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Profiles of early expressive vocabulary in children with typical and atypical language development

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The development of early childhood vocabulary is influenced by both biological and environmental factors, which shape language acquisition. This research investigates the variability in early expressive vocabulary among typically developing children (TD), Late Talkers (LTs), and those at risk for neurodevelopmental conditions like Autism Spectrum Disorder (ASD), and Developmental Language Disorder (DLD). Participants included 132 Mexican Spanish-speaking children: 37 with TD (M = 24.89, SD =4.01), 37 LTs (M = 24.78, SD 3.51), 41 at risk for ASD (M = 24.39, SD = 4.31) and 17 at risk for DLD (M = 37.71, SD = 4.50). The MacArthur-Bates Communicative Development Inventory II was utilized to assess 23 vocabulary categories, which were grouped into six broader categories (nouns, verbs, adjectives-adverbs, functional words, routines and sounds-onomatopoeias). The results indicated differences in vocabulary distribution among the groups. Although TD children generally exhibited the highest performance, there was notable variability within this group. Both LTs and children at risk for ASD showed differences compared to TD children, with LTs demonstrating the most reduced lexical usage. Children at risk for DLD and LTs displayed similar lexical profiles, characterized by reduced use of verbs and functional words. LTs and most children at risk for ASD exhibited low usage across all vocabulary categories. This analysis identified distinct vocabulary profiles among TD, LTs, ASD, and DLD groups, with variability across vocabulary categories reflecting the unique characteristics of each group. These findings enhance our understanding of the heterogeneity in early language development across clinical populations.

KEYWORDS

early expressive vocabulary, typically developing children, late talkers, autism spectrum disorder, developmental language disorder

1 Introduction

The rapid acquisition of language, influenced by linguistic and cognitive resources and shaped by psychosocial factors, is commonly observed in children aged 24–30 months (Bornstein and Putnick, 2012; Walker et al., 2011), across several languages (Braginsky et al., 2019). However, research has demonstrated variability in the early vocabularies of typically developing children (TD) (Fenson et al., 1994), Late Talkers (LTs) (Rescorla, 2011), and those at risk for a neurodevelopmental disorder including Autism Spectrum Disorder (ASD) (Rescorla and Safyer, 2013) and Developmental Language Disorder (DLD) (Leonard, 2014; Acosta Rodríguez et al., 2017).

In TD children, vocabulary development is influenced by child and parental factors as early as age two (Nylund et al., 2021). Variability in vocabulary acquisition may arise from cognitive and linguistic factors such as social cues, statistical learning mechanisms, context learning, and word frequency affecting learning nouns, verbs, adjectives, and functional words (Braginsky et al., 2019). While most TD children exhibit lexical growth between 24 and 30 months, LTs experience delays in the onset of first words and word combinations, with slow vocabulary growth after 24 months, despite having no hearing loss and intact cognitive abilities (Dale et al., 2003; Rescorla and Dale, 2013). LTs continue to exhibit delays at age three, with unusually small vocabularies (Fisher, 2017). Producing fewer than 100 words by 30 months can indicate early language delays (Rescorla et al., 2000), although variability is expected between persistent and non-persistent LTs (Auza and Murata, 2021; Rescorla, 2011; Desmarais et al., 2010).

ASD, characterized by social interaction deficits and repetitive behaviors, may or may not involve language delays (World Health Organization, 2024). Approximately 75% of ASD individuals are verbal (Lord et al., 2004; Sigman and McGovern, 2005; Tager-Flusberg and Kasari, 2013), yet they exhibit variability in vocabulary production (Rescorla and Safyer, 2013), sometimes producing fewer words than TD children at 12 months (Righi et al., 2014). Children with ASD may produce similar percentages of nouns, verbs, and functional words compared to TD children, but they may also demonstrate delayed onset of first words, limited functional word use, and reduced morphological production (Marini et al., 2020; Oetting and Hadley, 2017). Furthermore, they may lack word combinations or have short Mean Length of Utterances (MLU) (Charman et al., 2003) similar to persistent LTs that progress to DLD (Chilosi et al., 2019; Leonard, 2014; Rescorla, 2011).

In the absence of cognitive, motor, neurological, or hearing problems (Leonard, 2014), DLD is characterized by difficulties in understanding or producing language and using it in context for communication (World Health Organization, 2024). Typically, children with DLD experience delays in the onset of first words and word combinations (Fisher, 2017; McGregor, 2020). However, variability in language production is also anticipated, given the heterogeneity in language features associated with DLD (Bishop, 2017).

Therefore, comparing diverse groups of children is crucial to delineate unique and shared features among different conditions, refining diagnostic criteria among them, and elucidating expressive lexical profiles (Ellis-Weismer et al., 2011; Lord et al., 2004; Luyster et al., 2007). Analyzing vocabulary production across diverse groups involves examining those categories commonly used by TD children, revealing variability as the norm rather than the exception (Fenson et al., 1994). Instead of focusing on a single pattern that overlooks the inherent variability in language use across individuals (Bates et al., 1994; Bates et al., 1988), variability should be used as a key to understanding the process of language acquisition. Each child's developmental trajectory is indeed influenced by a complex interplay of factors, resulting in unique patterns even within clinical groups. Variability underscores the importance of personalized approaches to understanding and supporting each child's needs. By acknowledging and studying variability, we can better tailor interventions and support strategies that cater to individual strengths and challenges in language development. Emphasizing this variability also encourages a broader perspective on developmental patterns across clinical groups, promoting nuanced research and clinical practices.

