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Posted Date: 1 January 2026

doi: 10.20944/preprints202512.2752.v1

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Article

Fluency and Connectedness: Building the Foundation for Language Development in Deaf and Hard-of-Hearing Children

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Abstract

Parent-child interaction is a foundational component of language development. This study examined parent-child interaction in deaf and hard-of-hearing children 6 or 9 months after they received hearing aids or cochlear implants. Expressive, receptive, and overall language skill were probed 9 to 18 months later. Thirteen DHH children and their parents participated in a videorecorded, semi-structured play interaction. Items from an adapted version of the Joint Engagement Rating Inventory were used evaluate parent-child interactions (i.e., fluency and connectedness, shared routines and rituals, child joint engagement, and parental sensitivity). Language skills were assessed using the Preschool Language Scales-5th (Zimmerman et al., 2011). Results indicate statistically significant relationships between child-parent joint engagement and expressive (p = .004), receptive language (p = .043), and total language scores (p = .007). The shared routines and rituals item was significantly related to expressive language (p = .037) and approached statistical significance with total language (p = .076) but was not significantly related to receptive language. The fluency and connectedness item was significantly related expressive language (p = .008) and total language (p = .028) but did not reach statistical significance with receptive language (p = .077). A quantitative measure of parental language input (i.e., words per minute) was not significantly related to any language variables.

Keywords: deaf; language development; parent-child interaction; quality

1. Introduction

A primary focus of early intervention for deaf and hard-of-hearing (DHH) children is the parent-child relationship. Promoting positive interactions that are sensitive, responsive, and engaging are the foundation of language development (e.g., Hirsh-Pasek et al., 2015). Parental attention to infants' cries, vocalizations, and gestures in a way that is both temporally and semantically contingent way is the groundwork on which more sophisticated language skills develop (Moeller et al., 2013; Szarkowski et al., 2024). However, language outcomes among DHH children are highly variable, including for children with cochlear implants and who are implanted before 2 years of age (Cruz et al., 2014). Some children develop expressive and receptive language skills on similar trajectories as hearing children, but not all DHH children demonstrate similar rates beyond early childhood (Cruz et al., 2014; Holt et al., 2012; Niparko et al., 2010). While factors such as age at device fitting and degree of hearing loss explain some of the variability in language outcomes, most of the variance is still unexplained. Recent examinations of language skills in DHH children have focused on the role of

 doi:10.20944/preprints202512.2752.v1

parent-child interaction as an explanatory factor for the range of outcomes (Ambrose et al., 2015; Cruz et al., 2014).

The purpose of the current study is to extend previous research on the role of language input (Ambrose et al., 2015; Cruz et al., 2014; Hirsh-Pasek et al., 2015) on language outcomes in DHH children by: (1) considering an expanded scope of language input factors at an early timepoint in DHH children's development, and (2) determining the relationship between those factors and later expressive and receptive language outcomes. This study provides an in-depth examination of the degree to which language input quantity, quality of dyadic communicative behaviors, and parents' sensitivity at a critical stage in children's development (on the cusp of verbal expression) is associated with stronger language skills.

1.1. Language Input Quality

Language quality can mean different things – word diversity, mean length of utterance, grammaticality, grammatical complexity, etc. (Rowe & Snow, 2020). In this study, language input quality is the extent to which caregiver language input is integrated with caregiver-child interactions. This definition is motivated by a transactional perspective on language development, which emphasizes the importance of reciprocal interactions between caregivers and children in constructing their dyadic communication (Sameroff, 2010). The process of co-construction is dynamic and dyadic, the active child and responsive parent influence each other (Sameroff, 2010; Masek et al., 2024a). Parents' sensitivity and responsiveness to early communicative behaviors such as cries and coos encourage turn-taking, eventually lead to children to engaging in language that is increasingly symbol-infused and decontextualized (Adamson et al., 2014; Rowe, 2012). Attending to baby's focus of attention and responding contingently by providing a label for an object or holding it up, elicits a response such as smiling, vocalizing, and pointing in typically developing children. This interactional behavior often generates a feedback loop, facilitating vocabulary and grammatical development (Hirsh-Pasek et al., 2015).

Motivated by Sameroff's transactional theory (Sameroff, 2010), Hirsh-Pasek et al. (2015), we conducted an in-depth examination of three types of language quality features that focus on parent-child interaction during communication: Fluency and connectedness, shared routines and rituals, and symbol-infused joint engagement. These qualities were rated using the Joint Engagement Rating Inventory (JERI) (Adamson et al., 2020) at 24 months. Language skills were then assessed at 36 months.

The *fluency and connectedness* item on the JERI relates to the flow and cohesion of parent-child communicative interactions, in which there is a balance of communicative reciprocity between parent and child, even before children can talk. Both social partners appear motivated to interact and show enjoyment in engaging with each other, setting the stage for sustained "conversations" related to a shared topic (Nelson, 2008). The *shared routines and rituals* item assesses predictable patterns of interaction, or the sharing of cultural practices and scripts that become routinized such as playing "bedtime", "making breakfast," or reading a book together (Bruner, 1983). Interactions like these are varied and nuanced. *Symbol-infused joint engagement* refers to symbols infused the child's states of engagement with people and objects (Adamson et al., 2004).

