2) Gender (Male=1)	-2.13	1.36	-0.07	0.41	-3.37	1.18	-0.12	p<0.01	-2.49	1.13	-0.09	p<0.05	-0.07	0.04	-0.07	0.06
(3) Age (in months)	-0.1	0.09	-0.01	0.45	0.18	0.08	0.18	0.06	0.51	0.11	0.50	p<0.01	0.00	0.00	0.00	0.41
(4) Low birth weight (Yes=1)	-8.92	2.43	-0.03	p<0.01	-7.79	1.80	-0.02	p<0.01	-5.61	2.86	-0.02	0.05	0.02	0.10	0.00	0.72
(5) Mom as caregiver (Yes=1)	3.14	1.47	0.15	p<0.05	3.23	2.55	0.11	0.26	3.09	2.31	0.10	0.27	0.02	0.06	0.02	0.49
(6) Age (in years)	-0.08	0.07	-0.26	0.39	-0.14	0.09	-0.32	0.56	0.02	0.10	0.06	0.89	0.00	0.00	0.33	0.10
(7) Education (in years)	1.36	0.80	0.57	0.07	1.35	0.64	0.43	0.05	2.17	1.11	0.76	0.07	0.03	0.01	0.42	p<0.05
(8) Registered poverty household (Yes=1)	-2.98	1.71	-0.03	0.09	0.50	1.62	0.003	0. 69	-1.93	1.78	-0.02	0.35	0.07	0.07	0.02	0.39

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language, and motor development. In the adjusted regression model, the child's gender (Male=1) coefficients also remain negative and significant for the child's language, motor, and social-emotional scores. Consistent with our finding, girls are generally thought to perform better than boys in many aspects, such as verbal and linguistic functions (Barr, Kamil, Mosenthal, & Pearson, 1991; Joseph, 1996; McCormack & Knighton, 1996). Meanwhile, our results echo the findings of (Zhou et al., 2016)) that the gender gap in physical health and academic performance among school-aged children appears to be diminishing in poor rural western parts of China. Given that the caregiver's language richness works better for boys, it could be an effective way to help boys catch up with girls.

Our study reveals that older children benefit more from caregivers' language richness in language development. This result corroborates the findings of Vallotton et al. (2017), who tracked a group of 146 American infants and mothers of low-income families and assessed them at 14, 24, and 36 months. They found that the effect of maternal stimulation is increasingly more significant toward later toddlerhood. There are several theoretical and empirical evidence to support this finding (Vallotton et al., 2017). First, older children may have a more advanced language system, making them better able to benefit from the rich language input provided by caregivers. According to the "Zone of Proximal Development" theory by Vygotsky and Cole (1978), children's learning is facilitated by interactions with more knowledgeable others, such as caregivers. As children's language skills develop, they are better able to make use of the rich language input from caregivers to further enhance their linguistic abilities. Second, older children may have more opportunities to engage in complex language interactions with their

Table 7
Moderating effects of the caregiver's language suitability during interaction.

	Cognition				Language				Motor				Social emotion			
	B	SE	β	p-value	B	SE	β	p-value	B	SE	β	p-value	B	SE	β	p-value
(1) Language richness	0.71	0.44	0.05	0.05	1.11	0.60	0.08	p<0.05	1.22	0.55	0.07	p<0.05	0.02	0.01	0.05	p<0.05
(2) Suitability	0.68	0.36	0.04	p<0.05	0.75	0.05	0.01	p<0.05	1.26	0.72	0.03	0.39	0.01	0.05	0.01	0.37
(3) Richness* Suitability	0.15	0.03	0.02	p<0.05	0.61	0.18	0.04	p<0.05	0.63	0.40	0.04	0.12	0.02	0.02	0.03	0.83
(4) Gender (Male=1)	-1.17	1.10	-0.05	0.67	-2.01	0.87	-0.06	p<0.01	-1.72	0.71	-0.04	p<0.05	-0.01	0.01	-0.01	0.07
(5) Age (in months)	-1.14	1.11	-0.041	0.81	-2.05	1.00	-0.07	p<0.01	-1.79	0.77	-0.05	p<0.05	-0.02	0.01	-0.02	0.08
(6) Low birth weight (Yes=1)	-0.76	0.50	-0.91	0.78	0.14	0.07	0.15	0.06	0.37	0.10	0.37	p<0.01	0.00	0.00	0.00	0.25
(7) Mom as caregiver (Yes=1)	-6.38	2.06	-0.02	p<0.01	-6.46	2.00	-0.02	p<0.01	-4.31	1.65	-0.01	0.08	0.01	0.09	0.00	0.38
(8) Age (in years)	2.61	1.06	0.11	p<0.05	3.18	2.70	0.12	0.11	2.53	2.06	0.09	0.98	0.02	0.07	0.02	0.39
(9) Education (in years)	-0.07	0.05	-0.21	0.62	-0.10	0.06	0.28	0.53	0.02	0.07	0.05	0.72	0.00	0.00	0.16	0.06
(10) Registered poverty household (Yes=1)	1.29	0.81	0.54	0.33	1.22	0.66	0.46	0.06	2.00	0.88	0.70	0.07	0.03	0.01	0.04	p<0.05
(11) Richness*Gender (Male=1)	-2.36	1.22	-0.58	0.05	0.40	1.54	0.15	0.38	-1.46	1.38	-0.51	0.70	0.04	0.07	0.46	0.36
(12) Richness* Age (in months)	0.26	0.01	0.002	p<0.05	0.02	0.01	0.0001	p<0.05	0.88	1.33	0.01	0.92	0.00	0.03	0.00	0.42
(13) Richness*Low birth weight (Yes=1)	-0.13	0.12	-0.01	0.83	0.03	0.09	0.00	0.77	0.37	0.06	0.02	p<0.01	-0.00	0.00	-0.00	0.91
(14) Richness*Mother (Yes=1)	2.04	1.74	3.68	0.51	1.32	1.61	2.14	0.33	1.06	1.38	1.59	0.51	0.03	0.07	1.19	0.80
(15) Richness* Age (in years)	0.03	0.02	0.01	0.40	0.02	0.02	0.00	0.65	0.03	0.03	0.00	0.60	0.00	0.00	0.00	0.59
(16) Richness* Education (in years)	0.01	0.09	0.03	0.74	0.00	0.06	0.01	0.71	0.15	0.18	0.45	0.51	0.00	0.01	0.00	0.87
(17) Richness* Registered poverty household (Yes=1)	0.60	0.25	0.43	p<0.05	1.17	0.29	0.74	p<0.05	1.46	1.23	0.86	0.29	0.02	0.03	0.52	0.47