1.1 Early expressive vocabulary in diverse populations

Most in-depth studies have largely focused on the total vocabulary size at various child ages but only a few have examined separate lexical categories (Nylund et al., 2021). According to the MacArthur-Bates Communicative Development Inventory (Fenson et al., 1994) which categorizes vocabulary into 23 vocabulary categories, studies have adopted either a broader or narrower perspective when grouping these categories to study vocabulary composition. We adopted a narrow perspective and based on Bates et al. (1994) criteria, grouping the respective vocabulary categories into Nouns, Verbs, Adjectives-Adverbs, Functional Words, Routines, and Sounds-Onomatopoeias. A lexical profile refers to the specific pattern of vocabulary use and development within an individual, capturing aspects such as word frequency, and diversity of expressive vocabulary. It provides insights into how a person utilizes words within their language. This concept is widely used in language development research to assess and compare vocabulary skills across different populations, including those with typical and atypical language development (Ellis-Weismer et al., 2011; Jarrold et al., 1997). It is instrumental in identifying language delays and tailoring interventions to specific linguistic needs (Luyster et al., 2007). According to this criterion, in this paper, a lexical profile is defined as the comprehensive use of words across these six different vocabulary categories. These categories have also been studied to cross-culturally compare vocabulary composition (Bates et al., 1994; Choi and Gopnik, 1995; D'Odorico et al., 2001; D'Odorico and Fasolo, 2007). Nonetheless, previous studies have focused on the use of vocabulary categories among clinical groups, often neglecting within-group variability, even though it is commonly observed among TD children (Fenson et al., 1994). This variability can reveal distinct lexical profiles for each group. As Perry and Kucker (2019) note, new research is required worldwide to capture and interpret the inherent heterogeneity in children with language delay and disorders, enabling more targeted and successful interventions, especially in Spanish-speaking children which are underrepresented in research. Although most of the children live in developing countries (Olusanya et al., 2023), only 5% of the scientific knowledge on children and adolescence is generated outside North America, Europe and Australasia (Tomlinson et al., 2014). Our contribution is on providing information regarding children living in a developing country.

Thus, this study examines lexical profiles using the MacArthur-Bates CDI-II Inventory (Jackson-Maldonado et al., 2003) among four groups of children: Typically Developing (TD), Late Talkers (LTs), children at risk for Autism Spectrum Disorder (ASD), and those at risk of Developmental Language Disorder (DLD).

The research questions are as follows:

1 What are the distinct lexical profiles observed across TD, LTs, children at risk for ASD, and those at risk for DLD, in terms of vocabulary development across six vocabulary categories?
2 How does variability in vocabulary production differ across TD children, LTs, ASD children, and DLD children?

3 What associations exist between distinct vocabulary development patterns and TD children, LTs, ASD children, and DLD children?

For the first question, we hypothesize that TD children exhibit a distinct pattern of vocabulary production compared to LTs, ASD and DLD. Within these groups, differences are expected in the vocabulary production patterns across the six categories.

For the second question, we predict high variability in vocabulary production across all groups.

For the third question we anticipate finding distinct patterns in the production of the six vocabulary categories studied, which will allow us to identify subgroups of children that may be associated with the four groups established in the present study.

2 Methods

2.1 Participants

The study encompassed five public nursery schools, one private school, a community center for childhood development, a developmental care clinic, and the Child Psychiatric Hospital Juan N. Navarro (CPHJNN), serving a low-income population (Márquez-Caraveo et al., 2017).

A total of 132 Monolingual Spanish-speaking children (46% girls) comprised the sample including 37 TD children (65% girls), 37 LTs children (47% girls), 41 children at risk for ASD (39% girls), and 17 children at risk for DLD (29% girls). The ages ranged from 18 to 30 months for TD (M = 24.89 months, SD = 4.01), LTs (M = 24.78, SD = 3.51), and ASD group (M = 24.39, SD = 4.31). The DLD group included children aged 26–47 months (M = 37.71, SD = 4.50) and was not age-matched to children in other groups because grammatical difficulties, significant early predictors of DLD, typically emerge within this age range. While TD children begin using productive morphosyntax around this time (Serrati Sellabona et al., 2004), children with DLD increase their morphosyntactic errors around age 4 (Pavez et al., 2015; Jackson-Maldonado and Maldonado, 2017). The identification of DLD relies heavily on assessing morphosyntax, requiring comprehensive evaluation, leading to later diagnoses compared to LTs, who are identified based on early vocabulary and word combination delays (Sansavini et al., 2021). On average, maternal education was 12.92 years of schooling.

2.2 Instruments

Sociodemographic interview: This interview aimed at identifying biological (peri and post-natal conditions) and sociodemographic characteristics of participants and their families (mother's and child's education, parent's occupation, socioeconomic status). This interview includes assessment of parental concern questions about language development (Peñaloza et al., 2021).

Parental language concern questionnaire (PLCQ) (Auza et al., 2023): The questionnaire is a comprehensive tool that explores various factors related to the development of language disorders in children. It includes 36 variables that cover a range of topics, such as medical history, language milestones, and environmental influences, aiming to capture a holistic view of the child's development. The questionnaire addresses key areas like the child's early motor and psychological development, age of first word production, preschool attendance, parental education levels, and any family history of language issues. By encompassing both biological and environmental factors, the questionnaire provides a robust framework for identifying potential risks of language delay and early indicators of DLD in Spanish-speaking children.

Developmental evaluation test (EDI) (Rizzoli-Córdoba et al., 2013): This validated Mexican screening instrument was designed for the early detection of developmental issues in children from 0 to 5 years of age. The test includes 26–37 items evaluated based on the presence or absence of specific behaviors, gathered from both parent-reported data and direct observations. These behaviors are grouped into five areas: (1) biological risk factors, (2) warning signs, (3) developmental domains (including fine motor skills, gross motor skills, language, social interaction, and cognition), (4) alarm signals, and (5) neurological assessment. Warning signs indicate potential developmental issues in children, while alarm signals suggest a significant delay in developmental milestones or neurological markers. The results are interpreted using a traffic light system, which categorizes a child's development as typical (green), at risk of delay (yellow), or exhibiting a developmental delay (red).

