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ARTICLE

The multifaceted nature of early vocabulary development: Connecting children's characteristics with parental input types

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Abstract

Children need to learn the demands of their native language in the early vocabulary development phase. In this dynamic process, parental multimodal input may shape neurodevelopmental trajectories while also being tailored by child-related factors. Moving beyond typically characterized group profiles, in this article, we synthesize growing evidence on the effects of parental multimodal input (amount, quality, or absence), domain-specific input (space and math), and language-specific input (causal verbs and sound symbols) on preterm, full-term, and deaf children's early vocabulary development, focusing primarily on research with children learning Turkish and Turkish Sign Language. We advocate for a theoretical perspective, integrating neonatal characteristics and parental input, and acknowledging the unique constraints of languages.

KEYWORDS
deaf children, gesture, multimodality, parental input, preterm children, Turkish, Turkish sign language, vocabulary development

Babies are born ready to learn language, and with universal attentional and learning biases (Parish-Morris et al., 2013). In learning their native language, typically developing children move from being universal language users to language-specific users, tailoring the information they receive from the environment to the demands of their native language (Göksun et al., 2010, 2017). Multiple pathways of language development may occur as a function of the interplay between child- and environment-related factors.

In this article, we address the effects of parental overall multimodal input (amount, quality, or absence), domain-specific input (space and math), and language-specific input (causal verbs and sound symbols) on children's early vocabulary development. We selected these domains because children acquire these fundamental concepts early. Additionally, languages vary in how they encode spatial or causal relations that map onto these concepts (Göksun et al., 2017), which may require more specific input for young language learners. Variations in input can be examined more effectively with parents' use of specific vocabularies, referring to concepts and expressions specific to a language.

Language development does not unfold the same way for all children. One significant factor is the biological characteristics children bring to the language learning environment and how multimodal input varies or is absent as a function of neonatal characteristics. Our understanding of language development is incomplete without considering data from atypically developing children, so we also draw evidence from studies of children born preterm and from deaf children born to hearing parents. Children's characteristics, such as infants' attentional skills (Dixon & Smith, 2000), emotion regulation, and expression (Pérez-Pereira et al., 2016), are also associated with early language development, interacting with the parental input children receive (Spinelli et al., 2018). However, here, we focus mainly on the biological characteristics present at birth. Understanding how and whether parents provide early language input for different concepts across groups of children is necessary to formulate the exact interactions between parental input and children's vocabulary development.

Finally, theories of children's language development need to be diversified, integrating evidence from non-Indo-European languages (Kidd & Garcia, 2022). The

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variability in children's early language development may also be related to the specific characteristics of the language children learn. In the following sections, we examine studies of children learning a variety of languages, focusing primarily on children who are learning Turkish and Turkish Sign Language. (For the sociodemographic characteristics of the studies reviewed herein, please see Table S1.)

EARLY VOCABULARY DEVELOPMENT

Regardless of the language they are exposed to, during the first year of life, infants detect the regularities in their environment (Romberg & Saffran, 2010), attend to sound systems of languages (Kuhl et al., 2005), and use multimodal cues (Abu-Zhaya et al., 2017). Infants form concepts referring to objects, actions, agents, and their relations (e.g., Göksun et al., 2010, 2017; Mandler, 2012), onto which they later map linguistic labels (Mandler, 2000). Concepts that vary across languages may require more input and language experience than concepts that share cognitive and perceptual similarities across languages (Gentner & Bowerman, 2009).

Child- and environment-related sources should work in tandem longitudinally in the early language learning process (Demir & Küntay, 2014). Parental input, as an environmental source, is a primary factor guiding infants in learning their native language (Anderson et al., 2021; Rowe, 2012). Parents also tailor their verbal and gestural input based on their children's knowledge and needs (e.g., Kızıldere et al., 2022; Yurovsky, 2018). Here, we synthesize the accumulated evidence on how the total and specific type of input related to spatial, math, and causal concepts relates to vocabulary development. Parental input interacts with children's motor, cognitive, and social development through time (Kobaş et al., 2021). These interactions may vary across children following different developmental trajectories, such as in children born preterm and in deaf children born to hearing parents.

PARENTAL OVERALL MULTIMODAL INPUT

Children's language development is significantly influenced by language quantity (i.e., the total number of words, utterances, or phrases directed at the child) and quality (i.e., the complexity and diversity of the language input they receive from their parents; Hoff & Naigles, 2002; Rowe, 2012). The quantity of input is especially influential at earlier ages, whereas the quality affects children's learning of specific words (Anderson et al., 2021; Bergelson et al., 2023).

