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New trends in typical and atypical language acquisition

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New trends in typical and atypical language acquisition

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Editorial: New trends in typical and atypical language acquisition

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Editorial on the Research Topic
New trends in typical and atypical language acquisition

1 Introduction

This Research Topic presents a selection of contributions linked to the IX AEAL *International Congress on Language Acquisition*. The *Association for the Study of Language Acquisition* (AEAL; https://aeal.eu) promotes research on language acquisition and development in both, monolingual and multilingual contexts, with a particular focus on Spanish, Basque, Catalan and Galician, as well as the relationships between language and psychological, social, educational and biological processes. The triennial AEAL Congress has reached its 10th edition since 1995, and it has become one of the most relevant international scientific events in the field of language acquisition, bringing together experts in diverse areas, including grammar, lexicon, discourse analysis, pragmatics, psycholinguistics, neurolinguistics, sociolinguistics, and language teaching and education. A substantial body of research on language acquisition from these broad and interdisciplinary perspectives has been published in previous AEAL conference volumes (Pérez-Pereira, 1996; Mayor et al., 2005; Diez-Itza, 2008; Aguilar-Mediavilla et al., 2019).

The 18 articles included in this Research Topic provide an updated contribution to this research area, fostering and giving continuity to the dissemination and open discussion of new trends in the study of typical and atypical acquisition, as promoted by AEAL. They address the key topics covered in the AEAL Congress on Language Acquisition, including studies on phonological, morphosyntactic, and lexical-semantic levels, the development of discourse and pragmatics, literacy acquisition and development, language acquisition in bilingual and multilingual contexts, assessment and intervention in developmental language disorders, language learning and teaching, and new methodological approaches.

Accordingly, this Research Topic offers an integrated view of theoretical, methodological and applied issues from multilingual and multidisciplinary perspectives. It includes review articles, brief research reports and original research articles employing experimental, cross-sectional and longitudinal designs that cover a wide range of crucial issues in the field. The studies examine language acquisition among native speakers of

various languages and dialects (i.e., Chilean, Colombian, Mexican and Peninsular Spanish; Basque; Catalan; Italian; English); in both monolingual and bilingual participants, across different age groups (infants, children, adolescents, and adults), and in both typical and atypical development (e.g., Developmental Language Disorder, Autism Spectrum Disorder; Williams and Down Syndromes, Hearing Impairment). A variety of research methods and assessment tools for spontaneous and elicited oral and written language are employed, including those from the CHILDES Project (MacWhinney, 2000), PROESC (Cuetos-Vega et al., 2002), PREP-CORP (Diez-Itza et al., 2022), PDP-PI (Junquera and Zubiauz, this volume), MacArthur Bates CDI (Fenson et al., 2007), SSRT Repetition Task (Bravo et al., this volume), The Pragmatics profile (Dewart and Summers, 1995), and MUAQ (Aparici et al., this volume). Additionally, instruments such as eye-tracking, the preferential-looking paradigm, multimodal input in foreign language teaching or technology-assisted intervention in neurodevelopmental disorders can also be found.

2 Typical language acquisition

The significance of preverbal abilities during the first year of life as a foundation for language emergence has been increasingly recognized over recent decades through diverse experimental paradigms. In this context, the study by Marcet et al., employing an eye-tracking preferential-looking paradigm, explore how monolingual and bilingual infants form face-language associations during their first year of life.

The development and use of diverse assessment tools and instruments in the early stages of language acquisition are essential to detect language difficulties and factors influencing language acquisition, a focus of several studies in the present volume. Bravo et al. examine the potential of a Spanish Sentence Repetition Task for detecting language disorders in young children, comparing it with measures of spontaneous language (Mean Length of Utterance, lexical diversity, and structure of the Noun Phrase). Ezeizabarrena et al. provide a brief review of the adaptation of the short MacArthur-Bates Communicative Development Inventories (CDIs) for Basque, designed to measure young children's vocabulary size. They also present data from a large sample assessed through the Basque CDI on the effects of age, sex, and language input in early language developmen. Junquera and Zubiauz introduce a new protocol for assessing the development of pragmatic competence in early childhood (PDP-PI), based on taxonomies of communicative functions (Interactional, Referential, Subjective and Figurative), along with preliminary data from its application in 3–5-year-old children. Botana and Peralbo investigate the influence of parental beliefs about child development and other socio-familial variables on the pragmatic assessment of infants and young children using The Pragmatic Profile, underscoring the need for contextualized evaluation.

Research on grammar comprehension has traditionally received less attention due to its methodological complexity. The work of Torrens investigates preschool children's comprehension of object and subject relative clauses using a cloze test, comparing cases with identical or different morphosyntactic features to evaluate sentence processing predictions based on the Relativized Minimality hypothesis. Another topic involving language comprehension, the effects of input, is addressed by Alvarado et al. who examine how preschoolers' oral narrative retelling is influenced by the source text, specifically on the production of conceptual subordination, as evidence of an interpretive process beyond simple reproduction of input.

Bilingual acquisition and its relatioships with literacy development are also central issues at AEAL conferences. Aparici et al. describe a newly developed Multilingual Use Assessment Questionnaire (MUAQ), administered to bilingual Catalan-Spanish children and young adults to capture the heterogeneous nature of multilingual profiles based on self-assessment of language competence, language use in mental operations, and language use in different contexts. Leonetti Escandell examines by means of a cloze-test and a written narrative retelling task the reference production in Italian-Spanish bilingual children, investigating whether it is influenced by referential expression type or language dominance. Finally, Feijoo and Anglada analyze how multimodal input, particularly gesture, contributes to the development of morphological awareness in English-speaking adolescents learning Spanish as a second language after short-term training with different input modalities.

3 Atypical language acquisition

Language acquisition research increasingly focuses on differentiating developmental trajectories to improve early diagnosis of atypical development and design personalized interventions, a trend reflected in several studies in this volume. Auza-Benavides et al. use the MacArthur-Bates Communicative Development Inventory II to investigate the variability in early expressive vocabulary among typically developing children, late talkers, and children at risk for neurodevelopmental conditions like autism spectrum disorder (ASD), and developmental language disorder (DLD).

A frequent cause of atypical language acquisition is Developmental Language Disorder (DLD), a primary language disorder that persists into school age and beyond. This impairment is investigated in two experimental studies utilizing eye-tracking. Guerra et al. examine lexical-semantic processing in preschool children with DLD, focusing on their real-time comprehension of semantic relationships, to verify expected difficulties in lexical access and retrieval, as well as greater lexical competition among children with DLD. Lara-Díaz et al. investigate visual attention during phonological processing tasks, also testing language, vocabulary, and phonological awareness in Colombian children with DLD to assess its role in integrating visual perceptual information with diverse cognitive and linguistic processes. Children with DLD not only face challenges in oral language but also show significant writing difficulties. This aspect is explored by Balboa-Castells et al., who utilize a writing process evaluation battery (PROESC) to analyze how these children plan and code written expository texts, examining word frequency and sentence structure, grammatical complexity, lexical density, as well as omissions and errors.

Two contributions in this volume stem from the SYNDROLING Project, which aims to identify specific linguistic phenotypes in neurodevelopmental genetic syndromes, as postulated by neuroconstructivist models. These studies employ the methods of language corpus analysis provided by the CHILDES Project. Martínez et al. explore the profiles of late phonological development of children with Williams syndrome, focusing on the absolute frequency of phonological errors, in a longitudinal analysis that tracks an accelerated evolution from expansion to stabilization stages following non-linear trajectories. Viejo et al. explore the pragmatic profiles of adolescents with Down syndrome and Williams syndrome by comparing the microstructure and macrostructure of their narratives, highlighting atypical dissociations, using the Pragmatic Evaluation Protocol for Corpora (PREP-CORP) to assess productivity and complexity at both levels.

The relationships between language and cognition in children with hearing loss have been recurrently addressed in developmental research, as they show significant delays in understanding Theory of Mind. This has often been attributed to limited access to conversational interactions in their environment. In this vein, Serrat et al. assess the connection between language development and mind-reading abilities in hearing-impaired children, and specifically whether the successful completion of a second-order false-belief task requires the comprehension of complements or other language skills, such as expressive vocabulary, receptive and expressive syntax, recalling sentences, and a recursive sentential complement.

New trends in the research on atypical language acquisition increasingly focus on the development of innovative intervention methods that incorporate technological devices. Finally, Urrea et al. present a systematic review, preregistered in PROSPERO, evaluating the effectiveness of technology-assisted interventions—using tablets and computers— for vocabulary learning in children with autism spectrum disorder, emphasizing essential factors such as personalized assessments, recognition of prior experiences, and awareness of the context of usage.

4 Conclusion

In sum, the articles included in this Research Topic provide a rich tapestry of interdisciplinary perspectives in the study of language development, encompassing a wide array of topics. The studies presented illustrate the dynamic and evolving nature of research on typical and atypical language acquisition, incorporating a broad range of theoretical and applied perspectives. A salient feature of this volume is its methodological diversity, employing experimental, cross-sectional, and longitudinal designs to investigate language acquisition across various age groups and linguistic backgrounds. Furthermore, the focus on bilingual and multilingual contexts reflects the growing recognition of the need to understand language acquisition in increasingly diverse linguistic environments. This Research Topic contributes to a deeper understanding of the mechanisms underlying language production, comprehension and processing and demonstrates the field's commitment to advancing reliable assessment strategies. The contributions also emphasize the need of early detection and effective intervention in atypical language development, highlighting the results of interdisciplinary collaboration and innovative methodologies in addressing the complexities of language development. This Research Topic underscores the relevance of AEAL's mission in shaping future directions in language acquisition research.

Author contributions

ED-I: Writing – original draft, Conceptualization. VM-A: Conceptualization, Writing – review & editing. AA: Conceptualization, Writing – review & editing. EA-M: Conceptualization, Writing – review & editing.

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Conflict of interest

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Exploring Spanish writing abilities of children with developmental language disorder in expository texts

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Introduction: Numerous studies have shown that children with developmental language disorder (DLD), in addition to oral language difficulties, exhibit impaired writing abilities. Their texts contain problems in grammar, organization, cohesion, and length of written output. However, most of these studies have been conducted with English speakers. English is characterized by complex phonological structure, opaque orthography, poor morphology and strict word order. The aim of this research is to observe the writing abilities of children with DLD in a language with simple phonological structure, transparent orthography, rich morphology and flexible word order like Spanish in the production of expository texts.

Methods: Twenty-six children with DLD (mean age in months=128.85) and 26 age-and sex-matched typically developing (TD) children (mean age in months=124.61) wrote an expository text about their favorite animal.

Results: In order to analyze how the two groups plan and encode written texts, we looked at word frequency and sentence structure, grammatical complexity and lexical density, and omissions and errors. Compared to the TD group, the children with DLD omitted more content words; made more errors with functional words, verb conjugation and inflectional morphemes, and made a large number of spelling errors. Moreover, they wrote fewer words, fewer sentences, and less structurally and lexically complex texts.

Discussion: These results show that children with DLD who speak a transparent orthography language such as Spanish also have difficulties in most language areas when producing written texts. Our findings should be considered when planning and designing interventions.

KEYWORDS

developmental language disorder (DLD), specific language impairment (SLI), writing abilities, shallow language, expository text

1 Introduction

Developmental language disorder (DLD)—also known as specific language impairment (SLI)—is a neurodevelopmental disorder affecting around 7.5% of the child population (Tomblin et al., 1997; Norbury et al., 2016) with no significant difference in sex distribution (Calder et al., 2022). DLD is defined as a severe and persistent disorder in oral language

acquisition and development, unassociated with a medical condition, such as hearing loss, intellectual disability, autism, or any neurological disorder or genetic syndromes (Bishop et al., 2016). Moreover, DLD may co-exist with other neurodevelopmental disorders such as attention-deficit, hyperactivity, motor, speech and behavioral problems, or dyslexia (Bishop et al., 2016).