MacArthur-Bates communicative development inventory (CDI-II) words and sentences (Jackson-Maldonado et al., 2003): This parental report assesses children's language production abilities using a vocabulary list organized into 23 categories from a 680 checklist. Established norms based on the 10th percentile of inventory data help identify delays in vocabulary and early grammatical structures. The CDI's validity and reliability across diverse linguistic contexts have been supported by research with Mexican children (Thal et al., 2000), formal assessments (Jackson-Maldonado et al., 2003), and evaluations with Spanish-English bilingual children (Marchman and Martínez-Sussman, 2002). CDI-II: Each word from the CDI-II was categorized into one of six groups based on Bates et al.'s (1994) criteria: Nouns, Verbs, Adjectives-Adverbs, Functional Words, Routines, and Sounds-Onomatopoeias. These categories have been widely used in vocabulary composition studies (Bates et al., 1994; Caselli et al., 1995; Choi and Gopnik, 1995; D'Amico et al., 2001; D'Odorico and Fasolo, 2007; Goodman et al., 2008). Mean Length of Utterance (MLU), was also analyzed using the MLU3 method, derived from the three longest utterances reported by parents, calculated in words. Children scoring at or below the 10th percentile in word production and/or MLU3 for their age are classified as LTs, following criteria established in previous studies (Dale et al., 2003; Rescorla and Dale, 2013).

Child behavior checklist for ages 1 and a half to 5 years (CBCL/1.5–5) (Achenbach and Rescorla, 2001; Albores-Gallo et al., 2016; Rescorla et al., 2020): The Pervasive Developmental Problems (DSM-PDP) scale and Withdrawn Syndrome scale, completed by parents, were used to screen for ASD risk. This 100-item instrument evaluates children's behavioral patterns, either syndromically or according to the DSM-IV (Consistency: 0.95; test–retest reliability: 0.90). Children scoring "borderline" or "clinical" range on the Pervasive Developmental Problems scale and withdrawn syndrome scale were identified as positive for ASD risk.

The modified checklist for autism in toddlers, revised with follow-up (M-CHAT-R/F) (Robins et al., 2014; Albores-Gallo et al., 2012): The revised version of the M-CHAT removes three items from the original,

resulting in 20 dichotomous statements. A 3-level algorithm categorizes risk levels. Children scoring >3 initially and > 2 on follow-up have a 47.5% risk of ASD and a 94.6% risk of any developmental delay (Consistency: 0.63; area under the ROC curve: 0.97; cut-off point of 3) (Robins et al., 2014). This screening tool identified children at risk for ASD. Those scoring at a "medium or high risk" level underwent further evaluation.

Language difficulties´ screener/Tamiz de problemas de lenguaje (TPL) (Auza et al., 2018a, 2018b). This test identifies grammatical difficulties in Monolingual Spanish-speaking children through a morphology cloze task and a sentence repetition task. The technical manual provides cut scores for children between 3:0 and 6:11 years (Sensitivity range: 74.6–88.9%; specificity range: 92.1–95.0% across different age groups). According to the manual, children at risk of DLD are those who score at or below the 16th percentile.

2.3 Procedure

Ethical approval was obtained from the Ethics and Research Committees of the Juan N. Navarro Psychiatric Hospital (CPHJNN) (Registry II3/01/0618). The study included five public daycare centers, one private school, a developmental care clinic, and the CPHJNN, which serves a low-income population (Márquez-Caraveo et al., 2017). These sites were used as locations to engage parents and their children in our study. Recruitment strategies included distributing flyers within the developmental care clinic and hospital, direct contact with parents, leveraging referrals from existing patients, or through word-of-mouth recommendations. Approximately 10% of the invited parents declined to participate. Additionally, permission was obtained to make the respective invitations at the five public daycare centers and the private school. The exclusion criteria were: (a) Children with hearing loss, (b) Anatomic anomalies (e.g., cleft lip and palate), and (c) Motor impairment (e.g., cerebral palsy). Those who expressed interest underwent a comprehensive informed consent process, meticulously documented to ensure ethical compliance. Of the 206 who consented, 74 were excluded (12 for being outside the evaluated age range and 62 for incomplete data), leaving 132 children for analysis. Each child was interviewed along with their primary caregiver simultaneously. The interviewers, trained in the study method and supervised by the researchers, conducted a single-session interview with the caregiver and child; additionally, the caregiver completed the study questionnaires. All interviews were conducted between March 2019 and April 2021.

Children were classified into four groups based on standardized assessments. (1) TD Group: Parents showed no parental concern about language development in the Socio-demographic interview and the PLCQ (Auza et al., 2023; Peñaloza et al., 2021), had normal ("green") results across all Developmental Evaluation Test (EDI) domains, scored above the 10th percentile in the MacArthur-Bates CDI word production and/or MLU3, and had normal ranges on both the Child Behavior Checklist (CBCL) and M-CHAT/RF. (2) LTs Group: Parents exhibited concern about language development (Auza et al., 2023; Peñaloza et al., 2021), had atypical results in the language domain of the EDI, scored at or below the 10th percentile in word production and/or Mean Length of Utterance at 3 years (MLU3) on the CDI, and had normal CBCL and M-CHAT/RF results. (3) ASD Risk Group: Children were identified as at risk for autism spectrum disorder if they scored in the "borderline" or "clinical" range on the CBCL pervasive developmental problem and withdrawn syndrome scales, or as "medium or high risk" on the Modified Checklist for Autism in Toddlers, Revised with Follow-up (M-CHAT/RF) These children we assigned to the ASD group, regardless of the outcome of the PLCQ or EDI. (4) DLD Risk Group: Children at risk for developmental language disorder were screened using the Parental Linguistic Concerns Questionnaire (PLCQ) (Auza et al., 2023), scoring low on language in the EDI, and scoring at or below the 16th percentile on the Test de Problemas de Lenguaje/Language Difficulties Screener (TPL), and had no signs of ASD as measured by the CBCL and MCHAT.