In Hirsh-Pasek et al.'s (2015) analysis of the contributions of each item to children's language skill at 36 months, fluency and connectedness accounted for a greater amount of the variance (26.9%) in children one year later than symbol-infused joint engagement and routines and rituals (14.2% and 11.8%, respectively). It also accounted for a greater amount of variance than a measure of sensitive parenting (12%), which involves how caregivers interact with children but does not involve language. For example, a parent can comfort a distressed child with just a hug. Hirsh-Pasek et al.'s (2015) findings suggest that language interactions characterized as cohesive and connected, in which parent and child use verbal and non-verbal communicative acts to engage in a shared topic are particularly important for facilitating language growth. These interactions also involve a relative balance in turn-taking between child and parent even before children begin to talk.

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Findings from Hirsh-Pasek et al. (2015) substantiate earlier research showing that children benefit linguistically from frequent and sustained interactions with parents (e.g., Adamson et al., 2014). Episodes in which parent and child express shared interests (through eye gaze, gesture, pointing, and other communicative acts) are the building blocks upon which infants learn to regulate attention, acquire novel words, and engage in increasingly representational and symbolic communication (Adamson et al., 2014; Masek et al., 2024a). Before children learn to use spoken (or signed) utterances, they engage in various everyday activities (e.g., mealtime, bath, grocery shopping) that typically elicit engagement with caregivers.

1.2. Language Quantity

The amount of parent talk and linguistic complexity expressed during such interactions relate to children's expressive and receptive language skills (e.g., Anderson et al., 2021; Hart & Risley, 1995; Rowe, 2012; Rowe & Snow, 2020; Masek et al., 2024b). Children who are exposed to a large and diverse vocabulary are more likely to have a larger expressive lexicon and better comprehension skills compared to children who hear fewer words and a limited lexicon (Rowe & Snow, 2020). A meta-analysis of studies using the Language Environment Analysis (LENA), an automated measure of children's language environments, showed the amount of input correlated with language outcomes (Wang et al., 2020). However, number of conversational turns was more strongly related. Quantity may matter as it may give more opportunities for interactions. Studies suggest that quality of parent-child interaction is the more potent predictor of children's vocabulary size than quantity of input (Anderson et al., 2021; Hirsh-Pasek et al., 2015; Rowe, 2012; Masek et al., 2024a). Furthermore, amount of parent talk remains relatively stable over time, while quality of language input appears to be less stable (Cartmill et al., 2013; Cruz et al., 2013; Huttenlocher et al., 2010; Rowe, 2012).

1.3. Language Input in DHH Children

Much less is understood about how *quality* of language input early in a DHH child's life relates to later language abilities. Recent studies have focused on quantitative aspects of language input in efforts to explain variability in language outcomes (Ambrose et al., 2014; Ambrose et al., 2015; Arjmandi et al., 2022; Dirks et al., 2020; VanDam et al., 2012). While directionality between language input and children's language abilities is unspecified, number of conversational turns and total number of caregiver words and utterances are positively associated with stronger language outcomes in DHH children with hearing aids (Ambrose et al., 2014; Dirks et al., 2020). Young DHH children (i.e., 2- and 3-year-olds) with mild to moderate hearing levels who experience more conversational turns with caregivers, demonstrate stronger language outcomes compared to toddlers engaged in fewer conversational turns (Ambrose et al.., 2014; Dirks et al., 2020).

DHH children as a group experience linguistic environments that vary in terms of exposure to lexical diversity and grammatical complexity (Ambrose et al., 2015; Arjmandi et al., 2002; Cejas et al., 2014), factors that explain some of the variability in language outcomes (Ambrose et al., 2015; Dirks et al., 2020; Quittner et al., 2013). For instance, hearing mothers tend to use more directive language (with their DHH children, compared to Deaf mothers of DHH children (Meadow-Orlans & Spencer, 1996). Although directives are frequently used by hearing parents, they do not carry the positive impact of higher-level language input, such as open-ended questions (Cruz et al., 2013). High levels of directing ("play with this doll") is negatively correlated with language development (Cruz et al., 2014). Research also suggests that DHH children spend less time in sustained interactions with parents compared to hearing children (Cejas et al., 2014; Gale & Schick, 2008).

Studies examining symbol-infused joint engagement and language abilities in DHH children and hearing mothers indicate DHH children spend less time in symbol-infused joint engagement and demonstrate less robust language skills compared to hearing children (Cejas et al., 2014; Gale and Schick, 2008). Sustained interactions that consist of children's joint engagement with words and symbolic gestures are critical for language development (Adamson et al., 2004). Gale and Schick (2008) found that DHH toddlers with hearing mothers produced significantly fewer different words

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and spent less time in sustained interactions than hearing toddlers. The DHH children in a study by Cejas and colleagues demonstrated delayed language levels compared to age-matched hearing children.