Studies of children with DLD have found that they exhibit an heterogeneous oral language profile (Conti-Ramsden, 2008) which may, to differing degrees, involve one or several expressive and receptive language components and which affects social and/or school development (e.g., Leonard, 1998; Bishop et al., 2017). Previous studies have documented significant difficulties across the different components of oral language including phonology, morphology, syntax, vocabulary, semantics, pragmatics, discourse, and verbal learning and memory (Bishop et al., 2017). Research have found some phonological issues in productive phonology such as omissions of unstressed syllables and final consonants and changing syllabic structures (e.g., omitting final consonants and reducing consonant and vowel clusters; Aguilar-Mediavilla et al., 2002, 2007; Bishop and Clarkson, 2003; Gallon et al., 2007; Broc et al., 2013; Larkin et al., 2013). Additionally, children with DLD struggle with other phonological abilities, such as in phonological awareness abilities including complex tasks like deleting phonemes, substituting phonemes, or producing rhyming words (Thatcher, 2010; Vukovic et al., 2022; Korlaet et al., 2023). A considerable body of research has focused on studying morphological problems in children with DLD. They have deficits in the use of inflectional morphology, such as verb tense and agreement. Specifically, they omit the ending-s in the third singular person (e.g., 'She read a book' instead of 'She reads a book') and the past tense marker-ed (e.g., 'Yesterday, I play with Rachel' instead of 'Yesterday, I played with Rachel; Van der Lely and Ullman, 2001; Abel et al., 2015). Research has shown that these children struggle also with functional words since they omit articles, pronouns and prepositions (Bedore and Leonard, 2001; Restrepo and Gutierrez-Clellen, 2001; Sanz-Torrent et al., 2007; Coloma et al., 2016). Children with DLD produce syntactically simpler sentences (Marinellie, 2004) and find it difficult to understand both complex syntactic structures, such as dependent clauses and passive sentences (e.g., Bishop, 1997; Leonard and Deevy, 2006; Novogrodsky and Friedmann, 2006; Montgomery and Evans, 2009; Van der Lely et al., 2011; Leonard, 2014). Different studies have analyzed vocabulary and semantics in children with DLD and have observed that they typically present smaller and less rich lexicons than their typical peers (McGregor et al., 2023) and show slower latency times and more errors in picture naming (Lahey and Edwards, 1996; Lahey and Edwards, 1999; McGregor et al., 2002). Moreover, in receptive single-word vocabulary tests, they tend to score within the average range but statistically lower than their matched TD peers (Gray et al., 1999; McGregor et al., 2002, 2013; Sheng and McGregor, 2010; Haebig et al., 2015). Furthermore, they show semantic impairments encompass problems with expressing or understanding meaning from word combinations (Katsos et al., 2011). In pragmatics, children with DLD have difficulties understanding figurative language such as metaphors, double meanings or idiomatic expressions (Norbury, 2005) and understanding communicative intentions (Andrés-Roqueta and Katsos, 2020).

Having these problems in oral language, children with DLD are very likely to also experience difficulties in literacy. Different studies have reported that they are at greater risk for reading difficulties than children with typical language development (TD) (Sanz-Torrent et al., 2010; Bishop et al., 2017; Adolf and Hogan, 2018). It has been estimated that around 50% of children with DLD present also dyslexia (Bishop et al., 2009; Ramus et al., 2013) and they may exhibit reading comprehension difficulties (Ramus et al., 2013; Gough Kenyon et al., 2018).

Regarding writing, according to Hayes and Flower (1980) model, the writing process can be divided into three stages: planning, translating, and revising. The planning stage involves generating ideas, organizing thoughts and ideas, and setting writing goals. The translation stage is where these ideas are transformed from oral language into written form, and the revising stage involves reading and editing the written material. Additionally, the Not-So-Simple View of Writing (Berninger et al., 2002; Berninger and Amtmann, 2003) which is a modification of the Hayes and Flower model that incorporates various cognitive and executive function components, including working memory, into the writing process. Thus, children with DLD are expected to face difficulties in producing written content due to their challenges both in oral language and executive functioning, particularly in working memory (Im-Bolter et al., 2006; Archibald and Joanisse, 2009; Montgomery et al., 2010; Ebert and Kohnert, 2011). Accordingly, different studies have found problems in written production in children with DLD (i.e., Broc et al., 2021; Tucci and Choi, 2023). Written productions can be evaluated accordingly through analyses of microstructure and macrostructure (Liles et al., 1995). According to Hughes et al. (1997), microstructure refers to the syntactic and lexical levels of the production, that is, the language form and content. It has been characterized in terms of productivity as well as complexity. Conversely, macrostructure denotes the hierarchical structure and coherence of the text beyond the level of a single sentence. The way the story's episodes are arranged, how events are sequenced, and how the protagonists' internal states drive or respond to the story's events are all examples of macrostructure (e.g., McCabe and Peterson, 1984; McCabe and Rollins, 1994; Liles et al., 1995).

As far as we know, previous studies about writing in children with DLD have focused on analyzing the microstructure. Tucci and Choi (2023) performed a scoping review of literature focused on the effects of DLD on writing skills across the lifespan. Results showed that spelling may be the most vulnerable area for individuals with DLD. In this sense, previously studies show that children with DLD make a significantly higher percentage of spelling errors when producing written texts compared to TD children of the same age (Mackie et al., 2013; Williams et al., 2013; Dockrell et al., 2014; Reilly et al., 2014; Joye et al., 2019). For the most part, these spelling errors are due to phonological and morphological errors, which involve substituting, inserting or eliminating letters within a word (Mackie and Dockrell, 2004). Broc et al. (2021) conducted a scoping review about the nature of spelling errors in children with DLD across different orthographies. They divided the 18 reviewed studies into those based on dictation tasks and those containing written narratives because these two types of tasks involve different writing processes. In addition, they separately analyzed those two types of studies regarding the typology of the orthography of language in which they were carried out (opaque or transparent orthographic system). On dictation tasks, children with DLD produced more phonologically unacceptable spelling errors. These errors varied by age and by the nature of the words dictated. Moreover, children with DLD produced less phonologically

unacceptable spelling errors when the spelling could be derived by applying one-to-one sound-letter correspondences (transparent orthographic system) than when the phoneme-grapheme correspondences were irregular (opaque orthographic system). On written narratives, they found that most of the studies to assess the spelling skills of children with DLD had been conducted in opaque orthographies and only identified one study conducted in a transparent orthography language, Spanish (Soriano-Ferrer and Contreras-González, 2012). Overall, on written narrative tasks, results were contradictory about phonologically unacceptable spelling errors. Some studies found more difficulties than the control groups (Mackie and Dockrell, 2004) but others did not replicate those results (Broc et al., 2013; Dockrell and Connelly, 2015). In the only study conducted in a transparent orthography (Soriano-Ferrer and Contreras-González, 2012) children with DLD produced more spelling errors that were phonologically unacceptable compared to their peers of the same age. However, both groups made four times as many errors when the phoneme correspondence was irregular, as opposed to when it was regular, resulting in observable errors. Finally, on written narratives, only studies conducted in opaque orthographies were reported to examine errors in inflectional morphological spelling. Children with DLD overall showed problems in their ability to accurately use inflections in their spelling. Error patterns in children with DLD were similar to younger language matched peers but more frequent than their age-matched peers.

Moreover, children and adolescents with DLD also may have difficulties with grammar, organization, cohesion, and length of written output (Tucci and Choi, 2023). They make more errors and omissions when writing nominal inflectional morphemes and using derivational morphemes (prefixes and suffixes) than age-matched children (Connelly et al., 2011; Mackie et al., 2013). For example, they produce more errors in the use of plural forms and past simple verb tenses (Windsor et al., 2000; Mackie and Dockrell, 2004; Larkin et al., 2013). Additionally, they use fewer words that contain prefixes, such as *im/patient* or *dis/agree* and suffixes, such as *teach/er* or *profession/al* (Mackie et al., 2013). Interestingly, these differences are still significant when children with DLD are matched with children possessing the same language skills. The percentage of omitted auxiliary verb *be* and content words—such as nouns as subjects—is also significantly higher than in TD children of the same age with a similar receptive vocabulary (Windsor et al., 2000; Mackie and Dockrell, 2004). Moreover, they display poorer lexical diversity (Scott and Windsor, 2000; Mackie et al., 2013; Williams et al., 2013; Levlin and Waldmann, 2020; Stuart et al., 2020). The differences are once again significant when children with DLD are compared to a younger cohort with the same language skills. Research has also shown differences in writing abilities to be significant when children with DLD are compared to younger children of a similar reading age (Mackie et al., 2013). In addition, written texts produced by children with DLD are also shorter (i.e., contain fewer written words; Mackie et al., 2013; Dockrell et al., 2014; Stuart et al., 2020; Ralli et al., 2021) and contain a lower percentage of meaningful syntactic units (T-units) and coordinated sentences than texts produced by TD children of the same age. The sentences in their texts are also significantly shorter and contain fewer words per clause (Scott and Windsor, 2000; Mackie et al., 2013).

Most of these studies about the characteristics of the written language in DLD have been conducted with English speakers, a language with an opaque orthographic system. However, English has a number of characteristics that make it very different from transparent orthographic system languages such as Spanish. First, Spanish has a simple phonological structure. It has approximately 23 phonemes and the majority of syllables follow a simple consonant–vowel (CV) structure and have limited clusters and blends (Gorman and Gillam, 2003; Goikoetxea, 2005). Therefore, in Spanish, segmentation of syllables at the level of onset–rime is often equivalent to segmentation at the phonemic level. For example, a Spanish speaker who segments the syllables of the word "casa" [house] into onset and rime (onset:"c," rime: "a") will also identify the phonemes that make up the word (/c/ /a/ /s/ /a/; Goswami, 2008). This is not the case for the English, where many onsets and rimes contain clusters of phonemes, as in "sport" and "cost" which must be segmented further (De Cara and Goswami, 2002). Spanish has a transparent orthography both in terms of reading and writing since practically every phoneme is represented by a single, unique letter. Thus, children need to learn fewer phoneme-to-letter conversions in Spanish than in English, where one phoneme can be represented by multiple spellings (as the phoneme /f/ in words like frog, tough, and photo). Moreover, Spanish is a morphologically rich language: it uses inflections to indicate the relationship between the elements; that is, the composition of the words changes (e.g., "casa" [house], "casas" [houses], "casita" [little house]). This implies important morphological changes in words that include a lexeme or radical morpheme, to which one or more grammatical morphemes can be added (e.g., cas-a, cas-as, cas-ita). Another feature of Spanish, as in other Romance languages, is that the order of the words within the sentence is flexible (e.g., "Juan ama a Maria" ["John loves Mary"]; "A Maria ama Juan" ["To Mary loves John"]; "Juan a Maria ama" ["John to Mary loves"]), although there is a basic order of words in the sentence (canonical order: subject > verb > object). In addition, Spanish is a pro-drop language that allows personal pronouns to be dropped in the sentence ("Juega al fútbol" [Plays football]).

Previous cross-linguistic research suggests that both the simple phonological structure of Spanish and its highly regular phoneme-to-letter correspondence facilitate the process of learning to read and write in Spanish children with TD (Müller and Brady, 2001; Seymour et al., 2003; Ellis et al., 2004; Ziegler et al., 2010; Florit and Cain, 2011; Castejón et al., 2015). In theory, this should also help Spanish-speaking children with DLD as they learn to write. However, to our knowledge only two studies have been conducted concerning written language production among the DLD population in Spanish (Soriano-Ferrer and Contreras-González, 2012; Buil-Legaz et al., 2023). Buil-Legaz et al. (2023) analyzed the difficulties of children with DLD in spelling. Participants were 18 children with DLD (aged 7;0–11;5, M = 8;4, SD = 1.25) and 18 children with DLD with TD (aged 7;0–11;6, M = 8;2, SD = 1.29) that completed a spelling-to-dictation task of words and pseudowords, where length was manipulated. They used digital tablets to collect data and obtain measures of accuracy, latencies and total writing durations. Results showed that children with DLD produced more errors, longer latencies and longer writing durations than age-matched children. Regarding accuracy, analysis of the errors showed that children in the control group produce few errors, most being substitutions, while children with DLD made more errors and of more varied types (substitutions, omissions and additions). Moreover, they were more affected by length on writing accuracy than the control group. Soriano-Ferrer and Contreras-González (2012) examined the written narrations and the influence of linguistic

measures on narrative competence of children with DLD. Children did a written narrative task, where they had to recall, in writing, a story given to them previously orally twice. The story was composed of 19 propositions, with a simple grammatical structure. The children with DLD created short narratives, poorly organized and less cohesive. Also, their writings contained more syntax errors and had a higher proportion of phonologically inaccurate spelling errors in natural spelling but not in arbitrary spelling errors.

However, in these two previous studies, written performance was measured by single-word dictation (Buil-Legaz et al., 2023) and by a narrative based on a story given orally (Soriano-Ferrer and Contreras-González, 2012). As stated Broc et al. (2021), in dictated tasks the words to be written are predetermined while on written narratives participants can choose words they know, which may result in fewer spelling errors as they may opt for words they feel to spell. However, in the study of Soriano-Ferrer and Contreras-González (2012) children had to retell in writing a story given orally. Therefore, as far as we know, there are not any studies that analyze the production of expository texts in Spanish-speaking children with DLD. An expository text or informational text is a non-fiction text that gives facts and information about a topic. It aims to inform, explain, describe, or define a particular topic or subject. Its primary purpose is to present factual information, clarify ideas, and provide insights in a clear, concise, and organized manner. This kind of text is very common in subjects such as science, history and social sciences. There are several different types of expository structures. Meyer and Ray (2011) proposed six structures: compare-and-contrast, problem-and- solution, cause-and- effect, sequence, enumeration, and description. Each text structure type represents a distinct text organization and purpose. For example, description focuses on describing a topic, person, place or thing by listing a collection of its features or examples while. Expository texts serve as valuable tools for assessing writing abilities in children due to their inherent structure, which demands clear, organized, and coherent expression of ideas. Evaluating a child's ability to comprehend, synthesize, and communicate information effectively can be achieved through their creation of expository texts (Fisher and Frey, 2017). In this way, the aim of this study was to examine and compare text writing of children with DLD in the production of expository texts in Spanish. More specifically, by looking at how these children and their aged-matched TD counterparts plan and encode expository texts, we sought to find out what variables are most frequently impaired in children with DLD compared to the TD group. We hypothesize that, given the errors that children with DLD tend to make in oral language, we expect to find significantly more difficulties in this population compared to TD children in all areas of writing. Specifically, we expect to find more inflectional morpheme and verb conjugation errors, as well as a higher percentage of omitted functional words.