2.4 Statistical analysis

First, we describe the demographic and language development characteristics of the participants in the four group conditions. Due to significant skewness in the score distributions for overall word production, the six vocabulary categories, and MLU3, the median, interquartile range, and range were reported with the aim of describing the distributions and patterns of the studied variables.

To address the first research question, we used generalized linear mixed models (GLMM) to compare differences in the production of six vocabulary category scores (Nouns, Verbs, Adjectives-Adverbs, Functional Words, Routines, Sounds-Onomatopoeias) among four groups of children (TD, LTs, ASD, DLD). The models were constructed to evaluate the main effects of the children's groups and the six vocabulary categories, as well as the interaction effects between these two factors on vocabulary development scores. The full model was:

$$VSCORE_{ijk} = \beta_0 + \beta_1 VCATEG_j + \beta_2 DX_k + \beta_3 \left(VCATEG_j \times DX_k\right) + u_i + \varepsilon_{ijk}$$

Where VSCORE represents the vocabulary category scores; DX, the group of children; VCATEG, the vocabulary category scores; DX × VCATEG, the interaction term; u, the subject identifier as the random effect of the model; and ε, the error term. The subscripts j, k, and i denote the group of children, vocabulary category, and each child, respectively. The reduced model without interaction effects was:

$$VSCORE_{ijk} = \beta_0 + \beta_1 VCATEG_j + \beta_2 DX_k + u_i + \varepsilon_{ijk}$$

The optimal model among all variations from the full model to the reduced model was determined using the Akaike Information Criterion (AIC). The estimated regression coefficients, their standard errors, *t*-values, *p*-values, and effect sizes for each term in the optimal model were reported. As the effect size index, we reported the standardized estimates, calculated by dividing the estimates by their respective standard errors, which is equivalent to *t* ratio. The results of the characterization of each of the four children's groups were shown through profiles obtained by connecting the median values of the six vocabulary categories.

To examine the second question concerning variability, we utilized box plots to visually represent the variability in vocabulary score distributions. We then assessed differences in variability using the Brown-Forsythe test, a non-parametric statistical test for

homoscedasticity. Initially, we tested the overall null hypothesis of homoscedasticity. Upon rejection of this hypothesis, we conducted pairwise comparisons using the same test, adjusting the alpha level with the Holm-Bonferroni method to account for multiple comparisons.

To address the third research question, we investigated the identification of distinct patterns of vocabulary development. A hierarchical cluster analysis was conducted using the six vocabulary category scores as variables to form clusters among subjects. The resulting clusters were characterized by visualizing differences through bar charts comparing the standardized scores. Subsequently, the relationship between these clusters and the four conditions was examined using correspondence analysis.

All statistical analyses were performed using R statistical software (Version 4.0.3; R Core Team, 2023) within the RStudio (RStudio Team, 2020) environment, with specific R packages installed, including FactoMineR (Lê et al., 2008), ggplot2 (Version 3.3.3.; Wickham, 2009), lme4 (Version 1.1.23; Bates et al., 2015), multcomp (Version 1.4–16; Hothorn et al., 2008) and tidyverse (Wickham et al., 2019).

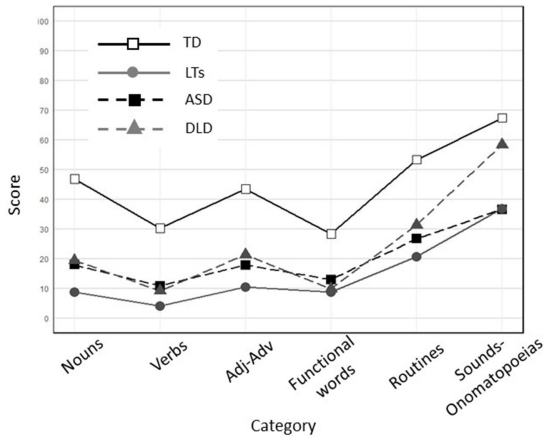


FIGURE 1
Profiles of four groups (TD, LTS, ASD, DLD) based on six vocabulary category scores. Each plotting symbol denotes the mean value for the score.

3 Results

From a descriptive perspective, differences in overall word production and MLU3 are observed between children with atypical development and TD children. Specifically, the median values for overall word production were: TD (M = 289, IQR = 166.5, 412); LTs (M = 34, IQR = 17.5, 72); ASD (M = 47, IQR = 3, 160.5); and DLD (M = 74, IQR = 45, 196.5). For MLU3, the median values were: TD (M = 2.7, IQR = 2, 3.6); LTs (M = 0, IQR = 0, 2); ASD (M = 0, IQR = 0, 2.5); and DLD (M = 0, IQR = 0, 2.7) (See Supplementary Table S1).

To address the first research question, which focuses on the vocabulary production patterns across the four groups, we employed Generalized Linear Mixed Models (GLMM). Based on the optimal model, we reported the main effects and interaction terms, estimated regression coefficients, standard errors, *t*-values, and *p*-values (Supplementary Tables S2, S3.1–3.5). The same results were also presented and visualized as profile plots (Figure 1).