However, questions regarding dyadic behaviors in parent-child interactions and their relation to language outcomes for young DHH children remain. The current study builds on previous research by evaluating the relationship between joint engagement and later language abilities, rather than a concurrent examination. Also, whereas Cejas et al. (2014) focused on evaluating the development of joint engagement and included children within a wider age range (5 months to 5 years), this study is focused on early language input and language outcomes in children within a narrow range (14-33 months). Given the young age of our sample (M = 31.38 months; SD = 8.79) at the time of language testing, we use a different measure of joint engagement (child joint engagement) rather than symbol-infused joint engagement.

1.4. Present Study

The current study extends previous research on the relationship between quality indicators of positive parent-child interaction and how they relate to receptive and expressive spoken language skills in a small sample of young DHH children and their hearing parents. Language research with typically developing children has shifted focus to quality measures (Masek et al., 2021), an area in need of further examination regarding language development in DHH children. Thus, we focus specifically on associations between measures of parent-child communicative interactions – joint parent-child engagement, shared routines and rituals, fluency and connectedness – and children's language abilities 9 to 18 months later. As in Hirsh-Pasek et al (2015), we also assessed the relationship between parent sensitivity and later language outcomes. Following previous research on parental language input demonstrating that quantity of parental language input explains some variance in language outcomes in DHH children, albeit to a lesser extent than input quality, a measure of quantity (i.e., words per minute) is included in the analysis. Based on previous research (Masek et al., 2024a), we expected that the quality of parent-child interaction would vary among dyads and that our qualitative features and language outcomes would be positively associated.

2. Materials and Methods

2.1. Participants

The present research study was approved by the Institutional Review Board at [BLINDED]. Participants were primarily recruited from the clinical caseload at a nearby children's hospital. Informed consent was obtained from all subjects involved in the study. Inclusion criteria were (1) hearing aid fitting or cochlear implant activation by age 24 months, (2) English as the primary language in the home, and (3) no comorbid diagnoses. Dyads were included based on availability of usable parent-child interaction video recordings at the first interval of focus for the present study (i.e., 6 or 9 months of device use), as well as language scores on the Preschool Language Scale - 5th edition (PLS-5) at the second interval,18 or 24 months of device use.

Thirteen prelingually deaf children participated (9 girls, 4 boys), all diagnosed with bilateral sensorineural hearing loss within the moderate to profound range. Eight children used cochlear implants: five used hearing aids. Average age of cochlear implantation was 14.25 months (SD = 4.43). Average age at hearing aid fitting was 8.4 months (SD = 9.18). Children were majority White non-Hispanic (n = 12); one child was identified as biracial (Black/African American and White) non-Hispanic. The average chronological age at the first research visit (i.e., 6- or 9-month interval from receiving hearing support) when parent-child interaction was recorded was 20 months (SD = 5.6, range = 14 to 33). Language outcomes were collected at the second visit (i.e., 18- or 24-month interval), in which the average age was 31.38 months (SD = 8.79, range = 20 to 48). Child demographic information is provided in Table 1.

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Table 1. Child Demographics.

Characteristic	n (%)
Gender	
Female	9 (69)
Male	4 (31)
Race	
White	12 (92)
Biracial	1 (8)
Ethnicity	
Non-Hispanic	13 (100)
Device type	
Cochlear implant	8 (62)
Hearing aid	5 (38)
Mean age at CI (months)	14.25 (SD, 4.43)
Mean age at HA (months)	8.4 (SD, 9.18)

Note. CI = cochlear implant; HA = hearing aid.

Twelve mothers and one father participated. Nine parents had earned a bachelor's or master's degree; the remaining had an associate's degree or high school diploma or GED. Most households earned an estimated annual income of $50,000 and above. All parent participants were hearing. English was the primary language of the households. One mother was a child of Deaf adults and was raised in a household that used English and American Sign Language. Five of the 13 parents used some sign language (mostly spoken language with accompanying signs) with their child. See Table 2 for parent characteristics.

Table 2. Parent Characteristics.

Characteristic	N (%)
Sex	
Female	12 (92)
Male	1 (.08)
Race/ethnicity	
White/non-Hispanic	13 (100)
Highest education level	
High school graduate	3 (23)
Associate degree	1 (8)

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Bachelor's degree	7 (54)
Master's degree	2 (15)
Annual household income	
Less than 5,000	1 (8)
25,000-34,999	2 (15)
35,000-49,999	1 (8)
50,000-74,999	4 (31)
75,000-99,999	3 (23)
100,000	2 (15)