2 Materials and methods

This study was approved by the Universitat Oberta de Catalunya's (UOC) Ethics Committee. Furthermore, it was conducted in accordance with the ethical standards laid out in the 1964 Declaration of Helsinki and subsequent updates (WMA. World Medical Association, 2013).

2.1 Participants

This sample of children was a subsample of the study conducted by Ahufinger et al. (2021), which included 70 children (35 children with DLD and 35 typically developing (TD) children). The subset of children in this study included 52 participants (12 girls and 40 boys): 26 children had DLD (mean age in months = 128.85 (10.73 years); SD = 25.02; range: 95 to 188 months) and 26 were age-and sex-matched TD children (mean age in months = 124.61 (10.38 years); SD = 24.25; range: 90 to 184 months). All participants met the following inclusion criteria: (a) nonverbal intellectual quotient (NVIQ) > 75; (b) typical hearing at 500, 1000, 2000 and 4,000 Hz at 20 dB, in accordance with the American National Standard Institute (1997); (c) typical or corrected vision; (d) typical oral and speech motor abilities, as confirmed by a certified speech language pathologist; and (e) native Spanish-Catalan bilingual speakers as reported by parents. Children were excluded if parents reported (a) other biomedical conditions commonly linked to genetic or neurological causes, such as autism, intellectual disability, Down syndrome or Williams syndrome (Bishop et al., 2017); (b) frank neurological signs; or (c) seizure disorders or the use of medication to control seizures.

In 2017, children with DLD were identified with the help of the Catalan Center of Resources for Language-and Hearing-Impaired People (CREDA), members of the Catalan service for school counseling and guidance (EAP), and the Catalan Association of Specific Language Impairment (ATELCA), who work in conjunction with public and private schools throughout Catalonia to identify children with DLD or children with language difficulties. Children in the DLD group had a formal diagnosis of DLD or a suspected diagnosis and were in the process of being diagnosed, or were children whose families or teachers were concerned about language difficulties and/or were receiving speech–language services at the time of the original study per parental report. The TD children were recruited from public schools within the larger Barcelona metropolitan area. The TD children were at grade level in school, had no history, or diagnosis, of language learning disability, and had never received speech and language services.

To confirm each participant's language status, standardized tests were administered by two trained researchers at the time of the study. These were the non-verbal IQ (NVIQ) Kaufman Brief Intelligence Test (K-BIT; Kaufman and Kaufman, 2004) and the Clinical Evaluation of Language Fundamentals - Fourth Edition, Spanish (CELF-4 Spanish; Semel et al., 2006). In the latter case, the researchers evaluated and recorded the participants' Core Language Score, Expressive Language Score and/or Receptive Language Score. For the children with DLD, the CELF Core, Expressive or Receptive composite scores were at least 1.5 standard deviation below age-level expectations. For the children in the TD group, the CELF composite scores were all at or above age-level expectations. Each child with DLD was matched with a TD child of the same sex and age (+/− 3 months), as shown in Table 1.

Table 1 shows no significant age or NVIQ differences between the participants with DLD and their matched TD peers when the sample was selected. However, the children with DLD obtained significantly lower scores than the TD group on the three CELF language test scales.

In 2019, these children were invited to participate in the current study to examine and compare text writing abilities in the production of expository texts. All families were asked to sign a new consent form

TABLE 1 Age and standardized cognition and language measurement scores for the group of children with developmental language disorder (DLD) and the group of typical developing (TD) children.

	DLD (n = 26)			TD (n = 26)			Comparison	
Variable	Mean	SD	Range	Mean	SD	Range	t(50)	p
Age in months	128.85	25.02	95–188	124.61	24.25	90–184	0.62	$p = 0.54$
K-BIT mat (NVIQ)[a]	98.96	11.57	77-119	102.85	9.84	88–129	−1.30	$p = 0.20$
CELF-CLS[b]	73.50	10.62	45–89	108.58	8.32	95–130	−13.63	**p < 0.01**
CELF-ELS[c]	73.65	8.61	52–85	107.92	9.25	89–128	−13.82	**p < 0.01**
CELF-RLS[d]	78.27	10.05	59–97	104.77	7.98	90–122	−10.53	**p < 0.01**

For each variable, the scores by age have a mean of 100 and a standard deviation (SD) of 15 (except age in months). Significance p-values are shown in bold. NVIQ, non-verbal intelligence quotient.
[a]K-BIT mat = Kaufman Brief Intelligence Test, Spanish version: non-verbal intelligence quotient score (Kaufman and Kaufman, 2004).
[b]CELF-4 CLS = Spanish Clinical Evaluation of Language Fundamentals, Fourth Edition: Core Language Score (Semel et al., 2006).
[c]CELF-4 ELS = Spanish Clinical Evaluation of Language Fundamentals, Fourth Edition: Expressive Language Score (Semel et al., 2006).
[d]CELF-4 RLS = Spanish Clinical Evaluation of Language Fundamentals, Fourth Edition: Receptive Language Score (Semel et al., 2006).

following the IRB protocol from the Universitat Oberta de Catalunya (UOC).

2.2 Instruments and procedure

Children completed two testing sessions of approximately 60 min each. These sessions were part of a larger study examining reading and writing skills. In the first session, children completed a reading assessment. In the second session, children completed two brief oral morphological tasks first, and the writing test for the present study after. The time allocated to carry out the writing task was approximately 15/20 min per child. The evaluation sessions were carried out individually in the research laboratories of the Universitat Oberta de Catalunya and the Universitat de Barcelona by two research assistants trained for this purpose. All participants were administered the narration writing task from the Spanish Batería de Evaluación de los Procesos de Escritura (Writing Process Evaluation Battery – PROESC; Cuetos et al., 2018). The children had to write an expository text about their favorite animal. If they were unable to think of an animal, they were given suggestions such as cats, dogs or lions. The children were given unlimited time to write a one-page text explaining whatever they wanted to about the animal. The instructions on how to complete the task were given in Spanish, but the examiner explained to the children that they could write the text in the language they preferred. All the participants wrote the text in Spanish.

2.3 Coding

The children's texts were transcribed for analysis using the Codes for the Human Analysis of Transcripts (CHAT) program and were analyzed using the Child Language Data Exchange System (CHILDES) Project's Computerized Language Analysis (CLAN) program (MacWhinney, 2000). The following category system was created to study the transcribed data, drawing on Mackie et al. (2013) and Salas and Caravolas (2019):

2.3.1 Word frequency and sentence structure

- Total number of words (TNW): Total number of words written in the text.
- Number of different words (NDW): This index was used to score the lexical diversity of the vocabulary in the text. To prevent an effect caused by the length of the text, we calculated Guiraud's R index: types/$\sqrt{}$tokens (Guiraud, 1954).
- Main clauses ($MC): Total number of simple sentences the child has written as a proportion of the total number of sentences. A simple sentence is defined as a meaning unit that has a noun phrase, functioning as subject, and a verb phrase, functioning as predicate. Thus, it is a sentence expressing a single action, e.g., 'El gato come verdura' ('The cat eats vegetables').
- Coordinate clauses ($CC): Total number of coordinate sentences the child has written as a proportion of the total number of sentences. A coordinate sentence consists of two simple clauses, with equal syntactic importance, linked by a conjunction, e.g., 'El perro ladra y el gato maúlla' ('The dog barks and the cat meows').
- Subordinate clauses ($SC): Total number of subordinate sentences the child has written as a proportion of the total number of sentences. A subordinate sentence consists of a simple independent clause and at least one simple dependent clause. In subordinate sentences, dependent clauses do not make sense on their own; they need to be embedded in the independent clause to convey their meaning, e.g., 'El perro, que es mi animal favorito, come comida de perro' ('Dogs, which are my favorite animal, eat dog food').
- Total number of clauses (TNC): Total number of main, coordinate and subordinate clauses.
- Words per clause (WpC): This index is calculated by dividing the total number of words the child produces by the total number of clauses in the text.

2.3.2 Grammatical complexity and lexical density

- Number of adjectives ($NAj): Number of adjectives the child uses in the text.
- Number of adverbs ($NAv): Number of adverbs the child uses in the text.
- Number of connectors ($CO): Number of connectors the child uses in the text. Connectors include conjunctions, e.g., 'y', 'o' and 'también' ('and', 'or' and 'also'), and discourse markers, e.g., 'Primero de todo' and 'finalmente' ('first of all' and 'finally'). The purpose of linguistic connectors is to provide contextual meaning and clarity to the text by combining sentences and paragraphs.

2.3.3 Errors

- Spelling errors ($SE): Spelling errors in the children's texts are defined using the categories established by Matute et al. (2010).
- Omission errors ($SEo): Omitting a letter, syllable or segment from the word, e.g., writing 'hose' instead of 'horse'.
- Joining words ($SEw): Omitting the space between words, e.g., writing 'elcaballo' ('thehorse') instead of 'el caballo' ('the horse').
- Segmentation errors ($SEs): Dividing words incorrectly, e.g., writing 'con migo' ('to gether') instead of 'conmigo' ('together').
- Translocation errors ($SEt): Changing the letter or syllable order in a word, e.g., writing 'fuetne' ('soucre') instead of 'fuente ('source').
- Addition errors ($SEa): Adding a letter or syllable to a word, e.g., writing 'cominida' ('dininer') instead of 'comida' ('dinner').
- Phoneme substitution errors ($SEp): Substituting an unvoiced sound for a voiced sound, e.g., 'peso' ('weight') instead of 'beso' ('kiss'). An English example would be 'pear' instead of 'bear'.
- Articulatory substitution errors ($SEas): Natural spelling errors caused by substituting a consonant for another that has a close production point, e.g., 'cato' instead of 'gato' ('cat'), and/or a similar mode of articulation, e.g., 'mida' instead of 'mira' ('look'). An English example would be 'coal' instead of 'goal' for the first case and 'deal' instead of 'real' for the second.
- Arbitrary spelling errors ($SEar): Spelling errors related to spelling rules. In Spanish, these manifest as substitution errors between the letters /v,b/, /c,s,z/, /g,j/, /y,ll/ and /h,∅/., e.g., 'cantava' instead of 'cantaba' ('sang'). An English example would be 'liv' instead of 'live' or 'werked' instead of 'worked'.
- Accent errors ($SEc): Errors such as 'tenia' instead of 'tenía' (had).
- Code-switching ($CSE): Words written in Catalan instead of Spanish, e.g., 'gos' ('dog' in Catalan) instead of 'perro' ('dog' in Spanish).
- Word omissions ($WOM): Omission of nouns, verbs, articles, prepositions or pronouns that are required to understand the context of the expository text (including argument omissions and subject elisions), e.g., writing "es alto" ('is tall') instead of 'el caballo es alto' ('the horse is tall').
- Functional words errors ($WE): Errors in the use of articles, prepositions or pronouns.
- Errors in nominal inflectional morphemes ($EIM): Changing or omitting a word's gender inflection (feminine and masculine), e.g., writing 'el niña' ('girl' with masculine article 'el') instead of 'la niña' ('girl' with feminine article 'la'); or changing or omitting the nominal number inflection (singular and plural), e.g., 'los perro' (singular 'dog' with plural article 'los') instead of 'los perros' (plural 'dogs' with plural article 'los').
- Verb conjugation errors ($VCE): Verbal inflection errors made when conjugating regular and irregular verbs (errors of number, person or mode). This category also includes errors in gerund and participle use.
- Semantic errors ($SEE): These occur when the child writes one word instead of another, i.e., the child tries to activate a given concept but activates another in the same semantic category (González et al., 2008), e.g., writing 'gato' ('cat') instead of 'perro' ('dog'), or replacing a word with another semantically unrelated word, e.g., writing 'yo he abierto la puerta con la bolsa' ('I unlocked the door with the bag') instead of 'con la llave' ('with the key').
- Pragmatic errors ($PrE): This error is counted when the child uses literal expressions, writes oral expressions or uses a set phrase incorrectly, e.g., 'El animal te muerde y estás acabado' ('The animal bites you and you are done').

2.3.4 Other

- Language switch ($LS): An occasional use of Catalan to write the text. This category includes switching language for whole sentences, in which case the code is $LSS.
- Colloquialisms ($CW): Slang words, e.g., 'guay' ('cool') instead of "bueno" ('good'), 'mega' instead of 'muy' ('very') or 'chicha' (colloquial way to refer to 'meat' in Spanish) instead of 'carne' (meat).

2.3.5 Reliability

Approximately 30% of the written texts ($n = 16$) were randomly selected from the sample to test the reliability using Cohen's Kappa. Errors were coded by two independent reviewers. The reliability estimates for each writing measure are as follows: MC, 1; CC, 0.93; SC, 0.95; NAj, 0.89; NAv, 0.91; CO, 0.88; SE, 0.97; WOM, 0.92; WE, 0.70; EIM, 1; VCE, 0.82; SEE, 1; PrE, 1; LS, 1; LSS, 1; and CW, 1. If the two evaluators disagreed, they discussed the discrepancy until they reached an agreement. In the exceptional cases that no agreement was reached, the scores of the first author was used in the main analyses.