Gestural input in the forms of pointing to objects or iconic gestures referring to objects and actions can also provide opportunities for learning vocabulary. These multimodal patterns of input predict and shape children's later vocabulary development (Iverson et al., 1999; Pan et al., 2005; Rowe et al., 2017). For instance, in one study, encouraging North American parents to use pointing gestures with their 10-month-olds increased parents' use of intentional gestures to direct attention to objects and events when their children were 12 months, which was later associated with children's word comprehension at 18 months (Choi et al., 2021). Moreover, the characteristics of multimodal input directed at children are intricately tied to the context of parent–child interactions (e.g., Rowe & Weisleder, 2020). Studies of children learning Turkish have demonstrated changes in multimodal language input over time and across contexts (e.g., Aktan-Erciyes & Göksun, 2023; Küntay & Slobin, 2014; Özdemir et al., 2023; Ünlütabak et al., 2022). For example, in a study of book reading, the more parents produced gestures with questions that labeled items in the pictures, the more toddlers responded to these questions (Ünlütabak et al., 2022).

Input children receive from parents does not unfold in isolation of children's characteristics. One way to examine interactions between different children's characteristics and parental input is to focus on children who are born with different constraints and varying neural and environmental circumstances. Preterm children and deaf children born to hearing parents present interesting test cases since they face unique challenges that can shed light on mechanisms of language development. While children born preterm have differing biological profiles, deaf children born to hearing parents have varying environmental/input profiles. Both groups tend to fall behind in their language development and vary more in their language developmental trajectories than do typically developing children. Analyzing the benefits of overall, concept-specific, and language-specific input, as well as the lack of parental multimodal input, in these groups may illuminate preventive strategies to help parents provide input to their children.

Input for preterm children

As a group, preterm children (i.e., those born before the 37th week of gestation) fall behind their full-term peers in early communication and language development (e.g., Ionio et al., 2016; Sansavini et al., 2014). These disparities may be attributed to preterm children's weaker preverbal and verbal skills, reduced activity or responsiveness in parental interactions, and poorer co-regulation ability (e.g., Bozzette, 2007; De Schuymer et al., 2011; Salerni et al., 2007; Sansavini et al., 2014). Although interest in parents' role in preterm children's neurocognitive development is growing

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(Nelson & Demir-Lira, 2023), we know little about how parents' multimodal input is associated with preterm children's early language development.

Positive environmental influences like parent–child interactions may affect preterm children's developmental trajectories more than those of full-term children since enriched experiences can serve as supplementary tools for neurocognitive development (DeMaster et al., 2019; Demir-Lira & Göksun, 2024). Hence, preterm children may benefit more from parental multimodal input than do full-term children. In a longitudinal study, parents of Turkish-learning preterm children used fewer words and pointing gestures when their children were 14 months than did parents of full-term children when their children were the same age. Parents' pointing gestures were concurrently related to infants' vocabulary. However, parents' pointing gestures when children were 14 months predicted infants' vocabulary at 20 months only for the preterm group, highlighting the importance of parental input for language delays (Doğan et al., 2023).

Absence of input

Deaf children born to hearing parents also vary considerably in communication ability and the role of input. Given equal opportunities for language exposure, deaf children's language development trajectories parallel those of hearing children (e.g., Marentette & Mayberry, 2000; Newport & Meier, 1985; Pizzuto & Volterra, 2000). However, only 5% of deaf children have deaf parents and receive sign language input following birth; most deaf children, who have hearing parents (Mitchell & Karchmer, 2004), are not exposed to sign language or spoken language in their early years (Lillo-Martin et al., 2020; Lillo-Martin & Henner, 2021), even if they wear hearing aids (Hall et al., 2019). These children usually receive their first language input in sign language after starting schools that are geared to deaf children and interacting with other deaf children (Karadöller et al., 2022).

Delayed exposure to sign language has profound consequences for language development, which persist into adulthood for complex sentence structures (Mayberry et al., 2023) or spatial descriptions (Karadöller et al., 2021). Still, studies comparing the language development of deaf adolescents with delayed sign language input to the language development of deaf babies exposed to sign language from birth show comparable developmental trajectories for certain language milestones, such as using two-word combinations (Berk, 2003). Scholars have proposed several reasons for this lack of differences despite impoverished input for some domains but not others (Goldin-Meadow, 2019; Henner & Robinson, 2023). For instance, the ability to convey needs and ideas in gestural communication systems used in the household (i.e., homesign systems; Goldin-Meadow, 2013) may help deaf children form an initial system of communication (Goldin-Meadow, 2019). Thus, despite the impoverished input received by most deaf children with hearing parents, later achievements in language development should be considered together with potential dependence on longitudinal connections of multiple communicative interactions.