2.2. Measures

Play Protocol: Three-Boxes Task

We implemented the three-boxes task, a semi-structured play protocol originally used in the NICHD Study of Early Child Care and Youth Development (SECCYD, NICHD ECCRN, 1999). Parent-child dyads engage with various toys provided in three separate numbered bins. In the current study, Box 1 contained a set of multi-color building blocks, Box 2 contained a toy kitty and doll clothes, and Box 3 contained a doll, toy food items and utensils. First, a research assistant described the contents of each box and asked parents to use pre-determined prompts and stories (i.e., use color labels for the blocks; dress the kitty because she is going to Alaska to meet her friend Turtle; make a meal for baby). Second, parents were instructed to play with their child as they would normally while generally staying within the confines of a 5 x 7-foot carpet for video-recording purposes. Boxes were placed on a shelf near the play area. The time of the protocol was 5 minutes per box. A research assistant knocked on the door of the laboratory room at the 5-minute mark, at which time the parent and child were directed to put the toys back in the box, place it on the shelf, and place the next box on the floor. All sessions were video recorded using two GoPro video cameras placed on opposite corners of the rug. Sound was recorded using body-worn microphones on parents.

2.3. Quality Indicators of Parent-Child Communicative Interaction

Parent-child interactions were rated using an adapted version of the Joint Engagement Rating Inventory (JERI) (Suma et al., 2023), based on Adamson et al. (2016). The JERI is divided into four clusters (i.e., engagement state, child activity, caregiver activity, and dyadic interaction) with a total of 32 items. The present study included three JERI items within each of these clusters (Adamson et al., 2020). All items are rated on a 1-7 Likert scale (1 = low; 7 = high). Children in the current sample were younger than those in Hirsh-Pasek et al. (2015) and Cejas et al. (2014) and not yet exhibiting symbol-infused joint engagement. For that reason, we decided to use the child joint engagement item on the JERI, rather than the symbol-infused joint engagement.

The child joint engagement item assesses both the quantity and quality of a child's joint engagement with topics that they share with their caregiver such as working together to dress baby. On the lowest end, 1 indicates no episodes of child joint engagement as when a child picks up a doll and briefly glances at parent; on the highest end, 7 indicates many continuous or frequent rich and varied episodes of joint engagement (i.e., child picks up doll, shows it to parent, parent comments on the doll, ask the child if they should dress the doll, leading to a back-and-forth putting items of clothing on the doll). A midrange rating of 4 indicates the dyad spent approximately a third of the

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interaction in joint engagement that is of moderate quality, more time in joint engagement that is of markedly low-quality (e.g., highly prompted, broken turns) or less time in joint engagement in a strikingly high-quality manner (i.e., parent and child engage with doll, taking turns putting on clothes, child walks away before the doll is dressed).

Regarding shared routines and rituals, a low rating of 1 indicates no evidence of naturalistic shared routines and rituals that caregivers and young children often fall into, typically involving "my turn-your turn" (e.g., picking up a book, looking at a page, and putting it down); a rating of 7 indicates sustained, varied, and nuanced evidence of shared rituals and routines (e.g., shared book reading, taking turns turning pages, pointing to characters in the book, parent and child mimicking characters' actions, concluding with a "yay" at the end of story). A 4 indicates some shared routines and rituals but are not sustained throughout the interaction or highly repetitive routines (i.e., reading a few book pages, pointing to pictures with some turn-taking).

While the measure of child joint engagement reflected the frequency with which the child brought the parent into their sphere of attention, fluency and connectedness was a more complex measure of how their interaction proceeded. The fluency and connectedness ratings consider three components of the interaction: fluency – how the parent and child pass turns back-and-forth; connectedness – how the dyad shares their enjoyment with each other within the interaction; balance – how equally the partners contribute to the interaction. A rating of 1 indicates that no interaction between parent and child was established during the play session. An example of an episode that would be rated a 1 would be the following: parent tries engaging the child in "making breakfast" by handing them multiple "food items", and child wanders to another activity. A rating of 7 indicates fluent and balanced interaction with both parent and child indicating investment and enjoyment in the play. Seven would mean that the play is sustained throughout the 5-minutes with each box. A score of 7 would be given to the following sequence: parent and child "making breakfast" involving sustained and smooth turn taking, and a balance of parent and child participation. A midrange rating of 4 indicates the presence of one of the three components– often connectedness – and some indications of the other two in lesser amounts (i.e., parent and child "make breakfast" but some communication bids are not responded to, or long pauses between turn taking). Fours are often indicated when a parent is highly involved and a child that seems motivated to interact has some difficulty sustaining and initiating a back-and-forth pattern of engagement.

In addition to the three measures of language input quality, parental sensitivity, defined as a parent's accurate perception and interpretation of their infant's signals and the prompt and appropriate response to these signals (Ainsworth et al., 1974), was rated using a modified standard global measure of parent and child behavior developed as part of the NICHD Study of Early Child Care (Owens et al., 1996). We used the Qualitative Ratings for Parent-Child Interactions, the scale for children ages 3 to 15 months (Frosch & Owen, 2006) and the scale for children ages 2-4 years (Owen et al., 2010). We applied the Sensitivity to Non-Distress items for the children 3 to 15 months and the Sensitivity/Responsiveness item for the children in the 2-to-4-year range. The scales were used with the children in the sample within the appropriate age range. For the children between 15 and 24 months, we applied both scales and averaged the scores. Sensitivity to Non-Distress centers on how the parent demonstrates the ability to adapt interactions to the child's mood and level of development.