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Table A1
Moderating effects of the subscales of caregiver's language suitability during interaction

	Cognition				Language				Motor				Social emotion			
	B	SE	β	p-value	B	SE	β	p-value	B	SE	β	p-value	B	SE	β	p-value
(1) Language richness	0.68	0.43	0.06	0.05	1.13	0.39	0.07	p<0.05	0.98	0.32	0.06	p<0.05	0.03	0.01	0.05	p<0.05
(2) Pacing speed	1.05	0.47	0.04	p<0.05	0.15	0.05	0.01	p<0.05	1.26	0.72	0.03	0.39	0.02	0.06	0.02	0.54
(3) Tone	0.67	0.38	0.02	0.06	0.23	0.08	0.01	0.07	0.66	0.97	0.01	0.27	0.06	0.02	0.03	p<0.05
(4)Volume	0.61	0.10	0.01	p<0.05	0.61	0.33	0.01	0.06	0.57	0.87	0.01	0.68	0.02	0.15	0.01	0.69
(5) Richness* Pacing speed	0.14	0.04	0.02	p<0.05	0.65	0.20	0.04	p<0.05	0.70	0.37	0.03	0.11	0.02	0.03	0.02	0.85
(6) Richness* Tone	0.07	0.03	0.01	0.07	0.15	0.05	0.01	p<0.05	-1.01	1.25	-0.05	0.66	0.05	0.02	0.09	p<0.05
(7) Richness* Volume	0.36	0.15	0.01	p<0.05	0.63	0.17	0.04	p<0.05	0.51	1.33	0.02	0.29	0.07	0.03	0.09	0.65
(8) Gender (Male=1)	-1.17	1.10	-0.05	0.67	-2.01	0.87	-0.06	p<0.01	-1.72	0.71	-0.04	p<0.05	-0.01	0.01	-0.01	0.07
(9) Age (in months)	-0.69	0.49	-0.90	0.72	0.16	0.06	0.18	0.07	0.37	0.10	0.32	p<0.01	0.00	0.00	0.00	0.23
(10) Low birth weight (Yes=1)	-6.51	2.01	-0.03	p<0.01	-6.60	1.83	-0.03	p<0.01	-4.23	1.62	-0.01	0.07	0.01	0.08	0.00	0.42
(11) Mom as caregiver (Yes=1)	2.52	1.01	0.10	p<0.05	3.20	2.51	0.13	0.10	2.55	2.02	0.11	0.88	0.01	0.06	0.01	0.29
(12) Age (in years)	-0.08	0.04	-0.22	0.54	-0.08	0.05	-0.22	0.56	0.02	0.06	0.04	0.71	0.00	0.00	0.14	0.05
(13) Education (in years)	1.31	0.80	0.57	0.27	1.19	0.63	0.44	0.05	2.11	0.85	0.81	0.06	0.02	0.01	0.03	p<0.05
(14) Registered poverty household (Yes=1)	-2.33	1.20	-0.57	0.06	0.42	1.52	0.16	0.29	-1.39	1.35	-0.49	0.73	0.03	0.05	0.39	0.29
(15) Richness*Gender (Male=1)	0.28	0.01	0.01	p<0.05	0.02	0.01	0.00	p<0.05	0.91	1.32	0.01	0.94	0.00	0.02	0.00	0.39
(16) Richness* Age (in months)	-0.11	0.12	-0.01	0.82	0.02	0.08	0.00	0.68	0.35	0.05	0.02	p<0.01	-0.00	0.00	-0.00	0.87
(17) Richness*Low birth weight (Yes=1)	2.02	1.75	3.61	0.53	1.27	1.53	2.10	0.32	1.10	1.33	1.52	0.49	0.04	0.06	1.21	0.76
(18) Richness*Mother (Yes=1)	0.20	0.64	0.00	0.81	0.06	0.58	0.00	0.54	0.53	0.50	0.01	0.53	0.01	0.02	0.01	0.29
(19) Richness* Age (in years)	0.03	0.02	0.01	0.40	0.02	0.02	0.00	0.65	0.03	0.03	0.00	0.60	0.00	0.00	0.00	0.59
(20) Richness* Education (in years)	0.01	0.09	0.03	0.74	0.00	0.06	0.01	0.71	0.15	0.18	0.45	0.51	0.00	0.01	0.00	0.87
(21) Richness* Registered poverty household (Yes=1)	0.59	0.25	0.43	p<0.05	1.16	0.29	0.74	p<0.05	1.46	1.23	0.86	0.29	0.02	0.03	0.52	0.47