As shown in Figure 1, TD children, as expected, scored significantly higher in all vocabulary categories compared to LTs, ASD and DLD. Notably, across all groups, the categories Routines and Sounds-Onomatopoeias consistently scored higher than Nouns, Verbs, Adjectives-Adverbs, and Functional Words. Nouns and Adjectives-Adverbs had relatively higher scores. Children with DLD notably showed high scores in Sounds-Onomatopoeias.

The results of a more detailed analysis of the aforementioned profiles using GLMM are summarized in Supplementary Tables S2, S3.1–3.5. Supplementary Table S2 shows the comparison of scores between the six lexical categories in each of the four groups. In addition, Supplementary Tables S3.1–3.5 report the main effects of the four groups for each vocabulary category, as well as the interaction effects between vocabulary categories for the following pairs: Nouns vs. Verbs; Verbs vs. Adjectives/Adverbs; Adjectives/Adverbs vs. Functional Words; Functional Words vs. Routines; Routines vs. Sounds-Onomatopoeias.

The average scores for LTs, children with ASD, and those with DLD were all significantly lower than those for TD children. Specifically, the estimated average score differences were − 38.2 for LTs ($p < 0.001$), −28.9 for ASD ($p < 0.001$), and − 27.5 for DLD ($p < 0.001$) (Supplementary Table S3.1). These results highlight significant differences in vocabulary production across the four groups.

Regarding the main effects of vocabulary categories, Verbs showed significantly lower scores compared to Nouns (reference category) (estimate = −16.7, $p < 0.001$). In contrast, no significant differences were found for Adjectives-Adverbs (estimate = −3.5, $p > 0.05$). Functional Words had significantly lower scores (estimate = −18.5, $p < 0.001$), while Routines had significantly higher scores (estimate = 6.4, $p < 0.05$). Sounds-Onomatopoeias showed the highest scores (estimate = 20.4, $p < 0.001$), indicating clear differences across vocabulary categories.

With respect to the interaction effects, significant interactions were observed in specific vocabulary categories among the groups. For example, for the DLD group, a significant interaction was observed in Sounds-Onomatopoeias (estimate = 13.0, $p = 0.020$, Supplementary Table S3.5), indicating that this vocabulary category is particularly prominent in children with DLD compared to other vocabulary types.

To answer the second research question, the distribution of vocabulary production scores was observed and quantiles were calculated (Figure 2). Examination of the equivalence/non-equivalence of these distributions revealed statistically significant differences in non-equivalence across all six categories. However, for Routines, while the overall null hypothesis that the distributions are equal across the four groups was rejected with a *p*-value slightly below 0.05, the Holm-Bonferroni correction for pairwise multiple comparisons showed no significant differences in variability between groups. For Nouns, Adjectives-Adverbs, and Functional Words, the TD group exhibited greater variability compared to the LTs group. For Verbs, the TD group showed greater variability than the other groups. For Sounds-Onomatopoeias, the scores distribution slightly differed between the TD and ASD groups and between the LT and ASD groups (Supplementary Table S4).