Parental sensitivity was rated on a 5-point scale. A rating of 1 indicates very low to non-existent sensitive behaviors, and a 5 indicates exceptional sensitivity and responsivity. The three target items from the JERI were rated on 7-point scales, with a 1 rating representing very low amounts of the rating item and 7 representing very high presence within the interaction.

2.4. Reliability for Quality Indicators

The study's two observers received approximately 8 weeks of training before they rated the video records. Observers included a doctoral student in speech-language pathology and a research lab coordinator. Training followed the procedures described in Suma et al. (2017) and were led by co-

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developer of the protocol (co-author K.S.). Training involved viewing samples of parent-child interactions, discussion of each item, and practice ratings. Observers rated practice videos until they reached 90-100% agreement across items. Observers were blind to other information about the children, including PLS-5 scores. Rating typically entailed viewing the video record of a session two or three times, during which the observer took notes related to the child's joint engagement as well as the presence of sustained interactions and shared routines and rituals.

To check agreement, we assigned 3 of the 13 videorecorded play sessions independently to two observers. The observers did not know which sessions were double rated. The three JERI items selected for each subscale and sensitivity were rated in 9 play sessions for each dyad. For child joint engagement, reliability within 1 was acceptable with an estimated accuracy of 71% (see Bakeman & Querra, 2011). For both shared routines and rituals and fluency and connectedness, all ratings were within 1 point of each other, giving an estimated accuracy of greater than 99%. The overall total weighted kappa was .73 with an estimated accuracy of 91%, indicating good interrater reliability.

2.5. Quantity of Parental Language Input

Parents' words per minute (wpm) were used as an estimate of parental language input. Parental speech produced during the three-boxes task was transcribed; the number of words in each transcript was then computed to measure the quantity of parental language after 6 or 9 months of device use. One transcriber produced an initial transcript using the conventions specified by the Systematic Analysis of Language Transcripts program (Miller & Iglesias, 2010). A second transcriber reviewed the transcript while viewing the video record and suggested changes. The first transcriber then either accepted the suggested changes or asked a third transcriber to reconcile the disagreement. All transcribers were blind to the ratings and PLS-5 scores. Parents' quantity of language input used in subsequent analyses was defined as the number of a parent's intelligible words in the transcript per minute of observation.

2.6. Child Language Skills

We utilized language scores assessed at 18 or 24 months of device use. We used the Preschool Language Scales-Fifth Edition (PLS-5), a play-based assessment which measures receptive and expressive language skills in children from birth to age 7 years (Zimmerman et al., 2011). The PLS-5 is a well-validated norm-referenced assessment, with strong psychometric properties (internal consistency r = .93 - .98, test-retest stability r = .96 - .98; Zimmerman et al., 2011). The PLS-5 provides standard scores for auditory comprehension, expressive communication, and a composite total language score (M = 100, SD = 15). The PLS-5 was administered in spoken English by a research speech-language pathologist with experience assessing children who are DHH.

3. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

3.1. Descriptive Statistics

Descriptive statistics were calculated for all key variables. Dyads were rated, on average, higher for child joint engagement and fluency and connectedness compared to shared routines and rituals. Ratings for the child joint engagement item were moderate suggesting some dyads spent no more of a third of their interactions in a state of joint engagement and/or the child was minimally involved in a shared point of focus. Average ratings for the fluency and connectedness item ratings indicate were also moderate, indicating some disconnect between partners, either in balance, shared experience, or flow within the interaction. See Table 3 for individual participant scores.

 doi:10.20944/preprints202512.2752.v1

Table 3. Individual Scores for Variables and Chronological Ages at Key Timepoints.

	JERI				PLS-5				
Subject	CJE	RR	FC	Sens	Auditory Comprehension	Expressive Communication	Total Language	Age at three-box (months)	Months elapsed between three-box task and language test)
BT0310	4.00	3.33	4.33	3.67	40	38	78	33	15
BT0210	5.67	2.67	4.00	4.00	37	37	74	18	18
BT0193	3.33	1.00	3.33	5.00	25	28	53	18	12
BT0312	5.00	2.00	4.67	4.67	38	35	73	28	18
BT0122	5.00	2.67	4.00	3.67	30	32	62	14	9
BT0191	5.00	1.67	4.00	4.00	38	37	75	14	12
BT0299	4.33	2.00	3.67	3.67	35	35	70	18	12
BT0032	3.33	1.33	4.00	2.33	34	32	66	25	12
BT0255	1.33	1.00	3.00	2.67	19	23	42	18	12
BT0189	4.33	1.67	4.00	5.00	37	34	71	21	12
BT0120	4.67	1.00	3.00	5.00	25	30	56	18	12
BT0155	3.33	1.33	3.33	4.00	17	20	37	20	12
BT0257	2.00	1.00	2.33	3.00	30	23	53	15	12

Note. CJE = child joint engagement; RR = routines and rituals; FC = fluency and connectedness; Sens = sensitivity. PLS-5 raw scores reported.