SPECIFIC TYPES OF INPUT FOR SPACE AND MATH

In addition to general input or lack of input, parents also use specific types of input for concepts like space and math. The frequency of spatial and math words in parental input can significantly influence children's acquisition of these linguistic elements (e.g., Levine et al., 2010; Pruden et al., 2011), over and above the overall input, which may also interact with child-related characteristics.

Spatial input

During the first 2 years of life, as children learn languages, they start to form concepts of spatial relations in their minds and later map relevant words in their language to these concepts (e.g., Johnston & Slobin, 1979). In these early years, parents provide input to their children concerning the spatial location of objects and their relations to other objects or landmarks in the environment.

Studies investigating the relations among spatial input in speech, speech-gesture combinations, and English-learning children's spatial language development suggest that they are positively related (e.g., Cartmill et al., 2010; Levine et al., 2012; Pruden et al., 2011; Wu et al., 2022). In more recent studies, researchers have investigated the potential characteristics brought into this equation in children learning English (Pruden & Levine, 2017) and Turkish (Kısa et al., 2019; Kobaş et al., 2021). In Turkish, the frequency of parents' spatial verbal input, but not their overall verbal or gestural input, increased as a function of children's age between 16 and 21 months and was positively related to children's early spatial word comprehension. In addition, parents' specific type of spatial input when their children were 19 months predicted Turkish-learning children's object word comprehension at 25 months, irrespective of children's early fine motor abilities at 14 months (Kobaş et al., 2021). Thus, how parents talk about object-specific properties can be associated with children's later vocabulary development for objects beyond their motor skills.

What is the role of specific input for children with atypical developmental trajectories? In a study of

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English-learning preterm and full-term preschool-aged children, participants received similar verbal and gestural spatial input in a puzzle play setting (Clingan-Siverly et al., 2021). Studies of deaf children who received either early or late input demonstrated an interesting pattern for developing linguistic forms to encode spatial relations. Although learning to encode linguistic terms to encode space is challenging for hearing children learning spoken languages, especially for left–right relations (Abarbanell & Li, 2021; Karadöller et al., 2019, 2022), early exposure to sign language allowed deaf children to encode spatial relations (i.e., classifier constructions; Perniss et al., 2015) earlier than hearing children (Sümer, 2015; Sümer et al., 2014). This earlier encoding of space was attributed to linguistic forms' iconic and body-anchored nature in sign language (see Karadöller et al., 2022). Regardless, deaf children who lacked conventional sign language input lagged behind hearing children in their spatial expressions (Gentner et al., 2013). After 2 years of exposure to sign language, they still lagged behind early-exposed deaf children, and these effects persisted into adulthood (Karadöller et al., 2017, 2021; Karadöller, Sümer, et al., 2023; Newport, 1988, 1990).

Math input

Symbolic numerals refer to the precise human-invented representations of numerical values, such as number words or Arabic numerals (Cantlon & Brannon, 2006; Xu & Spelke, 2000). Children show wide individual variability in their symbolic numerical skills even before formal schooling. Early experiences with numbers, specifically in informal interactions with parents, contribute to this variability (e.g., Gunderson & Levine, 2011). In studies measuring these interactions via parental questionnaires assessing the frequency of parent–child numerical activities (e.g., counting) or direct observations of parents' number talk, parental input related significantly to children's numerical skills, even when parents' socioeconomic status or overall language input was controlled (Glenn et al., 2018; Mutaf-Yıldız et al., 2020). In a study of how parents of 26-month-old Turkish-learning preterm and full-term children used numbers and accompanying gestures (e.g., showing the total number of objects with fingers; Karadöller, Demir-Lira, et al., 2023), multimodal math input, as opposed to speech-only math input, was uniquely associated with gestational status, expressive vocabulary, and the interaction between the two. Full-term children with lower expressive vocabulary scores received more multimodal input, but no such association was found for preterm children. These findings again highlight that input about specific concepts might interact with children's vocabulary knowledge and neonatal characteristics.

LANGUAGE-SPECIFIC INPUT

Variations in input may also be assessed by examining parents' use of words and expressions specific to a language. Parents' use of these language structures can enhance children's vocabulary knowledge of certain word types, such as causal expressions and sound symbolic input. Languages vary in expressing cause-effect relations or sounds with transparent links to words. Some languages, like Turkish, provide regular, consistent, and overt cues to represent these linguistic structures.