3 Results

3.1 Data analysis

Starting with the coding of the expository texts using the CHAT system and the subsequent analysis using CHILDES, we obtained the values of each category for each subject. To assess the differences between the groups, descriptive data for each variable were used, and a non-parametric analysis, specifically the Mann–Whitney U test, was conducted. This choice was made due to the sample size, as it does not follow a normal distribution (as determined by the Shapiro–Wilk test) and the heterogeneity of variances (as determined by Levene's test). The data is available online in https://n9.cl/0er91.

3.2 Word frequency and sentence structure

Table 2 shows the mean, standard deviation and differences between the two groups with respect to word frequency, lexical diversity and sentence structure. The difference between the DLD and TD groups was significant for four out of the seven variables (total number of words, number of different words, total number of clauses and subordinate clauses). Children with DLD wrote significantly fewer words and sentences than TD children. Also, children with DLD wrote texts with less lexical diversity and used a significantly lower proportion of subordinate clauses compared to TD children.

3.3 Grammatical complexity and lexical density

Table 3 shows the mean, standard deviation and differences between the two groups with regard to grammatical complexity and

TABLE 2 Mean and standard deviation (SD) of the word frequency and sentence structure variables for the Developmental Language Disorder (DLD) and Typically Developing (TD) groups.

Writing variables	Group					
	DLD (*n* = 26)		TD (*n* = 26)		Comparison	
	Mean	SD	Mean	SD	*z*	*p*
Total number of words	56.54	37.44	131.15	83.281	−3.63	**p < 0.01**
Number of different words (types/$\sqrt{}$tokens)	4.78	0.97	6	1.15	−3.56	**p < 0.01**
Total number of clauses	4.12	1.88	7	3,795	−3.33	**p < 0.01**
Main clauses (%)	40.94	27.99	30.73	25.15	−1.31	*p* = 0.19
Coordinate clauses (%)	39.43	28.84	29.12	18.54	−1.34	*p* = 0.18
Subordinate clauses (%)	19.63	22.69	40.14	26.75	−2.76	**p < 0.01**
Words per clause	9.81	3.54	12.53	4.72	−1.95	*p* = 0.051

Significance *p*-values are shown in bold.

TABLE 3 Mean and standard deviation (SD) of the grammatical complexity and lexical density variables for the Developmental Language Disorder (DLD) and Typically Developing (TD) groups.

Writing variables	Group					
	DLD (*n* = 26)		TD (*n* = 26)		Comparison	
	Mean	SD	Mean	SD	*z*	*p*
No. of adjectives	3.92	3.84	10.81	5.46	−2.77	**p < 0.01**
No. of adverbs	1.69	2.33	7.27	5.65	−4.50	**p < 0.01**
No. of connectors	3.63	2.73	8.62	7.16	−4.68	**p < 0.01**

Significance *p*-values are shown in bold.

lexical density. Using the nonparametric Mann–Whitney U test, significant differences between the DLD and TD groups were identified in all three variables. Children with DLD used significantly fewer adjectives, adverbs and connectors compared to TD children of the same age.

3.4 Errors

Table 4 shows the mean, standard deviation and differences between the two groups with regard to omissions and errors in their expository texts. Significant differences between the two groups were found in 5 out of the 7 variables. The DLD group made significantly more functional words, verb conjugation, nominal inflectional morpheme and spelling errors than the TD group. Children with DLD also omitted more words needed to understand the context of the text. A more detailed analysis was carried out for spelling errors. When the different categories of spelling errors were observed more closely, significant differences appeared between the two groups with respect to arbitrary spelling errors and articulatory spelling errors (z[2.309], $p < 0.05$ and z[3.105], $p < 0.01$, respectively). The children with DLD made significantly more arbitrary spelling errors (mean = 1.02, SD = 0.88) compared to the TD group (mean = 0.5, SD = 0.7). They also made significantly more articulatory spelling errors (mean = 0.81, SD = 1.34) compared to their TD peers (mean = 0.11, SD = 0.21; see Figure 1).

With regard to switching languages, the results revealed significant differences between the two groups (z[2.194], $p < 0.05$). The ratio of language switch per word is significantly higher in children with DLD (mean = 0.013, SD = 0.026) compared to TD children (mean = 0.001, SD = 0.003). No significant differences were observed between children with DLD and TD children (z[1.42], $p = 0.15$) in terms of language switches applied to whole sentences. There were also no significant differences between the two groups in the use of colloquialisms (z[0.487], $p = 0.648$).

4 Discussion

In this study we explored the Spanish writing abilities of a group of children with DLD in comparison to a group of sex-and age-matched TD children using a written expository text. We were particularly interested in analyzing the writing abilities of this oral-language-impaired population in Spanish. This language is characterized by simple phonological structure, transparent orthography, rich morphology and flexible word order like Spanish.

Building on previous research on English-speaking children with DLD, in this study we analyzed word omissions, inflectional morpheme errors and verb conjugation errors. The analysis showed that the ratio of word omissions, errors in inflectional morphemes marking gender or number, and verb conjugation errors were significantly higher in the texts written by children with DLD compared to TD children of the same chronological age. These results

TABLE 4 Mean and standard deviation (SD) of the omissions and errors variables for the Developmental Language Disorder (DLD) and Typically Developing (TD) groups.

Writing variables	Group					
	DLD (*n* = 26)		TD (*n* = 26)		Comparison	
	Mean	SD	Mean	SD	*z*	*p*
Spelling errors	0.20	0.13	0.11	0.09	−3.00	***p* < 0.01**
Word omissions	0.11	0.098	0.031	0.035	−3.97	***p* < 0.01**
Functional words errors	0.03	0.03	0.003	0.007	−3.51	***p* < 0.01**
Errors in nominal inflectional morphemes	0.013	0.017	0.003	0.007	−2.36	***p* < 0.05**
Verb conjugation errors	0.015	0.021	0.001	0.003	−2.78	***p* < 0.01**
Semantic errors	0.005	0.009	0.004	0.009	−0.178	*p* = 0.858
Pragmatic errors	0.007	0.014	0.001	0.005	−0.679	*p* = 0.497

Significance *p*-values are shown in bold.

FIGURE 1
Mean number of arbitrary spelling errors (arbitrary sp. err.), accent mark spelling errors (accent sp. err.) and articulatory spelling errors (natural sp. err) in children with Developmental Language Disorder (DLD) and Typically Developing (TD) children.

are similar to other studies, such as Mackie et al. (2013), Connelly et al. (2011) and Mackie and Dockrell (2004), who also found that children with DLD had trouble using gender inflectional morphemes, as well as plural (−s), past (−ed) and gerund (−ing) markers, in their writing. Another morphological measurement not reported in previous writing research but key among Spanish-speaking children with DLD are errors using functional words such as articles, prepositions and pronouns that are very frequent in oral language (Bedore and Leonard, 2001; Restrepo and Gutierrez-Clellen, 2001; Sanz-Torrent et al., 2008; Morgan et al., 2013; Coloma et al., 2016). In our study, the children with DLD produced texts with significantly more functional words errors compared to the TD group. All these errors are similar to those made by children with DLD when they express themselves orally, for example difficulties with verb morphology (i.e., No me gusta [:gustan] las avejas [:abejas] / I do not like [number error in Spanish] sheep [: bees]) and in the use of functional words, such as articles (i.e., …la [:las] leonas… / …the [sing.]: the [pl.] lioness…), prepositions (i.e., …pueden oir [:oír] [:a] distansias [:distancias]…/..They can hear [:from] distance) and pronouns (i.e., Mi [:la] raza de mi perro…/ my [:the] breed of my dog.). This clearly shows that such difficulties in oral language production also affect children with DLD's writing.

Spelling is one of the most impaired aspects of writing among English-speaking children with DLD when compared to TD children (Williams et al., 2013; Dockrell et al., 2014; Reilly et al., 2014). Our results showed that in Spanish, children with DLD also made significantly more spelling errors than their age-matched peers. A more specific analysis showed that they make significantly more articulatory and arbitrary spelling errors. These results are in line with previous research by Mackie and Dockrell (2004), who concluded that most spelling errors are due to letter substitution, insertion or elimination and letter combinations that do not comply with spelling rules. Although the research sample in Mackie and Dockrell (2004) were English-speaking children, their results are similar to ours. This means that children with DLD exhibit difficulties with phonological awareness whether they speak a language with shallow orthography or one with deep orthography.

Children with DLD performed worse in most of the other writing variables compared to their peers in the TD group. These results suggest that children with DLD had more difficulty writing longer texts, i.e., they wrote significantly fewer words and significantly fewer sentences than TD children. Texts by children with DLD were also structurally simpler, contained a significantly lower percentage of subordinate clauses and were not as lexically rich as those written by the TD group. These results track with previous studies done on English-speaking samples (Scott and Windsor, 2000; Puranik et al., 2006; Dockrell et al., 2014; Reilly et al., 2014), where children with DLD produced texts with significantly fewer words and a lower percentage of syntactic units. Our research found no significant differences between the two groups regarding mean sentence length. These results are consistent with Puranik et al. (2006), who found that, despite significant differences between children with DLD and children with TD in sentence production, mean sentence length does not vary significantly between the groups. However, these results contradict research by Mackie et al. (2013) and Scott and Windsor (2000), who found significant differences between the groups, with children with DLD producing fewer words per clause than their TD peers. Regarding clause types, no significant differences were found between the groups in terms of the percentage of simple and coordinate clauses used. There was, however, a difference when comparing the two groups for percentage of subordinate clauses. Proportionally, children with DLD used significantly fewer subordinate clauses than TD children, which indicates that their texts were simpler and less structurally complex. These results were also reported by Mackie and Dockrell (2004).

Along with structural characteristics, this study also evaluated the grammatical richness of the texts. The texts written by the children with DLD contained significantly fewer adjectives, adverbs and connectors (i.e., they were characterized by poor lexical density compared to the same-aged TD children). Another characteristic not analyzed in earlier research related to children with DLD's writing abilities is the role of pragmatic errors and semantic errors in written texts. We explored these characteristics and did not find significant differences between the DLD and TD groups in these areas.

Finally, we looked for code-switching in the written texts. This measurement was included because the children in our sample were bilingual, speaking both Catalan and Spanish. The results show that the ratio of language switch per word is significantly higher in children with DLD than in TD children, indicating a lack of consistency in language used while writing and supporting the idea that bilingual children with DLD code-switch more than TD children (Pert et al., 2004). This could also be explained as a difficulty in thinking of a word and using the same word in another language as a compensation mechanism. However, as regards oral language, both Gutiérrez-Clellen et al. (2009) and Sanz-Torrent et al. (2007) found that Spanish-English and Spanish-Catalan bilingual children with DLD, respectively, did not differ from age-matched control children in terms of code-switching. Future research might look more closely at code-switching in written texts by bilingual children to analyze the differences between oral and written language.

In summary, writing abilities of children with DLD in Spanish showed more morphology-related, spelling and other writing errors compared to their age-matched TD peers. These results highlight the limitations that children with DLD may face in school when instruction is based on written language, and how these can affect their academic performance.

5 Limitations and future directions

This is the first study to explore the characteristics of expository text production in Spanish by children with DLD. However, there are a few areas for future improvement. Although we aimed to recruit as many participants as possible, the final sample consisted of 52 children (26 with DLD and 26 TD children). This sample size aligns with prior studies on English (e.g., Mackie et al., 2013; Dockrell et al., 2014; Andreou and Aslanoglou, 2022; Brimo et al., 2023) and Spanish (Soriano-Ferrer and Contreras-González, 2012; Buil-Legaz et al., 2023) writing abilities in children with DLD. However, our study included participants ranging in age from 7;11 to 15;8 years, representing a diverse range of ages. In order to further enhance the generalizability and reliability of our findings, it is recommended for future studies to expand the sample size and include a more specific age range. By increasing the number of participants and narrowing down the age range, researchers can obtain a more comprehensive understanding of the topic at hand.

Our study centered on the production of expository texts, a common school activity that requires children to plan, translate, and revise. Although we primarily focused on microstructure, the task also allows for macrostructure analysis (global structure and coherence), a crucial factor in gaging the quality of children's written texts. This aspect could be examined in future studies. The expository text task is less controlled than other tasks like dictation, where evaluators can choose words with different spelling characteristics. When writing expository texts, children can use words they are familiar with, potentially resulting in fewer spelling errors as they may prefer words they can spell correctly. Additionally, even though we allowed unlimited time for children to write a one-page text, the length of their texts significantly varied. Future research should examine the microstructure abilities in children with DLD, and attempt to control the text length to yield a similar amount of information.

In conclusion, the findings from our study should be considered when planning and conducting activities with these children. We emphasize the value of using expository text writing in assessing children with DLD. It is a simple, quick method that yields substantial information about their language and writing skills. Additionally, it would be insightful to examine the effectiveness of interventions targeting oral language issues on improving writing impairments, and vice versa.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://n9.cl/0er91.