Average ratings on the shared routines and rituals were lower compared to child joint engagement and fluency and connectedness, suggesting dyads did not routinely establish prescribed patterns of behavior, or that when they did, it was infrequent and for a short duration. Average sensitivity ratings were moderately high with some parents interacting in an exceptionally sensitive manner (while others were in the low-mid range). Interactions rated on the low end indicated parents' delayed response to their child's acts of communication or infrequent responding.

Parents in this sample produced an average of 74 words per minute (*SD* = 16, range = 42–100). As expected, children's receptive, expressive, and overall language skills varied widely with average scores in the low-moderate range. Expressive scores were slightly higher compared to receptive scores but on both measures some children performed well under the normative mean of 100, indicating significant language delays, while other children performing almost one standard deviation above the mean. See Table 4 for descriptive data for the full participant sample.

Table 4. Descriptive Statistics for Key Variables.

Measure	*M*	*SD*	Range
Child joint engagement	3.95	1.25	1.33-5.67

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Shared routines and rituals	1.74	0.76	1-3.33
Fluency and connectedness	3.67	0.64	2.33-4.67
Sensitivity	3.90	0.88	2.33-5
Parental words per minute	74	16	42-100
Auditory comprehension	31.15	7.58	17-40
Expressive communication	31.08	5.94	21-35
Total language	62.31	13.14	37-78

Note. N = 13. PLS–5 raw scores reported. JERI items rated on 1-7 (lowest to highest) scale; sensitivity was rated on a 1-5 (lowest to highest) scale. Measures 1-3 are ratings from the play interaction at 20 months (*SD*, 5.6), items 3, 4, 5 are measures of parents' behavior, and items 6-8 are children's language outcomes at 31.38 months (*SD*, 8.79).

3.2. Analyses

Calculations indicated that the ratings of interaction qualities (i.e., child joint engagement, shared rituals and routines, fluency and connectedness, and parental sensitivity) correlated positively with age, with one correlation – Age and Fluency and Connectedness – reaching statistical significance (r = .56, p < .05). Thus, age needed to be factored in when determining the relationships between our interaction quality measures and our language measures. To do this, we conducted multiple regression analyses with PLS-5 scores as the dependent measures and the interaction quality and age at which the interaction quality measures were assessed as predictor variables. Because age needed to be factored into the model, we used PLS-5 raw scores rather than age-adjusted standard scores. Finally, because there was variable time between when interaction quality measures were assessed and the PLS-5 was administered, we also included that time interval as a predictor. By doing so, both the age at which dyad's interaction qualities were assessed and age at which the PLS-5 was administered was taken into account.

The fluency and connectedness item was significantly related to expressive language ($t(9)$ = 3.41, p = .008) and total language ($t(9)$ = 2.62, p = .028) but did not reach statistical significance with receptive language ($t(9)$ = 1.99, p = .077). This finding suggests that parent-child interactions characterized by balanced turn-taking, active engagement with a shared topic or object on the part of both communication partners, and general smoothness in interaction boosts expressive and receptive language skills.

Shared routines and rituals was significantly related to expressive language ($t(9)$ = 2.45, p = .037) and approached statistical significance with total language ($t(9)$ = 2.00, p = .076) but was not significantly related to receptive language, providing evidence that the process of parent and child engaging in familiar routines (e.g., getting dressed) is related to language production.

Statistically significant relationships were found between joint engagement with the parent and expressive language ($t(9)$ = 3.91, p = .004), receptive language($t(9)$ = 2.36, p = .043), and total language scores (r = .73, p = .007), suggesting a positive relationship between parent-child engagement in frequent and rich episodes of interaction with a shared topic for promoting language skills.

Notably, neither parental sensitivity nor words per minute were significantly related with any language outcomes (expressive, receptive, or total language) nor words per minute. See Table 5 for partial correlations controlling for chronological age.

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Table 5. Partial Correlations Controlling for Chronological Age (Raw Scores).

Variable	1	2	3	4	5	6	7	8
1. Child joint engagement	—	.63*	.79**	.54	.28	.73**	.62*	.80**
2. Shared routines and rituals		—	.63*	.02	.25	.62*	.57	.66*
3. Fluency and connectedness			—	.24	.31	.70**	.62*	.77**
4. Sensitivity				—	.34	.18	.09	.25
5. Words per minute					—	.10	-.02	.24
6. Total language						—	.98**	.97**
7. Receptive language							—	.89**
8. Expressive language								—

Note. $N = 13$. $p < .05$*, *$p < .01$. Variables 1-3 are ratings from the play interaction at 20 months (*SD*, 5.6), variables 3, 4, 5 are measures of parents' behavior, and items 6-8 are children's language outcomes at 31.38 months (*SD*, 8.79).