Causal input

Languages vary in how they encode cause-effect relations (Shibatani & Pardeshi, 2002). Some languages, like English, express causes only as lexical verbs (e.g., throw). Others, like Turkish, along with lexical causal verbs, can use verb suffixes for making causal verbs (e.g., morphological causal verbs *-ye* "to eat," becomes *ye*-DIR "to feed" by adding the suffix -DIR). In one study, researchers assessed parents' different uses of causal input during free- and guided-play sessions when their infants were 14 and 19 months (Aktan-Erciyes & Göksun, 2023). Although parents produced more lexical causal verbs than morphological ones at both time points, only the composite score of parents' morphological causal verb production was associated with children's causal verb knowledge at 36 months, assessed by a verb production task. Hence, hearing language-specific causal cues overtly and regularly over time assists children's learning of causal verbs. In another longitudinal study, researchers compared lexical versus morphological causal input for Turkish-learning preterm and full-term children at 14, 20, and 26 months via semi-structured play sessions (Özdemir et al., 2023). Parents mainly produced lexical causal verbs across all time points. Overall, the use of causal input increased from 20 to 26 months, regardless of the group, possibly due to parents' assumptions that children would have a better sense of cause-effect relations as they grew older.

Sound symbolic input

Sound symbols, such as *woof* for a dog or *crash* for the sudden noise of a collision, refer to non-arbitrary connections between speech sounds and their meanings, which provide more effective learning opportunities by linking the perceptual properties of the referents to the word meanings (Imai & Kita, 2014). Although many languages have sound symbolic words, some, like Japanese and Turkish, feature these word types more than others and use them flexibly in different forms (Demircan, 1996; Imai & Kita, 2014). In Turkish, several verbs may be derived from the same sound symbolic roots with different

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suffixes, providing children overt attentional cues during word learning (e.g., *pat* "hitting of an object with a loud sound," pat-*la* "to explode" and pat-*ır* "to bang").

Children acquire sound symbolic words before learning arbitrary words (e.g., Massaro & Perlman, 2017). Parents use many different sound symbolic words with children learning English (Motamedi et al., 2020) or Korean (Jo & Ko, 2018), which decreases as children grow older. In one study, of Turkish-learning children, both the quantity and quality of sound symbolic parental input decreased from 14 to 20 months during semi-structured play sessions (Kızıldere et al., 2022); this input positively scaffolded infants' vocabulary development at 14 months. Parents adjusted their sound symbolic input based on children's vocabulary levels. Children with lower word knowledge at 14 months received more sound symbolic input at 20 months. In a follow-up study, researchers demonstrated similarities in sound symbolic input for preterm and full-term infants at 20 months (Esmer et al., 2023). Preterm parents tended to use sound symbolic adverbs when considering children's verb knowledge at 14 months. Additionally, the specific type of input presented in highlighting the verbs in adverb form (e.g., *pat pat* yürümek "to walk *pat pat*; clomping") related to children's motion verb production at 48 months, but only for the full-term group. These findings highlight the contribution of commonly used sound symbolic input to children's vocabulary learning, which may be useful for full-term children.

CONCLUSION AND LOOKING AHEAD

Infants' early vocabulary development involves a reciprocal and dynamic exchange between child- and parent-related factors. Although children go through well-described, common steps in their vocabulary development, there is also immense individual variability in their developmental trajectories. Individual-based analyses of neurodevelopmental changes in children learning non-Indo-European languages have contributed to our understanding of early language development. In this article, we have emphasized variations in early vocabulary development as a result of differences in input quantity, type, and parental adjustments based on children's needs and neonatal conditions.

More research is needed on the predictive effects of the interactive child–parent processes on children's reasoning of space, math, and cause-effect relations. Additionally, few studies have examined neural (e.g., Nguyen et al., 2021; Zivan et al., 2022) and behavioral synchrony in parent–child dyads (Abney et al., 2020) using functional near-infrared spectroscopy, electroencephalogram, and head-mounted eye-tracking. Researchers should investigate how these interpersonal neural and behavioral responses change over time and lead to specific vocabulary outcomes. For example, do preterm and full-term children focus on and follow their parents' multimodal cues (e.g., eye gaze, gestures, words) similarly for different concepts? How would their attentional patterns synchronize behaviorally and neurally based on the responses of their parents? Do these synchronization patterns predict later outcomes in reasoning about different concepts? Focusing on distinct neurodevelopmental trajectories longitudinally can offer new insights into preventive strategies to achieve the best outcomes for language interventions.

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