Ethics statement

The studies involving humans were approved by the Universitat Oberta de Catalunya's (UOC) Ethics Committee. Furthermore, it was conducted in accordance with the ethical standards laid out in the 1964 Declaration of Helsinki and subsequent updates (WMA. World Medical Association, 2013). 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

RB-C: Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. NA: Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. MS-T: Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. LA: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, 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.

Publisher's note

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Longitudinal profiles of late phonological development in children with Williams syndrome

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Williams syndrome (WS) is a genetic neurodevelopmental disorder characterized by language skills above what is expected considering non-verbal intelligence. Research on phonological development is scarce, with many studies focusing on grammar in children and adolescents. In one of our previous studies transversally explored the profiles of late phonological development in Spanish-speaking WS children, adolescents, and adults, while our objective is to longitudinally determine these profiles for WS children based on present error indexes in spontaneous speech. Participants were seven WS children (aged 3;7–8;2), engaging in two spontaneous conversations within a 6-month interval. They were compared cross-sectionally with 240 typically developing (TD) children aged 3–6 years, divided into six groups. All speech samples were transcribed and analyzed with the CLAN software package of the CHILDES Project. Phonological profiles were established on the basis of phonological error indexes obtained dividing absolute frequency of errors by the total number of words produced. WS children showed a mean reduction of more than 25% in the absolute frequency of phonological errors after 6 months. As for the comparison with the normative groups, their error index was consistent with the stage of expansion in TD, however, after 6 months, this was consistent with the stage of stabilization. This atypical acceleration in phonological development could be related to lexical growth in the context of relative preservation of phonological memory. Furthermore, the trajectories of late phonological development in WS children might not be linear, as postulated by neuroconstructivist models, suggesting the need for intervention approaches specifically adapted to the phonological profiles of WS children.

KEYWORDS

Williams syndrome, phonological profiles, spontaneous speech, atypical language development, neurodevelopmental disorder

1 Introduction

Williams Syndrome (WS) is a multisystem neurodevelopmental disorder caused by a heterozygous deletion on chromosome 7q11.23 (Pérez-Jurado, 2003), whose prevalence according to the most cited epidemiological study, is estimated at 1 in 7,500 births (Strømme et al., 2002), with no sex difference, racial or ethnic predilection (Morris et al., 2020). The WS physical phenotype includes distinctive and easily recognizable facial features, cardiovascular anomalies, endocrine-metabolic alterations, hoarse voice, and sound sensitivities (hyperacusis, odynacusis, auditory allodynia, and auditory fascinations) (Kozel et al., 2021). Individuals with WS show a specific neurocognitive profile

characterized by a complex pattern of strengths and weaknesses (Karmiloff-Smith et al., 2003b; Vicari et al., 2004; Mervis and John, 2010; Hocking et al., 2015; Wuang and Tsai, 2017; Miezah et al., 2021) and they may show mild-to-moderate intellectual disability (Bellugi et al., 2000; Mervis et al., 2000). In general, deficits in visuospatial construction skills constitute a specific weakness (Mervis et al., 2000; Brown et al., 2003; Farran and Jarrold, 2003; Van der Geest et al., 2005; Porter and Coltheart, 2006), whereas auditory processing and face recognition are strengths in the WS profile (D'Souza et al., 2015; Miezah et al., 2021).

Earlier studies described language as selectively preserved and dissociated from other cognitive functions (Bellugi et al., 1988, 1994, 2000). Further research highlighted that superior verbal skills reported in individuals with WS may be explained in terms of asynchronous trajectories of development, with verbal abilities increasing more rapidly than non-verbal abilities (Jarrold et al., 2001). This asymmetric profile of WS would not be explained as the product of a cluster of damaged or preserved static modules, but as the emergent result of the dynamic processes of development where genes, the brain, cognition, behavior, and the environment interact multidirectionally throughout the life span (Karmiloff-Smith et al., 2003a; Karmiloff-Smith, 2009).

In general, pragmatic abilities have been described as an area of relative weakness in individuals with WS, arising both in narrative and conversational settings (Stojanovik, 2006; Diez-Itza et al., 2018, 2022). In contrast, structural components of language, i.e., phonology, morphosyntax, and vocabulary, have been considered relative strengths. From a preservation perspective, the results of different studies on morphological skills in WS were interpreted in terms of a typically functioning system with some impaired components (Clahsen and Almazan, 1998; Clahsen et al., 2004; Penke and Krause, 2004). However, more recent studies suggest a certain degree of atypical morphological processing (Benítez-Burraco et al., 2017; Diez-Itza et al., 2017, 2019). Several studies have pointed out that grammatical ability is strongly correlated with expressive vocabulary size (Vicari et al., 2002; Volterra et al., 2003).

Regarding lexical acquisition, several studies have emphasized that young children with WS follow an atypical pattern. Unlike typically developing (TD), children with WS produce their first words before understanding or producing protodeclarative gestures (Mervis and Bertrand, 1997) or produce them in smaller quantities even while producing referential language (Laing et al., 2002). It is also known that adolescents and adults have a vocabulary which is extensive and sometimes unusual for their age with an atypical pattern of semantic categorization (Purser et al., 2010). However, the initial stages of development are not clearly indicative of these results.

The idea of good phonological skills in individuals with WS has been mainly consolidated from studies on phonological short-term memory by using word repetition and pseudoword tasks, suggesting that they may depend more on phonology than semantic information (Grant et al., 1997; Majerus et al., 2003), probably because of a semantic-phonological mismatch (Thomas and Karmiloff-Smith, 2003). Nonetheless, very few studies have focused on assessing this level. In this sense, the results of direct studies of production by using articulation test show that these skills are not fully preserved and that difficulties persist into adolescence and adulthood (Hidalgo, 2019; Hidalgo and Garayzábal, 2019; Huffman, 2019).

A recent cross-sectional study explored phonological development profiles across late stages in Spanish-speaking children, adolescents, and adults with WS based on the analysis of phonological processes in spontaneous speech samples when compared to two TD groups. The results showed atypical and complex trajectories, from the expansion of the system (around 3 years of age) for the children group to its resolution (around 5 years of age) for the adolescent and adult group, which cannot be described as simply delayed or protracted (Pérez et al., 2022). Nevertheless, in late phonological development, individuals with WS reach more advanced stages than other neurodevelopmental disorders, such as Williams duplication syndrome, Smith-Magenis syndrome, Down syndrome, and Fragile X syndrome (Mervis et al., 2015; Huelmo et al., 2017; Hidalgo and Garayzábal, 2019; Diez-Itza et al., 2021).

Regarding phonological development in TD, three late stages have been described using a methodological approach based on the analysis of spontaneous speech corpora in Spanish-speaking children aged 3–5 (Diez-Itza et al., 2001; Diez-Itza and Martínez, 2004; Martínez, 2010). The results showed a reduction of the frequency of errors and changes in their relative distribution as age increased, suggesting a first stage of expansion (age 3), an intermediate stage of stabilization (age 4), and a final stage of resolution (age 5). Within the same theoretical framework, the present study aimed to further advance in a detailed description of longitudinal phonological development in children with WS.

1.1 Objectives

The main goal of this study was to determine the longitudinal profile of phonological development in a group of Spanish-speaking children with WS in order to find out changes across developmental stages and discover whether specific features would be exhibited. The profiles were based on the analysis of five error types (Syllable Structure, Segmental Substitution, Segmental Omission, Assimilation, Segmental Addition) in spontaneous speech. The frequency and percentage distribution of phonological error index were calculated for each of the two assessments. It was hypothesized that children with WS presented a lower frequency of errors from the first to the second assessment times, this reduction affecting differently in quantitative and qualitative terms. A second hypothesis was that phonological development in WS follows the stages of typical development (i.e., expansion, stabilization, and resolution) and that phonological patterns not only show quantitative differences (interpretable as "delayed") but also, taking into account the error types, atypical characteristics (interpretable as "disordered").

2 Method

2.1 Participants

The participants were seven individuals with WS, previously diagnosed by the molecular genetic test fluorescence *in situ*

hybridization system and presenting the characteristic physical phenotype. In addition, all participants had associated intellectual disability. The group with WS consisted of three boys and four girls (chronological age: $M = 5.9$; range: 3;07–8;02; verbal age: $M = 3.6$; range: 2;05–5;02). All participants were monolingual Spanish speakers, belonging to urban middle-class families, and attending mainstream schools ($n = 7$), and whose families provided informed consent to participate in the study. Verbal age was obtained from the Peabody Picture Vocabulary Test (Dunn et al., 2010).

The normative group consisted of 240 TD Spanish-speaking preschoolers [part of Martínez, 2010 study] aged 3–6 years divided into six groups based on chronological age and with 40 children in each group (20 girls and 20 boys): 3;0 TD: chronological age: $M = 3.2$; range: 3;00−3;05, 3;6 TD: chronological age: $M = 3.9$; range: 3;06–3;11), 4;0 TD: chronological age: $M = 4.2$; range: 4;00–4;05, 4;6 TD: chronological age: $M = 4.9$; range: 4;06–4;11, 5;0 TD: chronological age: $M = 5.2$; range: 5;00–5;05), 5;6 TD: chronological age: $M = 5.8$; range: 5;06–5;11. These children had no history of language disorder and were enrolled in regular schools distributed in the central area of Asturias (Spain).

2.2 Instruments and procedure

The RETAMHE methodology, -short for Recording, Transcription, and Analysis of Spontaneous Speech Samples (Diez-Itza, 1992; Diez-Itza et al., 1999) was used to obtain the spontaneous speech samples, which were collected via audio-visual recordings of dyadic conversations between each participant and a researcher, with an estimated duration of 45 min in natural settings, and which are part of larger corpora within the Syndroling Project (Diez-Itza et al., 2014). Individuals from the WS group were recorded in two sessions spaced 6 months apart. These conversations were transcribed in CHAT (Codes for the Human Analysis of Transcripts) format and analyzed with the FREQ program, one of the CLAN (Computerized Language Analysis) software programs, both provided by the CHILDES Project (MacWhinney, 2000). Each transcription was completed by a trained researcher and reviewed by two other researchers independently. Difficulties detected were analyzed jointly by the three investigators and discrepancies were resolved by the principal investigator.

The phonological errors were analyzed and classified into one of the following types: Syllable Structure (SYS), Segmental Substitution (SBT), Segmental Omission (OMI), Assimilation (ASM), and Segmental Addition (ADD). The following example illustrates the transcription and coding procedure according to the minCHAT format of the CHILDES Project:

*CHI: nombe [*] [: name].
%err: **nombe = nombre $PHO:SYS:CCR;**

2.3 Data analysis

Once the transcriptions were coded, the frequency of lexical variables was obtained using the FREQ program, that is, the total number of words produced ("tokens") by each participant, as well as the count of different words ("types") in each transcription. Next, the frequency of the classes of phonological errors encoded was obtained with the same program. In order to control for variability in the size of the spontaneous speech samples, a Phonological Error Index (PEI) was calculated to indicate the frequency of errors. This index is obtained dividing the absolute frequency of errors by the total number of words produced (tokens) per 100. In addition, the Relative Frequency (RF) was calculated, i.e., the percentage distribution of phonological errors by classes. To calculate the RF, participants in each group who did not present phonological errors in the classes or subclasses analyzed were eliminated.

Intra-group differences in PEI and RF regarding both the total number of errors and error types between the two assessment times were analyzed using the Wilcoxon-signed-rank test for dependent samples.

Additionally, the effect size was calculated by Cohen's d using G*Power 3.1 statistical software. The d values are typically quantified as small (0.2), medium (0.5), and large (0.8) (Cohen, 1988). In turn, the differences between groups by chronological age groups in total PEI and by error types, and RF were analyzed using the Kruskal-Wallis nonparametric test adjusted with the Bonferroni correction (expressed with the H value) for independent samples, given that the distributions did not always approach normality according to the Shapiro-Wilk test. Spearman correlation was used to analyze the bivariate relationships between chronological age, verbal age, and PEI.

Statistical analysis of the data was performed using SPSS software (Statistical Product and Service Solutions IBM SPSS Statistics 25.0).

3 Results

3.1 Intra-group differences in phonological error index and relative frequency

A strong positive correlation was found between chronological age and verbal age ($rs = 0.94$; $p = 0.002$) in the WS group. The PEI was negatively correlated with chronological age in the first assessment ($rs = -0.74$; $p = 0.058$) and in the second assessment ($rs = -0.72$; $p = 0.068$). Furthermore, PEI correlated negatively with verbal age at the first assessment ($rs = -0.71$; $p = 0.071$) and at the second assessment ($rs = -0.64$; $p = 0.012$). However, a strong positive correlation was found between the PEI at both assessments ($rs = 0.857$; $p = 0.01$).