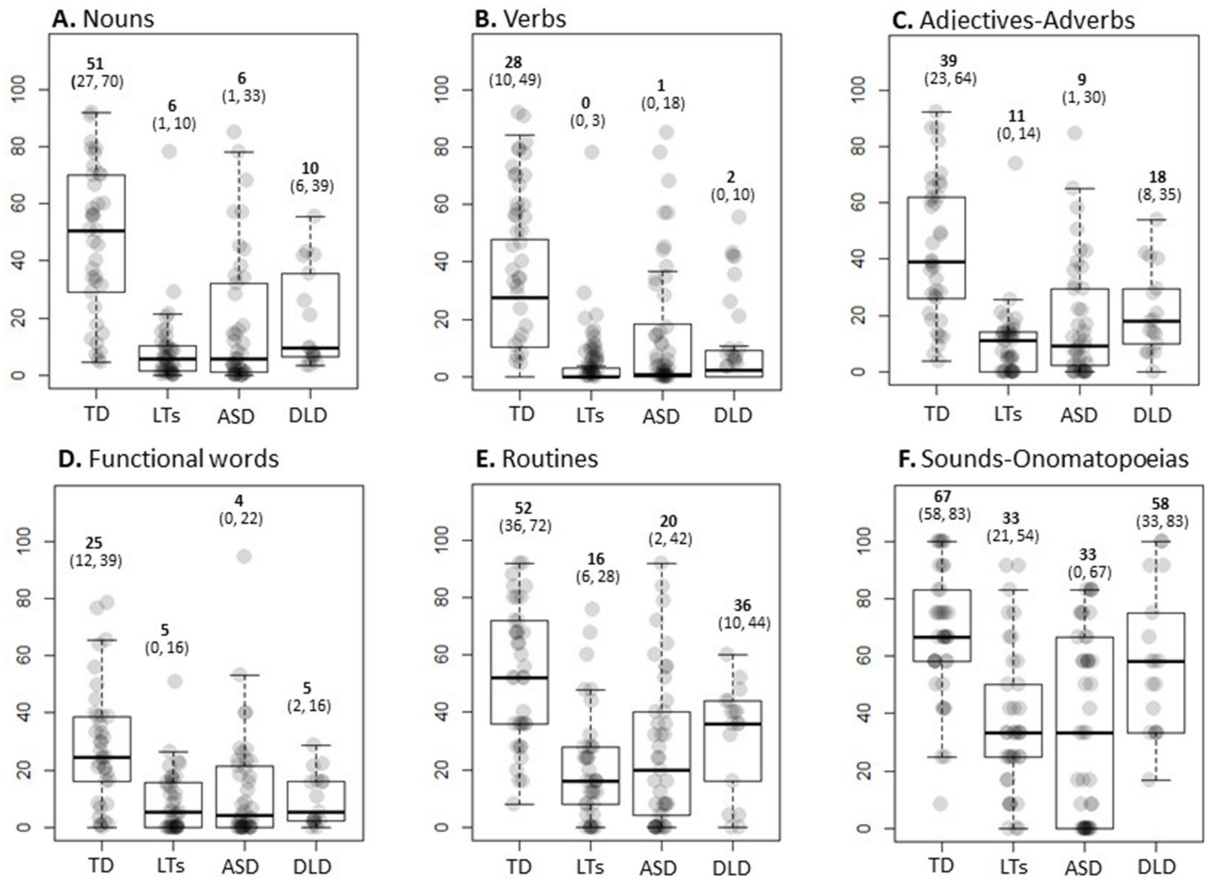


FIGURE 2
Comparison of variability among the four groups across six vocabulary categories. The values displayed at the top of each boxplot for **(A)** Nouns; **(B)** Verbs; **(C)** Adjectives-Adverbs; **(D)** Functional words; **(E)** Routines; **(F)** Sounds-Onomatopoeias, are median (interquartile range).

Regarding the third research question, a hierarchical cluster analysis revealed six distinct patterns of vocabulary development across the six categories, identifiable as clusters. Among them, three were in the high performance range and the other three were in the low performance range. The first three clusters were named as follows: cluster 1 "Highest vocabulary," cluster 2 "Moderately high," (with focus on Routines/ Sounds-onomatopoeias), and cluster 3 "Moderately high," (with focus on Adjective-Adverbs). Similarly, the three low-score clusters had three levels: cluster 4 "Moderately Low," (especially high on Sounds-onomatopoeias), cluster 5 "Moderately Low," (with focus on Nouns), and cluster 6 "Lowest vocabulary," (with focus on Routines and Sounds-onomatopoeias, Figure 3).

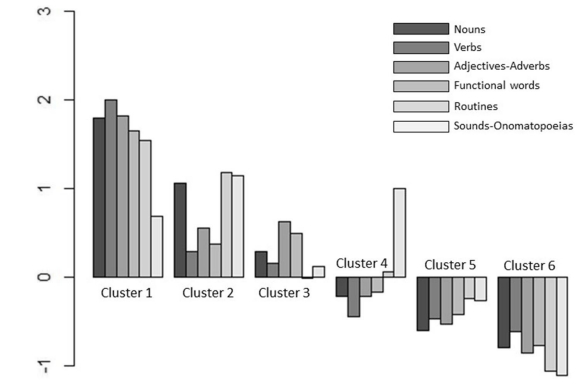
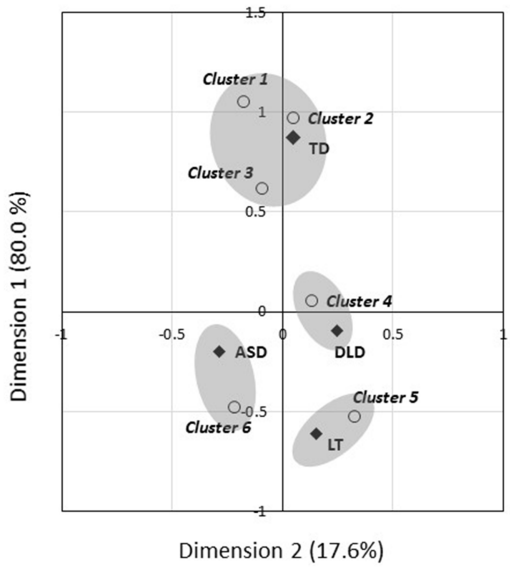


FIGURE 3
Contrasts in standardized scores across six clusters from hierarchical cluster analysis using six vocabulary categories as variables.

We subsequently examined the relationship between these six clusters and the four groups, revealing a highly significant association ($\chi^2 = 52.55$, d.f. 15, $p < 0.001$). The correspondence analysis captured nearly all the variability in two dimensions (Dimension 1: 80%, Dimension 2: 17.6%), as illustrated in Figure 4. Notably, three clusters strongly correlated with TD children, while the remaining three clusters corresponded to LTs, children with DLD, and ASD.

Specifically, 73% of TD children were associated predominantly with high-score clusters 1, 2, and 3 (primarily 1). For LTs, 98% were linked to clusters 4, 5, and 6 (mainly 6). Regarding DLD, 89% were primarily associated with clusters 3, 4, 5, and 6 (especially 4). The ASD group was associated with all clusters, with a predominant association with cluster 6.

Dimension 1 straightforwardly reflects positive values indicating high scores in vocabulary categories and association with TD children, whereas negative values correspond to lower scores and



	TD	LTs	ASD	DLD
Cluster 1	14 (38%)	1 (3%)	4 (10%)	1 (6%)
Cluster 2	6 (16%)	0 (0%)	4 (10%)	1 (6%)
Cluster 3	7 19%)	0 (0%)	4 10%)	3 (18%)
Cluster 4	4 (11%)	7 (19%)	4 (10%)	5 (29%)
Cluster 5	4 (11%)	14 (38%)	9 (22%)	1 (24%)
Cluster 6	2 (5%)	15 (41%)	16 (39%)	3 (18%)
Total	37 (100%)	37 (100%)	41 (100%)	17 (100%)

FIGURE 4
Correspondence analysis has pinpointed the relationships between four groups and six clusters. The statistical association between the six clusters and the four groups are highly significant ($x^2 = 52.55$, $p < 0.0001$).

association with the three groups of children with language delays. Dimension 2's interpretation is less definitive, but distinguishes the ASD group (negative values) from the DLD and LTs groups (positive values).

Furthermore, clusters associated with the DLD group exhibited relatively high scores, particularly in Sounds-onomatopoeias, followed by clusters associated with LTs. In contrast, clusters associated with ASD were characterized by lower scores.