4. Discussion

We conducted this study to explore whether the same factors that are associated with language development in typically hearing children are also implicated in how DHH children learn language. Our results expand the knowledge base on the importance of how parent-child interaction at an early stage of child development relates to later language skills in hearing children (Adamson et al., 2022; Hirsh-Pasek et al., 2015; Masek et al., 2024a). For the sake of comparison, the children in Hirsh-Pasek et al. (2015) were 24 months old, whereas the children in current study were an average age of 20 months. We also affirm previous findings demonstrating the critical role parents play in facilitating language development in DHH children (i.e., Ambrose et al., 2015). Our analyses revealed several compelling insights into expressive and receptive language development in DHH children, including: (1) the utility of examining quality elements of parent-child interactions rather than sheer quantity of parental input , (2) evidence showing dyads struggled to coordinate activities using familiar routines and rituals, and (3) the relationship between quality features of early parent-child interaction and language development over time.

To our first finding, results indicate that the quality of dyadic communicative interactions between DHH children and hearing parents is a stronger predictor of language outcomes compared to quantity of language input or parental sensitivity. Quality of language input as measured by fluency and connectedness, routines and rituals, and joint engagement predicted language outcomes. Children who experienced higher quality interactions at the first timepoint (6- or 9-months post-device) exhibited stronger language skills 9 to 12 months later compared to children who experienced lower quality interactions.

The present findings build on the work of Ambrose et al. (2015) by addressing a limitation cited by those authors related to coding parent-child interactions. Here, we measured the quality of dyadic interactions in lieu of individual parent behaviors during a play interaction. As Ambrose and colleagues state, creating a more comprehensive picture of the *dynamics within dyads* requires a model for examining caregiver characteristics such as sensitivity, responsivity, and positivity. Thus, our adoption of the quality measures used in Hirsh-Pasek et al. (2015), which emphasize the behaviors of parent and child in co-constructing the communication foundation for language development, add significantly to earlier findings. Integral to each of the quality measures is the active participation of the parent, often contingently responding to the child's interests, activities, and acts of communication.

Of note, while Hirsh-Pasek et al. (2015) measured symbol-infused joint engagement, we measured children's joint engagement, a state of engagement requiring the parent's active participation with their child and a shared object or event. For example, a child and parent putting clothes on a doll. Children in a state of symbol-infused joint engagement actively attend to and produce symbols such as spoken words or signs. Symbol-infused joint engagement tends to emerge as children's first words appear, therefore the youngest children in the current sample (i.e., 14

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months) would not be expected to engage in symbol-infused joint engagement. Here, we determined the child joint engagement item on the JERI as a more suitable measure of dyads' active engagement in shared activities, a skill that emerges before children's first words (Adamson et al., 2019).

Compared to Hirsh-Pasek et al. (2015), current results indicate similar levels of fluency and connectedness and joint engagement within dyads. Dyads in both studies generated scores below the midpoint of the ratings scale for fluency and connectedness, although dyads in the Hirsh-Pasek study exhibited a wider range in scores. Average rating on the fluency and connectedness item in this study was 3.67 (*SD*, 0.64) compared to 3.85 (*SD*, 1.13) in Hirsh-Pasek et al. (2015). In this study, for example, a dyad exhibiting a strong sense of flow and cohesion coalesced around building blocks and toy refrigerator. The child communicated their desire for the parent to put the blocks in the refrigerator, the parent responded in kind, the parent and child continued to take turns, and both engaged in looking through the "window" into the refrigerator. A counter example is a dyad in which the child wanders the play area, not fully engaging in any one object or activity, and the parent passively following the child's interest by onlooking rather than responding or inviting the child to play.

Nevertheless, average scores for joint engagement in the current study were comparable to the average and range of scores in Hirsh-Pasek et al. (2015) (M = 3.95, SD = 1.25 and M = 3.20, SD = 1.22), respectively). Some dyads in current study struggled to maintain child joint engagement for a duration considered an "episode" of joint engagement (i.e., at least 3 seconds) or a "state" of joint engagement (i.e., one third of the time spent in the interaction). The brevity of joint engagement episodes reflects findings from previous studies with DHH children demonstrating that DHH children experience joint engagement with less frequency and for shorter periods of time (i.e., Gale & Schick, 2009; Cejas et al., 2014; Dirks et al., 2020). This finding is concerning based on research indicating that duration of joint engagement is related to language development; children who spend more time in joint engagement are more likely to have stronger expressive vocabularies (Hirsh-Pasek et al., 2015).

Second, our analysis indicated low levels of shared routines and rituals and within a narrower range compared to Hirsh-Pasek et al. (2015). Dyads in this study exhibited rare instances of parent and child settling into patterns of behavior consistent with shared routines and rituals. Dyads in the Hirsh-Pasek et al. study ranged between 1 and 6 with a mean score of 3.47 on the 1 to 7 rating scale, slightly below the midpoint of 4. The range in scores in this study was between 1 and 3.33, clearly indicating the highest score falling below the midpoint. An example of an interaction indicating low levels of shares routines and rituals would be a child alternating between feeding herself and a doll, while the parent engaged with another toy. Dyads demonstrating higher levels of routines and rituals engaged in the same activity (i.e., feeding doll) but do so jointly and in a more sustained manner. More frequent instances of familiar patterns of behaviors occurred when dyads were on the high end of the scale.