Table 1 reports the PEI for the WS group in the first and the second assessment, including means for total errors and each class of errors. WS children showed a mean reduction of more than 25% in the absolute frequency of phonological errors after 6 months, although this difference failed to be statistically significant. Wilcoxon comparisons showed statistically significant differences between both assessments only for SYS errors ($p = 0.018$), with a large effect size and with this type of error leading the decrease up to almost 40%. In the OMI and ASM error types there was also a decrease of 28 and 44% respectively, although no statistical differences were observed, with a medium effect size. An increase in segmental SBT and ADD errors was observed in the second

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TABLE 1 Phonological error index (total and error types) means and standard deviations for WS group in the first and the second assessment times, Wilcoxon test, and effect size.

	WS1	WS2			
	PEI-M (SD)	PEI-M (SD)	*Z*	*p*	*d*
TOT	22.00 (18.162)	16.19 (18.006)	−1.690	0.091	0.742
SYS	13.25 (9.611)	8.131 (8.732)	−2.366	0.018	1.529
SBT	3.91 (3.886)	4.35 (54.202)	−0.169	0.866	0.130
OMI	3.22 (3.485)	2.37 (2.934)	−1.183	0.237	0.437
ASM	0.95 (1.158)	0.53 (0.543)	−0.734	0.463	0.541
ADD	0.25 (0.207)	0.44 (0.391)	−1.014	0.310	0.487

PEI-M, phonological index mean; TOT, total phonological processes index; SYS, syllable structure; SBT, substitution; OMI, omission; ASM, assimilation; ADD, addition; d, Cohen's effect size.

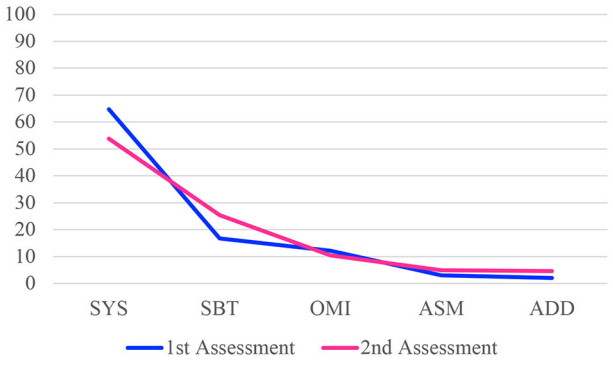

FIGURE 1
Profile of relative frequency of error types for WS group in the first and the second assessment. SYS, syllable structure; SBT, substitution; OMI, omission; ASM, assimilation; ADD, addition.

assessment although these differences were not statistical either, with a small and medium effect size, respectively.

The compared profiles of RF, i.e., the percentage distribution, for error types are shown for the WS group between the first and the second assessment times (Figure 1). At both times, the most frequent error types were those affecting SYS and segmental SBT. Nevertheless, the profile was different, since in the case of SYS a tendency to a reduction in the percentage from the first to the second assessments was observed, whereas in the case of SBT an increase from 16 to 25% was observed, also this difference being statistically significant ($Z = -2.197$; $p = 0.02$; $d = 1.15$). There was also a trend toward a reduction in the percentage of OMI errors and an increase in ASM and ADD errors. However, the Wilcoxon test did not yield statistically significant differences: SYS ($Z = -1.690$; $p = 0.09$; $d = 0.86$); OMI ($Z = -0.845$; $p = 0.39$; $d = 0.22$); ASM ($Z = -0.734$; $p = 0.46$; $d = 0.37$); ADD ($Z = -1.690$; $p = 0.09$; $d = 0.82$).

3.2 Inter-group differences in phonological error index and relative frequency in the first assessment

The Kruskal-Wallis test was applied to analyze whether there were differences between the WS and TD age subgroups in the Total phonological error index and by error types in the first assessment.

Significant differences were observed for all variables: PEI ($H = 80.17$; $p < 0.001$); SYS ($H = 78.80$; $p < 0.01$); SBT ($H = 67.43$; $p < 0.001$); OMI ($H = 36.21$; $p < 0.001$); ASM (H = 34.08; $p < 0.001$); ADD ($H = 34.08$; $p = 0.001$). Taking into account age group and after applying the Bonferroni correction, the test specifically showed that there were statistically significant differences between the WS and TD 3;6 years ($H = 59.52$; $p = 0.042$), 4;0 years ($H = 77.05$; $p = 0.008$), 4;6 years ($H = 90.42$; $p = 0.002$), 5; years ($H = 119.15$; $p = 0.001$), and 5;6 years ($H = 142.67$; $p < 0.001$) in the total PEI. In the case of error types, it was observed that in SYS there were also statistically significant differences between WS and TD 3;6 years ($H = 69.09$; $p = 0.018$), 4;0 years ($H = 87.82$; $p = 0.003$), 4;6 years ($H = 97.47$; $p = 0.001$), 5;0 years ($H = 128.29$; $p < 0.001$) and 5;6 years ($H = 146.04$; $p < 0.001$). For SBT these differences were observed at 4;6 years ($H = 70.80$; $p = 0.015$), at 5;0 years ($H = 101.55$; $p = 0.001$), and at 5;6 years ($H = 108.07$; $p = 0.001$). Regarding OMI, differences were observed between the WS with the group of 3;6 years ($H = 60.57$; $p = 0.034$), 4;0 years ($H = 88.60$; $p = 0.002$), 4;6 years ($H = 88.72$; $p = 0.002$), 5;0 years ($H = 78.37$; $p = 0.006$), and 5;6 years ($H = 124.42$; $p < 0.001$). Concerning ASM, these differences were found at 5;0 years ($H = 63.08$; $p = 0.028$) and 5;6 years ($H = 67.65$; $p = 0.018$), and for ADI also at 5;0 years ($H = 66.93$; $p = 0.048$) and 5;6 years ($H = 67.93$; $p = 0.019$).

To assess differences in relative frequency of phonological error index by types (Figure 2), the Kruskal-Wallis test was also applied. Statistically significant differences were only observed in terms of relative frequency for segmental OM between the WS and TD 4;0 years ($H = 66.21$; $p = 0.020$), 4;6 years ($H = 63.65$; $p = 0.026$), and 5;6 years ($H = 72.80$; $p = 0.005$).

3.3 Inter-group differences in phonological error index and relative frequency in the second assessment

The Kruskal-Wallis test was applied to analyze whether there were differences between the WS and TD age subgroups for the Total phonological error index and by error types in the second assessment. Significant differences were observed in the variables: PEI ($H = 73.91$; $p < 0.001$); SYS ($H = 71.63$; $p < 0.001$); SBT ($H = 65.07$; $p < 0.001$); OMI ($H = 31.78$; $p < 0.001$); ASM ($H = 35.96$; $p < 0.001$); ADD ($H = 23.57$; $p = 0.001$). Focusing on age group and after applying the Bonferroni correction, the test specifically showed that there were only statistically significant differences between WS and TD 5;0 years ($H = 88.42$; $p = 0.005$) and 5;6 years ($H = 106.21$; $p < 0.001$) in the total PEI. As for error types, statistically significant differences were observed for SYS and TD 5;0 years ($H = 85.86$; $p = 0.003$), and 5;6 years ($H = 103.96$; $p < 0.001$), for SBT and TD 4;6 years ($H = 57.27$; $p = 0.05$), 5;0 years ($H = 88.25$; $p = 0.003$), and 5;6 years (H = 104.60; $p < 0.001$), in OMI

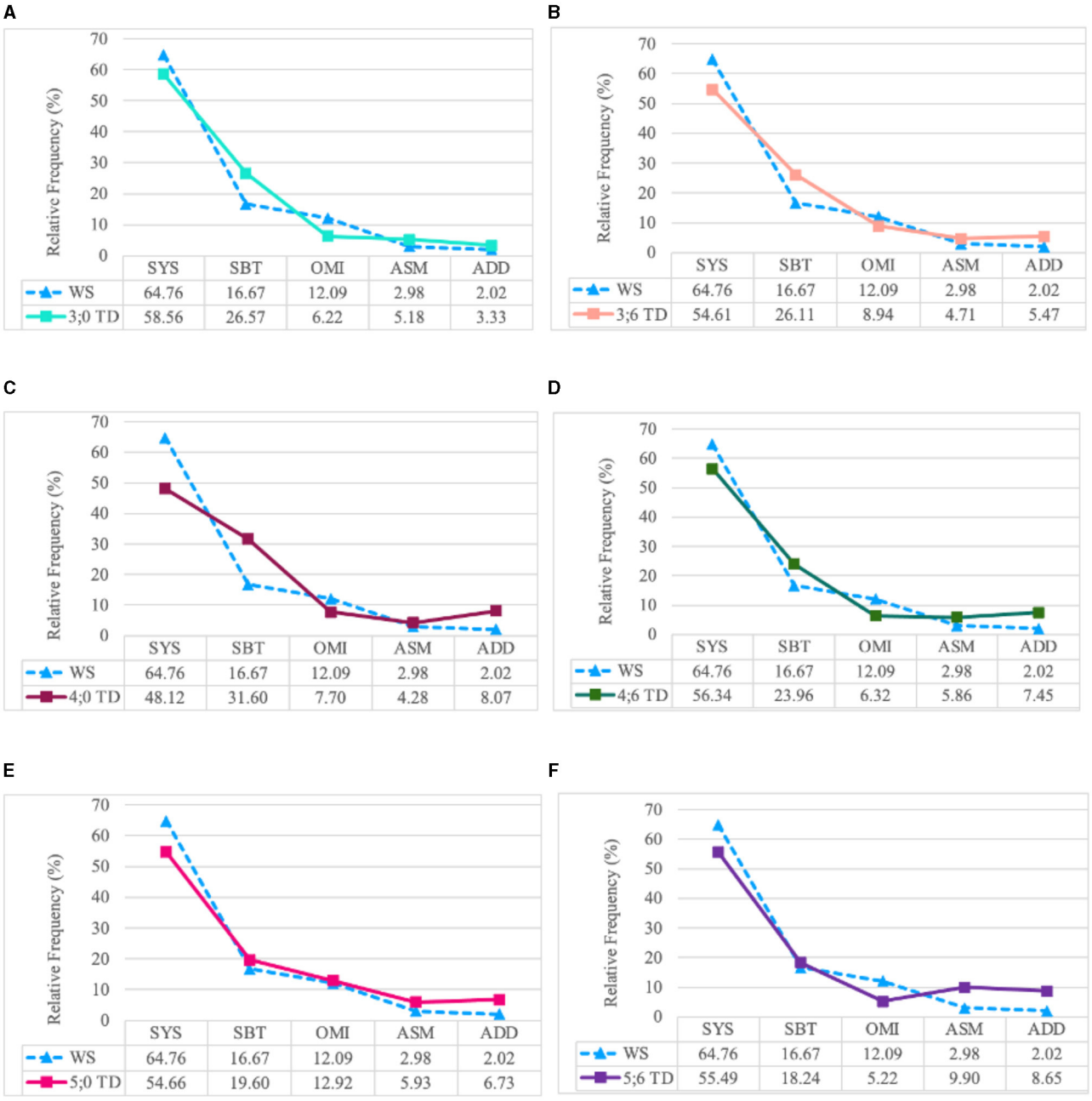

FIGURE 2
Profiles of relative frequency of phonological error index by types for WS group and TD age groups in first assessment. SYS, syllable structure; SBT, substitution; OMI, omission; ASM, assimilation; ADD, addition. **(A)** Profiles of WS and 3;0 TD group. **(B)** Profiles of WS and 3;6 TD group. **(C)** Profiles of WS and 4;0 TD group. **(D)** Profiles of WS and 4;6 TD group. **(E)** Profiles of WS and 5;0 TD group. **(F)** Profiles of WS and 5;6 TD group.

and TD 4;0 years ($H = 65.68$; $p = 0.021$), 4;6 years ($H = 65.79$; $p = 0.021$), and 5;6 years ($H = 101.52$; $p < 0.001$), in ASM and TD 5;0 years ($H = 73.39$; $p = 0.011$) and 5;6 years ($H = 78.02$; $p = 0.007$), and in ADD and TD 4;0 years ($H = 56.92$; $p = 0.049$), 4;6 years ($H = 61.85$; $p = 0.032$), 5;0 years ($H = 69.92$; $p = 0.015$), and 5;6 years ($H = 80.77$; $p = 0.005$).

To assess differences in relative frequency of phonological error index by types (Figure 3), the Kruskal-Wallis test was also applied. Statistically significant differences were only observed in terms of relative frequency in segmental Omissions between the WS group and the 5;6 TD group ($H = 66.45$; $p = 0.020$).