4 Discussion

This study aimed to analyze the lexical profiles in four groups of children with typical and atypical development by examining their word production across six categories. While existing English literature emphasizes variability in language acquisition (Bates et al., 2017; Dale and Goodman, 2004; Fenson et al., 1994) and vocabulary categories, this study makes a unique contribution by focusing on the variability of expressive language skills in Spanish-speaking children with typical and atypical language development.

In relation to the first hypothesis, the analysis of the profiles of the six vocabulary categories (Nouns, Verbs, Adjectives-Adverbs, Functional Words, Routines, and Sounds-Onomatopoeias) across the four groups (TD, LTs, ASD, and DLD) revealed significant similarities and differences between the groups. As anticipated, the TD group achieved the highest median scores, indicating robust and typical development across all vocabulary categories. Secondly, our findings suggest that the use of vocabulary categories in Spanish-speaking TD children is similar to those described in TD children acquiring other languages such as English or Italian (Bates et al., 1994; Caselli et al., 1995; D'Amico et al., 2001; D'Odorico and Fasolo, 2007; Rescorla et al., 2014). The order and rates of the acquisition of vocabulary categories, are highly similar regardless of the target language's typology. Serving as a baseline for comparison, the TD group stands out from the clinical groups due to its high production of vocabulary categories.

Among the clinical groups, one of the similarities was that they showed low production trends. LTs showed the lowest scores compared to those with TD, followed by ASD and DLD. The group with TD exhibited the highest scores in Routines and Sounds-onomatopoeias, compared to Nouns, Verbs, Adjectives-Adverbs, and Functional words. The consistent use of Sounds-onomatopoeias as the most produced category suggests that these sound-based expressions play a significant role in easing language production during early language development. This is likely due to their transitional status during early expressive vocabulary development (Auza and Murata, 2021; Caselli et al., 1995; MacRoy-Higgins et al., 2016). Sounds-onomatopoeias may stand in place of Nouns for children with language difficulties, as challenges in remembering words, particularly Nouns, can impair language processing abilities and comprehension, leading to lower overall vocabulary production (MacRoy-Higgins et al., 2016; Ellis-Weismer et al., 2013).

Some interesting interactions between the vocabulary categories and the four groups were observed in terms of profile differences. A strong interaction effect was observed between the Sounds-onomatopoeias and the DLD group, which showed markedly higher values than the other vocabulary categories. This is in contrast to the profile patterns of the other groups, highlighting their unique dependence on Sounds-onomatopoeias. These findings underscore the disproportionate retention or influence of certain vocabulary categories in each clinical group, pointing to a unique language profile.

Additionally, the low use of verbs and functional words indicated challenges in their production (Jackson-Maldonado et al., 1993; Marini et al., 2020; Oetting and Hadley, 2017; Tardif et al., 1999). Previous research has shown that the lower use of verbs may result from the lower use of adjectives-adverbs and functional words (Bates et al., 1994), which can impact word combinations. Moreover, if a child's verb repertoire is limited, concern should be raised for those

children who remain in the lowest 10%, using about half the verbs that typical children produce at 24 months. The low use of Verbs also affects MLU, as the verb repertoire supports the acquisition of sentence structure (Hadley et al., 2016). Recent studies have demonstrated that linguistic structure is crucial for acquiring non-nominal lexical categories, emphasizing its role over conceptual complexity (Braginsky et al., 2019). Cognitive demands also apply to adjectives and functional words, which rely on the prior acquisition of categories such as nouns and verbs (Bates et al., 1994). Overall, while common profile patterns were observed among the four groups, the interaction effects revealed that each group has distinct characteristics in their vocabulary production. In particular, the differences in verbs and functional words in the LTs and ASD groups (with effect sizes ranging from moderate to large), as well as in sounds-onomatopoeias in the DLD group (with a large effect size), were especially notable.

Regarding vocabulary production variability, the interquartile range provides additional insights and partly corroborates our second hypothesis. While the ASD and DLD groups show greater variability, the LTs displayed low variability. Our results reveal that within a clinical condition, some children can produce as many words in certain vocabulary categories, such as nouns, verbs, and routines, as TD children, while in other categories, they produce few or none. While the variability in sounds-onomatopoeias is broad but similar across all groups, the variability of other vocabulary categories differs. In nouns and adjectives-adverbs, the ASD and DLD groups exhibit similar patterns, with greater dispersion than LTs. This suggests that the ASD and DLD group include more individuals who produce either few or many words (greater dispersion) in these categories, whereas LTs mostly produce few words (low dispersion). For verbs, the variability differs, with each group showing distinct levels of dispersion: TD shows the greatest dispersion while LTs have the lowest dispersion, making the TD group distinguishable from the clinical groups. Despite the cognitive demands and dependency on other words that make verb production challenging in various languages (Childers and Tomasello, 2006; Tomasello et al., 1997), studies have shown that TD children as young as 2 years can produce verbs in languages like English or Spanish, or even as young as 1 year and 3 months in languages like Korean (Choi and Gopnik, 1995). Findings on Spanish acquisition in both monolingual and bilingual children indicate early usage of different types of verbs with expanded verbal morphology and low error rates (Gathercole et al., 1999; Ingram et al., 2008; Serra et al., 2001; Serrati Sellabona et al., 2004; Silva-Corvalán and Montanari, 2008). Indeed, cognitive and linguistic demands may affect variability in verb production, as evidenced by our results. A different panorama is observed with functional words. Despite the DLD group being older, their use of functional words shows low variability very much alike to LTs, indicating difficulties in producing this category. Thus, distinguishing between groups based on vocabulary categories requires considering both the number of words produced and their dispersion. For instance, verb variability does not help distinguish between ASD and DLD, while pronounced low dispersion in this category distinguishes LTs, indicating that most of the children do not produce or produce few verbs. In functional words, the low variability of LTs aligns with the DLD group and, to a lesser degree, with ASD children. Our results also showed that the latter group can produce functional words similarly to TD children, although most children with ASD may not produce them due to morphosyntactic difficulties (Marini et al., 2020; Oetting and Hadley, 2017). Variability in routines was common across all four groups of children, particularly in the ASD group. Interestingly, children with ASD exhibited more routines than LTs. This phenomenon may be partly attributed to the rote learning mechanism that many children with ASD develop early on, which occurs even more frequently than in TD children (Wivell, 2017).