One explanation for the low scores for routines and rituals is the child's age. There is some evidence of an effect of age on children's ability to engaged in coordinated activity in which parent and child settle comfortably into routines that become scripted over time (Aksan et al., 2006). Therefore, examining this qualitative feature in slightly older DHH children might show more frequent and longer lasting shared routines and rituals. Nevertheless, this finding is concerning considering the potential for cascading effects, such as children and parents struggling to sustain interactions sufficient for patterns of behavior to emerge.

And finally, the present study echoes previous findings demonstrating the importance of joint engagement, contingent responding, and overall connectedness between parents and children at an early timepoint and later language outcomes in DHH children. Hirsh-Pasek et al. (2015) involved a much larger sample (N = 158) than the current study (N = 13), allowing them to group dyads into tertiles based on children's language scores. Children in the top tertile (i.e., those with the highest language scores) received higher ratings on all three quality indicators compared to children in the lower tertiles, indicating the critical nature of high-quality interactions in relation to language growth over time in children from low-income households. Statistically significant relationships between

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measures of fluency and connectedness, routines and rituals, and joint engagement in our study suggest that these quality features are also important for promoting language development in DHH children.

Overall, the present findings suggest language input that is well integrated into parent-child interactions promote the ability of DHH children to express themselves and understand language. The three quality indicators, rather than *quantity* of language input and a general measure of parental sensitivity accounted for variance in language outcomes using a standardized language assessment. This suggests that sensitive parenting – although clearly beneficial for infants – is not the same as providing them with stimulating language interactions. The implication is that simply talking at children is not as useful as talking during interactions that are meaningful to children and motivating for them to attend. How language is being used, therefore, is more important than how much language is used.

Limitations and Future Directions

Several limitations of this study should be considered. First, as with numerous studies with DHH children, our sample size was small; therefore, generalization of findings should be made with caution. The chronological ages of full sample also ranged relatively wide, including a child as young as 14 months and as old as 33 months at the first time point. With that in mind, initial ratings of symbol-infused joint engagement with this sample revealed a floor effect, exposing the issue of analyzing episodes of joint engagement in which children must show evidence of actively using symbols (e.g., signs, gestures, pointing, spoken words) in children whose symbolic use of communication is just emerging. However, this limits a direct comparison between findings from this study and Hirsh-Pasek et al. (2015). Future studies should further investigate symbol-infused joint engagement with samples older than the current sample in relation to later language outcomes. Further research is also needed to substantiate the current findings using the measure of joint engagement implemented here.

A second limitation relates to parent-child interaction context used for this research. As Cejas et al. (2014) notes, using videotaped behavioral coding and a well-established coding system, relying on short lab-based interaction has limitations in terms of generalizing to joint engagement behaviors in other contexts. Future studies might leverage naturalistic daylong recordings to examine parental responsivity and the contingency of parent-child vocal interactions in children's everyday environments. A third limitation relates to the primary use of spoken language within our sample and during the recorded interactions. Some families of DHH children choose to use sign language as a supplement to using spoken language to communicate. Future research should consider how both formal visual language and informal visual communication affect the frequency and length of episodes of fluency and connectedness, routines and rituals, and joint engagement between DHH children and parents.

5. Conclusions

Our findings reflect previous studies demonstrating that while quantity and quality of parental language input is important for early language learning, quantity of input does not appear to correlate with language growth in children at risk for language delay, including DHH children. Key insights from this study include the further demonstration that the quality of communicative interactions between DHH children and parents is more important for language development than quality of language input. Just as language research with hearing children has shifted focus from quantitative to qualitative measures, this study highlights the need for a similar shift in research with DHH children. An additional insight is the varying levels of quality interactions experienced by DHH children, and for the dyads participating in this study, the infrequent occurrence of shared routines and rituals therefore fewer opportunities to settle into routines and rituals. And finally, this study indicates the importance of high-quality parent-child interactions and language skills 9 or more months later. Therefore, early intervention efforts should continue to focus on the parent-child

 doi:10.20944/preprints202512.2752.v1

relationship, specifically dyadic engagement behaviors that are likely to promote growth in DHH children's language skills.

Author Contributions: Conceptualization, C.D. and D.H.; methodology, C.D. and D.H.; formal analysis, D.H. and C.D.; investigation, K.S., P-J.R., R.B..; resources, D.H.; data curation, R.B.; writing—original draft preparation, C.D.; writing—review and editing, C.D., K.S., E.S., P-J.R., R.B., R.G.; visualization, C.D.; supervision, D.H.; project administration, R.B.; funding acquisition, D.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National Institute on Deafness and Other Communication Disorders, grant number R01DC017925.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of The Ohio State University.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviation is used in this manuscript:

DHH	Deaf and hard-of-hearing
JERI	Joint Engagement Rating Inventory
PLS-5	Preschool Language Scale-5th edition

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