4 Discussion

The purpose of this study was to determine the longitudinal profile of phonological development in a group of Spanish-speaking WS children in order to find out changes across developmental stages and whether specific features would be exhibited. Profiles were based on five error types (Syllable Structure, Segmental Substitution, Segmental Omission, Assimilation, Segmental Addition) in spontaneous speech, calculating their PEI (frequency of errors/100 tokens) and their RF (percentage distribution) for each of both assessments within

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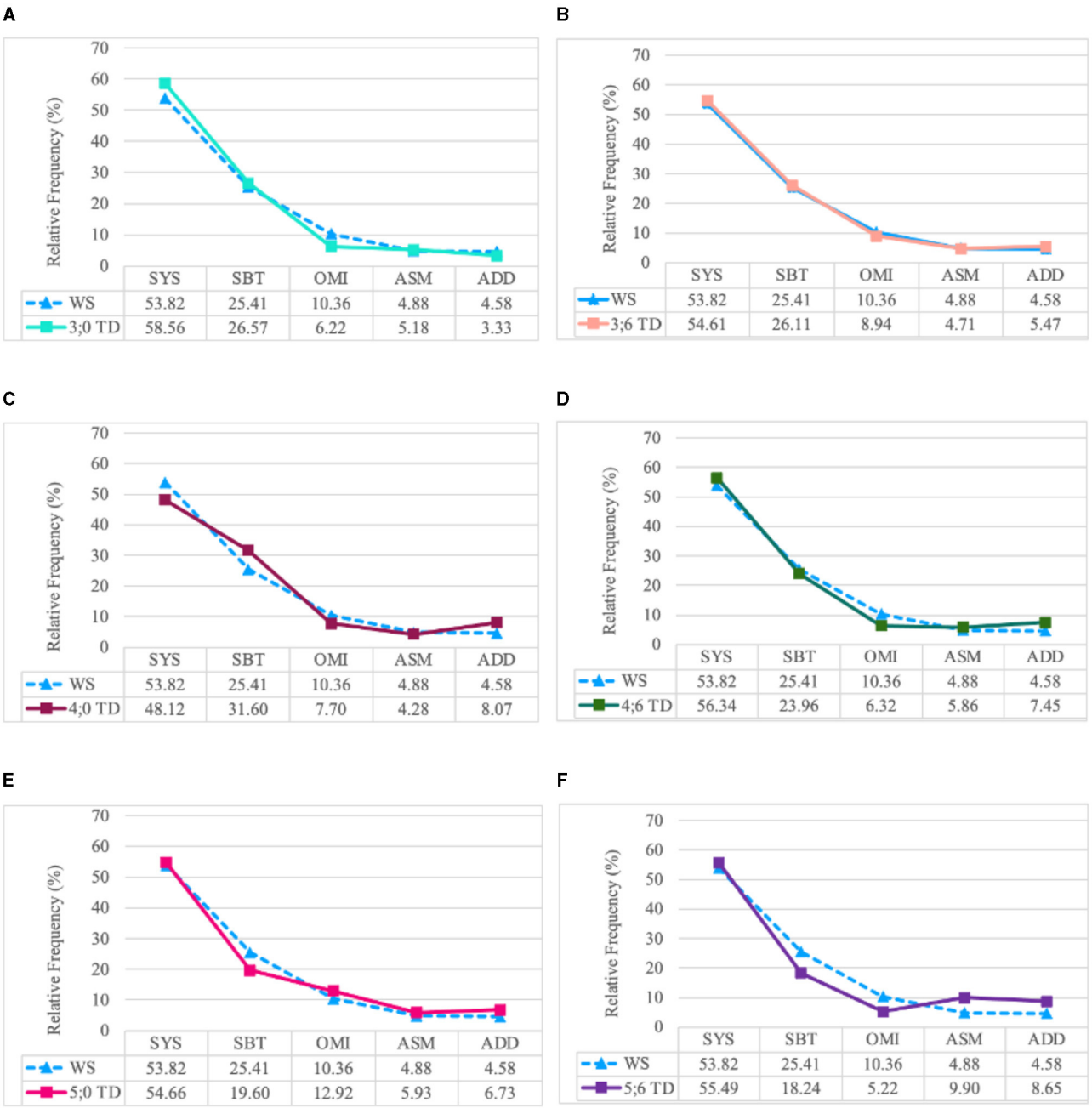

FIGURE 3
Profiles of relative frequency of phonological error index by types for WS group and TD age groups in second assessment. SYS, syllable structure; SBT, substitution; OMI, omission; ASM, assimilation; ADD, addition. **(A)** Profiles of WS and 3;0 TD group. **(B)** Profiles of WS and 3;6 TD group. **(C)** Profiles of WS and 4;0 TD group. **(D)** Profiles of WS and 4;6 TD group. **(E)** Profiles of WS and 5;0 TD group. **(F)** Profiles of WS and 5;6 TD group.

a 6-month interval. To determine if phonological development in WS followed the stages of typical development (i.e., expansion, stabilization, and resolution) and if they presented specific characteristics, not only quantitative differences (interpretable as delayed) but also atypical characteristics (interpretable as disordered), they were also compared with the profiles of TD preschool children of similar verbal age.

Our results showed that, although as chronological and verbal ages of WS children increased, the PEI decreased, but this reduction was not statistically significant for neither assessment. Taking into account that phonological development in TD children culminates at the age of 7 years (Bosch-Galcerán, 2004), this lack of significance between chronological age and PEI could be explained by age differences, as there were two children aged 3 and 4 years and other two over 7 years of age.

WS children showing a high frequency of phonological errors in terms of PEI in the first assessment were those who continued to present greater PEI in the second one. However, the PEI was reduced by 25% within a 6-month interval, indicating that late phonological development was in progress. The tendency for

phonological errors to markedly decrease over chronological age in WS children suggests that accelerated phonological development occurs, which is consistent with findings previously reported by Martínez et al. (2014) in two WS children. This accelerated rate of phonological development over a 6-month interval would compensate for the delay in language onset, which has been linked to delayed babbling (Masataka, 2001) and auditory-visual integration difficulties observed in young WS children and in other neurodevelopmental syndromes (D'Souza et al., 2015). Despite the PEI reduction in WS children within a 6-month interval, phonological development does not seem to culminate at these ages since WS adolescents and adults, as occurs in other neurodevelopmental disorders such as Down syndrome, Fragile X syndrome, or Smith-Magenis syndrome, continue to manifest phonological difficulties (Huelmo et al., 2017; Hidalgo and Garayzábal, 2019; Diez-Itza et al., 2021; Pérez et al., 2022).

Taking into account the error types, it was observed that WS children showed a higher frequency in SYS followed by SBT in both assessments, which is consistent with previous research in English-speaking WS children and adolescents (Huffman, 2019) and in Spanish-speaking WS children, adolescents, and adults (Hidalgo and Garayzábal, 2019; Pérez et al., 2022). This tendency has also been observed for TD (Bosch-Galcerán, 2004; Martínez, 2010) and in other neurodevelopmental genetic disorders (Barnes et al., 2009; Huelmo et al., 2017; Hidalgo and Garayzábal, 2019; Diez-Itza et al., 2021). Nevertheless, only for errors affecting SYS was a significant reduction observed after 6 months, since SBT segmental errors increased in frequency in the second assessment, a pattern also observed in TD at around 4 years of age (Diez-Itza and Martínez, 2004). It was also observed that the frequency of OMI and ASM segmental errors decreased in the second assessment. However, it was found that OMI errors continued to present a high frequency in WS adolescents and adults (Pérez et al., 2022). In the case of ASM errors, it has been observed that they were still present at ages 6 and 7 in WS (Hidalgo and Garayzábal, 2019), although with a lower incidence. The same occurs in TD (Martínez and Diez-Itza, 2012) where ASM errors have been considered representative of the late phonology of Spanish with a significant percentage at 7 years old (Bosch-Galcerán, 2004).

As for the profile of relative frequency of error types in the first and second assessment, it was observed that, as in absolute terms, the most frequent errors were those of SYS, STB, OMI, ASM, and ADD and this was similar to that observed in TD children of similar verbal age (Martínez, 2010) and DS children and adolescents in spontaneous speech (Diez-Itza et al., 2021). However, the intersections between the relative frequency profiles in WS children might suggest that the trajectories from the first to the second assessment was toward reducing the proportion of SYS and OMI and increasing the proportion of SBT, ASM and ADD errors, although only in the case of SBT this increase was statistically significant. This would suggest that in the second assessment there was a reconversion of the phonological system in relation to SBT segmental errors similar to that observed at the age of 4;6 years for TD (Diez-Itza and Martínez, 2004; Martínez, 2010).

When comparing WS children in the first assessment with the age groups of the normative group, it was observed that WS presented higher PEI than every normative group, except for the 3;0 TD group. These results would indicate that initially their phonological error index was analogous to that of the expansion stage, corresponding to ages 3;0–3;6 in TD. However, 6 months later, the frequency of the error index was significantly reduced and could be equated with the 4;6 year-old group, thus consistent with the stage of stabilization (ages 4;0–4;6 in TD), therefore showing an accelerated phonological development as previous studies had suggested (Martínez et al., 2014). There appeared to be dynamic development over the 6-month interval as WS children moved from one stage to another. Such atypical acceleration might be related to lexical growth, given the close relationship between lexical and phonological development, and their relatively preserved phonological memory (Majerus et al., 2003; Mervis et al., 2004; Stoel-Gammon, 2011), which would show the interdependence of the processes as well as the dynamic nature of linguistic development (Mareschal et al., 2007).

Concerning error types, the developmental pattern was different in both assessments. Thus, while WS children moved from the expansion stage to stabilization for SYS errors, showing a strongly accelerated growth rate of the phonological system, in the case of SBT, ASM, and ADD errors these children would be in the stabilization stage whereas for OMI segmental errors they would be in the expansion stage, although a reduction in their phonological index was observed in the 6-month interval. This contrast in evolution would suggest a slowdown in the growth rate of the phonological system of WS children, which could be interpreted in terms of delayed phonological acquisition (Pérez et al., 2022).

The study of the relative frequencies of error types showed that in the first assessment the profile was not comparable to that of children aged 3;0 because its frequency is higher for all types. However, in the second assessment the profile overlaps with that of children aged 3;6 years. In relative terms, these WS children would be in the expansion stage at both times although there would be certain progress in their phonological development. On the other hand, the high relative frequency of OMI at both assessment times may be considered atypical and specific to WS since TD children aged 4;0 years no longer produce this type of error with only between 20 and 30% of children showing absence of multiple vibrating/r/(Bosch-Galcerán, 2004; Diez-Itza et al., 2005). This was confirmed in our previous study where children, adolescents and adults showed a high frequency of vowel omission and liquid consonant omissions compared to the 5-year-old TD normative group therefore suggesting a deviant developmental trajectory (Pérez et al., 2022).

In conclusion, the results of the present study seem to confirm that the frequency of phonological errors in WS children decreases over a 6-month interval, showing an atypical acceleration. Moreover, the trajectories of late phonological development in WS children may not be linear, but dynamic as postulated by neuroconstructivist models since in a short period of time they move from the expansion stage (age 3) to the stabilization stage (age 4), perhaps favored by its interrelation with other components at different levels such as the lexicon (Mervis et al., 2004; Stoel-Gammon, 2011). Although the results are not conclusive on delayed *vs.* disordered phonological profiles, highly increased frequency of errors at the two time points assessed asynchronous

with verbal age, suggests atypical developmental trajectories of phonological development in the WS children. The description of the detailed longitudinal phonological profile results in a better understanding of the syndrome as well as improved effectiveness of assessments and speech therapy intervention.

The shortcomings of this study stem mainly from the absence of controlled individual differences that could explain significant percentages of the variance observed in WS children. A larger number of participants would have been necessary to minimize these differences and make comparisons by age groups in WS. However, this is a small-scale exploratory study and confidence in the conclusions drawn from the results is reinforced by the large effect size for total errors and for errors affecting SYS. Further study would be necessary to assess the specific features and errors for each of the five types studied.

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 study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Oviedo for studies involving humans (Approval code 6_RRI_2022 and Approval date 05/10/2022). 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. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

Author contributions

VM: Conceptualization, Data curation, Formal analysis, Investigation, Supervision, Writing – original draft, Writing – review & editing, Methodology. VP: Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Investigation. MAA: Investigation, Methodology, Writing – review & editing. MM: Investigation, Methodology, Writing – review & editing. PV: Data curation, Investigation, 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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Multimodal input in the foreign language classroom: the use of hand gesture to teach morphology in L2 Spanish

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Many studies describe the benefits of morphological awareness in reading comprehension in both first and second languages. In turn, several studies demonstrate the positive impact of multimodal input while learning. In this study, we looked for a relationship between multimodal input, gesture in particular, and the development of morphological awareness in L2 Spanish. An experiment was carried out with 38 students of L2 Spanish, aged between 14 and 16, from a secondary school in the UK. The experiment consisted of a pretest and a posttest of morphological awareness mediating three sessions of training. During the training sessions, the participants were divided into 4 groups with different input modalities: audiovisual, audiovisual with text enhancement, audiovisual-gestural and control. Participants worked on a series of words with a morphemic component through the visualization of videos. The experiment provided significant results in terms of learning from pre- to post-test in one of the groups, the audiovisual-gestural group. Hence, we conclude that, in the short term, this type of training might have a positive impact on the development of morphological awareness.

KEYWORDS

multimodal input, morphological awareness, gesture, foreign language learning, L2 Spanish

1 Introduction

The present study explores the relationship between morphological awareness (MA) and multimodality in the foreign language classroom. Morphological awareness has been defined as learners' conscious awareness of the morphemic structure of words and the ability to manipulate this structure (Carlisle, 2000). Unlike morphological knowledge (i.e., the ability to comprehend and produce morphologically complex words), morphological awareness is the metalinguistic ability to manipulate word formation rules (Kuo and Anderson, 2006). Several studies point out that MA impacts on the comprehension of complex words and, therefore, on reading comprehension (Carlisle, 2000, 2003) and written production (García and González, 2006; Sánchez-Gutiérrez et al., 2020).