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caregivers. As children grow, their social and cognitive skills develop, allowing them to participate in more sophisticated conversations with caregivers. This may lead to more extensive language input from caregivers and more opportunities for children to learn new vocabulary and syntactic structures. Empirical evidence has also supported this idea, with studies showing that older children have larger vocabularies and stronger language skills when exposed to more varied and complex language input from caregivers (e.g., Rowe and Snow (2019)).

Evidence shows that a child from a registered poverty household would benefit more from the caregiver's language richness in cognitive and language development, which has important implications for designing interventions for the most vulnerable children in rural China. Some studies attributed the development gap of rural Chinese children to the lack of family resources to create a stimulating home environment, such as buying toys (Yue et al., 2017). Our findings indicate that caregivers in poor households could seize the low-hanging fruit simply by using richer language while interacting with the child daily, without incurring any cost.

We find a stronger association between language richness and a child's social-emotional development among caregivers who talk with a more suitable tone. By talking to the child with rich content and a suitable tone, the caregiver defines ideas, explains concepts, and tests the child's knowledge, receptive to and sensitive to their children's signals, which positively influence the language development of young children (Baumwell et al., 1997; Carpenter et al., 1998; Vallotton et al., 2017).

Our results also reveal that it is not only the content of the caregiver's speech that matters but also the way the caregiver talks to the child. The caregiver who attempts to use rich language to introduce new objects or activities to the child will achieve better results by considering and adjusting based on the child's cues (Hubbs-Tait, Culp, Culp, & Miller, 2010; Tamis-LeMonda et al., 2001). Optimally, the caregiver's speech should be rich and suitable to achieve high-quality interaction with the child.

One strength of our study is that we use an observational method to measure the caregiver's language richness and suitability during the interaction, which has the advantage of objectivity compared with the self-reported data of caregivers (Maclaren et al., 2015). The other strength is that ours has a much larger sample size (N=591) than similar observational studies, giving higher statistical power and more robust external validity.

The findings of this study have practical implications. This study demonstrates that caregiver's language richness while interacting with a child plays an important role in the early development of children. Therefore, it is recommended that interventions promoting development outcomes of young children in rural China should consider improving the richness and suitability of caregivers' language, particularly for boys, children in later toddlerhood, and children in poor households. This involves: 1) raising caregivers' awareness on the importance of using richer language during daily interaction; 2) introducing caregivers with appropriate strategies (for instance, affectionate speech tone, use rich language to introduce new objects or activities to the child) to receive better early childhood development results.

Our study also has several limitations. First, we are only able to capture a snapshot of caregiver-child interaction. Even though 10-min

long videos have been used in many similar observation studies (Landry, Smith, Miller-Loncar, & Swank, 1998), it is still a relatively short period. It may not fully reflect the actual daily situation. Second, our study is not as well controlled as observational studies conducted in the lab. We chose the child's home as the venue because it has the advantage of approximating the daily situation of caregiver-child interaction.

5. Conclusion

Our study suggests that during the caregiver-child interaction, a positive and significant association exists between the language richness of caregivers and the cognitive, language, motor, and social-emotional development of children in rural China. We also find that the effects are stronger for boys, in their later toddlerhood or from registered poverty households. Moreover, we find that caregivers' language suitability, in terms of pacing speed, tone, and volume, could enhance the positive association between language richness and children's cognitive, language, and social-emotional development.

Author contributions

Renfu Luo, Chengfang Liu, and Scott Rozelle contributed to the design of this study, Jingjing Gao, Yang He, Tianyi Wang, Yuting Chen and Renfu Luo contributed to the analysis and interpretation of the data, and writing the manuscript. Chengfang Liu, Scott Rozelle provided feedback and edit the manuscript. All authors have read and agreed to the published version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix

Table A1

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