Our analysis highlighted differences in the language abilities of various groups of children. The variability in word production in typical and atypical children serves as an indicator of their increasing language proficiency. This variability reflects individual differences observed among different clinical groups. Some children learn words slowly and may remain at risk for language disorders (Bates, 2004), while others acquire words quickly and start using them at an early age (Fenson et al., 1994).Variability has been explored in many studies (e.g., Fenson et al., 1994; Fernald and Marchman, 2011; Huttenlocher et al., 2010) as it provides insights into the unique developmental paths of both typical and atypical children, allowing for tailored interventions and better understanding of vocabulary acquisition processes within each clinical condition.

In general terms, six clusters of word production were identified, confirming our third hypothesis: three clusters exhibited high production profiles and three exhibited low production profiles. This suggests a typical and well-distributed language development profile, varying from low but age-expected production to medium or high production across all vocabulary categories. TD children exhibited a diverse and balanced distribution across three clusters of high production, indicating three levels of word production. Variations among different vocabulary categories are expected; other studies have shown that they may involve different learning mechanisms, such as concreteness for nouns, frequency for predicates, or linguistic structure for functional words (Braginsky et al., 2019). This result is consistent with the literature, which has stated that language production is highly variable among TD children (Bates et al., 2017). Concerning the three low production profiles, LTs were predominantly associated with these clusters, showing three levels of word use, with a strong presence in clusters five and six, which were the lowest of all the clusters. They appear to lack visible production strategies, suggesting a delayed profile in language development. This result indicates that LTs are, also in some way, heterogeneous in lexical production, consistent with findings from previous studies (Dale et al., 2003; Desmarais et al., 2010; Perry and Kucker, 2019). In Desmarais et al. (2010), heterogeneity among LTs was also observed, with three different clusters, one being more affected, particularly in the number of words. Accurately characterizing LTs and others at risk for language delays is essential for precise diagnosis and targeted interventions. This requires specific statistical methods that account for the inherent heterogeneity in populations with language delays (Perry and Kucker, 2019). In our study, the association of LTs with clusters five and six suggests a significant delay, with greater language difficulties compared to other groups. This may indicate that some of these children could be classified in the future as presenting with DLD, especially given the low use of verbs and functional words found in these clusters. The ASD group showed associations with all clusters; notably, 30% were associated with a typical language cluster, consistent with previous findings (Charman et al., 2003; Ellis-Weismer et al., 2011; Luyster et al., 2007). Our finding aligns with Vogindroukas et al. (2022), in that ASD can belong to either a typical or an atypical language profile. This highlights the importance of defining clinical subgroups within this spectrum.

Nonetheless, the highest percentage of individuals with ASD (39%) were comprised in the lowest cluster, which also encompassed a high proportion of LTs (41%). This indicates that while the lowest cluster is representative of the ASD group, it also overlaps with LTs. Regarding these findings, Rescorla and Safyer (2013), suggested that lexical composition in ASD is delayed more than atypical. This perspective aligns with a "dimensional account" (Jiménez et al., 2021) of language delay, implying that language disorders in ASD primarily reflect quantitative differences along a single dimension. Nonetheless, Lazenby et al. (2016) found that by 12 months, children later diagnosed with ASD had low receptive and expressive language scores but were also producing and understanding certain words in an "unexpected way." This finding supports the "categorical account" (Jiménez et al., 2021) which posits that children with ASD have different language profiles. Our findings align with both perspectives, as we observed distinct vocabulary category discrepancies between LTs and ASD, highlighting the discriminatory potential of specific categories. Most of the children in the DLD group (71%) were linked to clusters of low production, predominantly cluster four. However, another third (30%) was associated with clusters of high production, possibly due to being the oldest among the children. The similarities in lexical profiles between the LTs and DLD group suggest shared lexical production traits, possibly indicating parallel lexical acquisition trajectories in verbs and functional words. Previous research has supported the idea that vocabulary composition is a critical factor in differentiating children with language delays (Ellis-Weismer et al., 2011; Jiménez et al., 2021; Perry et al., 2023). Regarding verbs, persistent LTs that evolve into DLD can be detected with the use of this category (Auza and Murata, 2021; Hadley et al., 2016). These profiles of association with clusters can provide insights into the linguistic strengths and challenges within each group. It is essential to consider that individual differences can contribute to this variability in children with TD and with clinical conditions.

5 Conclusion

This analysis highlighted distinct lexical profiles among TD, LTs, ASD, and DLD groups, showing variability across vocabulary categories. Rather than simply confirming lower vocabulary levels in clinical groups, the study suggests that the variability within each category may reflect the unique characteristics of each group. This variability offers additional insight into the characterization of these groups, contributing to a deeper understanding of heterogeneity in early language development across clinical populations.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Comité de Ética en Investigación, Child Psychiatric Hospital. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

AA-B: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. MM-C: Conceptualization, Methodology, Project administration, Writing – original draft, Writing – review & editing, Formal analysis, Investigation. CM: Data curation, Formal analysis, Investigation, Writing – review & editing. VP-B: Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2024.1368076/full#supplementary-material

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