Given the impact of MA on the successful development of reading skills, recent research has highlighted the benefits of MA training both among L1 and L2 learners in a number of different languages. For instance, Lyster et al. (2016) evaluated the short- and long-term effect of morphological training in Norwegian preschool children and found evidence of improvement in reading comprehension test scores both 1 year and 6 years after the training. In a study on MA among Italian monolinguals and Arabic-Italian bilinguals, Vernice and Pagliarini (2018)

concluded that working on MA explicitly at school provides significant improvements in reading comprehension, but that we cannot assume that MA is automatically transferred from L1 to L2, nor that in an L2, even if introduced early, the development MA will be implicit. In the context of Korean learners (L1) learning English (L2), Kim (2019) concluded that it was MA work that contributed to the improvement of reading comprehension and vocabulary knowledge in L2 English for these Korean learners. Kieffer and Lesaux (2008) presented a similar situation with Spanish (L1).

speakers learning English (L2). This study concluded that MA at the derivational level was an important factor in the development of reading skills, and that it was from age 10 onwards that a clear and increasing correspondence between MA and reading comprehension was developed.

Thus, the empirical evidence available so far seems to agree on two aspects: on the one hand, we cannot assume implicit learning of the complexities of the morphological system in any language, regardless of its level of transparency or morphological complexity (Carlisle and Goodwin, 2013; Vernice and Pagliarini, 2018). On the other hand, studies carried out so far show a benefit in explicit MA training, especially in early stages of language learning (Kieffer and Lesaux, 2008; Lyster et al., 2016; Sánchez-Gutiérrez et al., 2020).

Regarding multimodality, the second factor under exploration in the present study, since Paivio's (1991) proposal of the Dual Coding Theory, the advantages of multimodal input have been highlighed in a number of studies. For instance, previous literature has shown the benefits of multimodal input for the acquisition of new phonological categories (Hazan et al., 2006; Ter Schure et al., 2016). Other studies have also pointed to the benefits of multimodal or audiovisual input for word learning in a second language (e.g., Bird and Williams, 2002; Peters and Webb, 2018; Montero-Perez, 2020) or even the development of L2 grammar (Pattemore and Muñoz, 2020).

A particular form of multimodal input that has been described to facilitate communication and processing is the combination of language (oral input) and the so-called co-speech gesture (visual information). In their seminal paper on the use of gesture in the mathematics classes, Goldin-Meadow et al. (1999) drew attention to how teachers recurrently and unconsciously used gestures to present problem-solving strategies and, most importantly, that students not only noticed those gestures but also benefited from them during and after class.

Since then, many different studies have highlighted the importance of visual information (i.e., gesture) in conveying a message through conversation, the high perceptual sensitivity that speakers exhibit towards gesture when it accompanies speech, and the way speech and gesture complement each other (McNeill, 2005; Bernardis and Gentilucci, 2006; Drijvers and Özyürek, 2017; Crimon et al., 2022; Feijoo et al., 2023). Esteve-Gibert (2016) emphasized the relevance of the integration between gesture and speech and how, as early as 9 months of age, infants are able to perceive alterations in the synchronicity between the two. In a similar line, Igualada et al. (2017) showed the benefits of using non-verbal language to convey linguistic information to preschool children, and the capacity that children have to remember words that were given prominence with gestures during a storytelling session.

A number of different studies have also identified advantages in the use of gesture among L2 language learners. For instance, Andrä et al. (2020), carried out a study on the influence of gestures and pictures on L2 vocabulary learning among 8-year-old children. They found that both the gesture and the picture group outperformed the control group and that the improvement of the picture and gesture group persisted six months after the training. These results contrasted with previous experiments (Mayer et al., 2015; Repetto et al., 2017) done with adults that showed a significant difference in the benefits of gesturing over imagery. Macedonia (2014) also showed that gesturing when learning vocabulary benefited foreign language learners.

While several studies point out the benefits of using gesture to teach L2 vocabulary, there is still no evidence that gesture can also be useful to teach foreign language morphology. Thus, the present pilot study aims at testing whether the use of multimodal elements in general, and of gestures in particular, improves the training of morphological awareness among English learners of Spanish as a foreign language.

2 Method

2.1 Participants

A total of 38 participants (14 male, 24 female) took part in our pilot study. They ranged in age from 14 to 16 years ($M = 15$; SD = 0.83). All students attended the same school, an Independent School located in the West Midlands, England. The language of instruction at the school was English, and 33 of the participants were also L1 English speakers. The other 5 participants were English-Chinese or English-Turkish ballanced bilinguals. All the participants showed native-like proficiency in English. They were all learners of Spanish as a foreign language and had an A2 proficiency level in Spanish at the time of the experiment. Their regular Modern Foreign Language courses included traditional instruction based on memorization of basic syntactic structures in Spanish. None of the participants had received previous explicit instruction in morphological awareness before the beginning of this study, neither in their L1 nor in their L2. The sample population was randomly divided into 4 groups: a control group (10 participants) and 3 groups (two of 10 participants and one of 8) defined by the different sensory stimuli to which they were exposed in the training phase. All participants signed an informed consent form and agreed to participate in the experiment.

2.2 Instruments

In the present study, participants were assessed on their level of morphological awareness before and after three training sessions. The morphological awareness test (which served both as pre- and post-test) was created as an adaptation from previous existing tests: the MA test (Carlisle, 2000), the IECMO test (González-Sánchez et al., 2018), and the IECME test (García and González, 2006). As suggested by Goodwin et al. (2011), three assumptions were considered when adapting our MA measurement tools for native speakers of English: first, older learners perform better than younger learners; second, more proficient L2 learners outperform lower-proficiency learners; third, items that are less morphologically transparent or that include orthographic, phonological, or morphological modifications consistently present greater difficulties.

Our adapted test had two subtests: a derivation subtest (16 items) and a decomposition test (15 items). In the derivation subtest,

participants were given a morphologically simple word and were told to complete a sentence with a morphologically complex word derived from it. For the decomposition test, participants were given a morphologically complex word and they were told to complete a sentence with a morphologically simple word derived from it. Following Kuo and Anderson (2006), our test items included both inflectional and derivational morphology. The MA test is provided as Supplementary material.

Our final MA test had a total of 31 items, equivalent to a total of 62 points: 0 points were given for totally incorrect answers, 2 points were given for totally correct answers, and 1 point was given when the right morpheme was chosen but it was misspelled. The 31 test items included 14 words and 17 pseudowords. Following Carlisle (2000), pseudowords were used in the test in order to avoid that the limited vocabulary available to the participants could alter their decisions, that is, that they chose an answer motivated by their familiarity with a word instead of using their morphological strategies.

As for the training material, it consisted of videos which contained 16 morphologically complex words each. They were all Spanish words and no pseudowords were used at training. The types of morphemes involved in the training were similar to those in the test. There were three videos for each group (i.e., three training sessions per group) and a total of four different groups in different experimental conditions. The total of 48 trained words were identical in each group and condition. The four experimental groups at training varied according to the following different input conditions (Figure 1):

- Group A (control): words appeared at an interval of 10 s each, with no visual or acoustic cue to morpheme boundaries.
- Group B (audiovisual input): words appeared at an interval of 10 s each. Synchronized with each word, its recorded oral pronunciation was given with a short pause between the root and the morpheme.
- Group C (auditory and visual-gestural input): words appeared at an interval of 10 s each. Synchronized with each word, its recorded oral pronunciation was given with a short pause between the root and the morpheme while a hand gesture appeared on the slide marking the morphemic boundary.
- Group D (audiovisual input, with visual enhancement): words were shown at an interval of 10 s each. Synchronized with each word, its recorded oral pronunciation was given with a short pause between the root and the morpheme, while the morpheme of each word was highlighted with another color. This condition was included in order to discard the possibility that participants in group C only would outperform the rest simply because their input was visually more enhanced than the input in all the other conditions: if participants in group C outperform participants in group D, then we can be sure that it was gesture, and not simply visual enhancement, what triggered improvement in MA among participants.

2.3 Procedure

This experiment sought to evaluate the development of morphological awareness as a dependent variable from pre- to post-test after 3 training sessions in four different input conditions. The experiment was carried out over a period of 1 week, in the students' own classrooms. The tests were administered by the students' Spanish teacher, who was previously instructed on the variables and each of the steps to be followed. Participants were assigned one of the four different input conditions randomly through blind assignment.

As mentioned earlier, the experiment consisted of three phases: the pre-test, the training and the post-test. On the first day, participants took 30 min to complete the pre-test all together in their classroom.

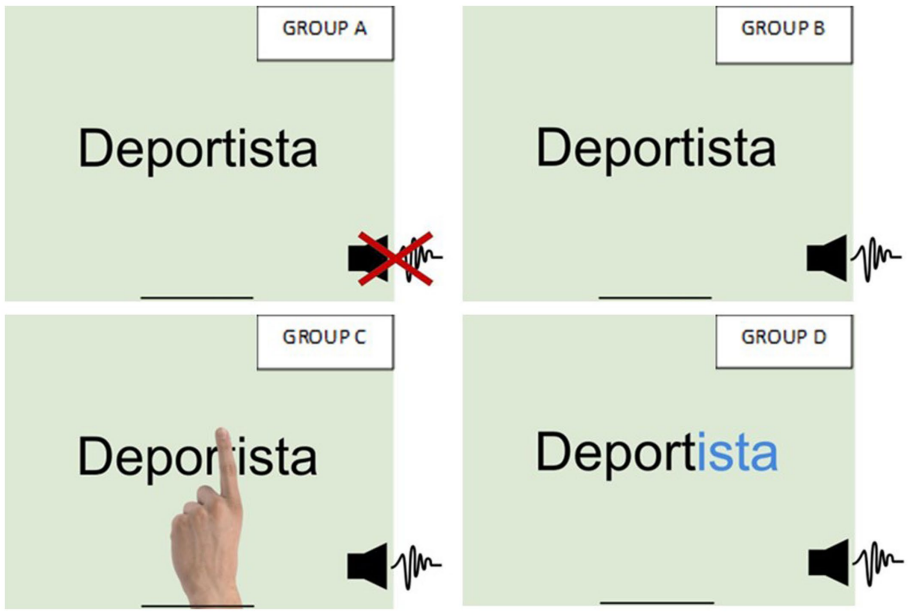

FIGURE 1
Example of training materials for the four training conditions.

Then, the training phase was spread over a week in which, on three different days, participants were exposed to one of the vocabulary videos per day. Each participant was sent a different link depending on the group to which they were assigned, and they viewed the videos in their own tablets with headphones. The input modality of each video was consistent with the group each participant was assigned to. Each video was about 3 min long. The third phase consisted on the participants' taking the post-test, which would serve to compare participants' development after the training. The procedure was the same as that carried out during the pre-test. The post-test was carried out after viewing the third training video, in the same session.

3 Results

Table 1 presents the mean scores in the two subtests of morphological awareness for each training group.

A mixed-design repeated measures ANOVA was performed to compare the effect of input modality on total morphological awareness (i.e., derivation plus decomposition) from pre- to post-test (Figure 2). There was a statistically significant effect of time (F (1, 34) = 10.27, p = 0.003, η^2 = 0.232), but not of condition (F (3, 34) = 1.246, p = 0.308, $\eta 2$ = 0.091) or the interaction between time and condition or input type (F (3, 34) = 1.19, p = 0.327, η^2 = 0.095). A more detailed analysis (Duncan *post hoc* contrast) showed that differences were found in the gesture group alone, from pre-test (M = 34.4; SD = 8.57) to post-test (M = 41.1; SD = 8.39), with a statistically significant difference (p = 0.027, d = 0.814).

We further explored whether there were differences between groups in the results of each subtest separately (i.e., derivation and decomposition). For the derivation subtest, a mixed-design repeated measures ANOVA with time (pre- and post-test) as within-subject factor and input type as between-subject factor showed no significant effect of time (F (1, 34) = 2.002, p = 0.166, η^2 = 0.056), nor of input type (F (3, 34) = 0.926, p = 0.439, $\eta 2$ = 0.079) or the interaction of time and input type (F (3, 34) = 0.907, p = 0.448, η^2 = 0.074). For the decomposition subtest, an equivalent ANOVA showed again no main effect for input type (F (3, 34) = 1.313, p = 0.286, $\eta 2$ = 0.091), although there was a significant effect of time (F (1, 34) = 13.09, p < 0.001, η^2 = 0.278) and the interaction between time and input type (F (3, 34) = 2.95, p = 0.046, η^2 = 0.207) (Figure 3).

A more detailed analysis (Duncan *post hoc* contrast) showed that differences were found between the learning gains from pre- to post-test in the gesture group (M = 4.7; SD = 3.23) in comparison with the audiovisual group (M = 0.87; SD = 3.87), with a statistically significant difference (p = 0.036, d = 1.085), as well as with the visual enhancement group (M = 0.21; SD = 3.61), also with a statistically significant difference (p = 0.009, d = 1.312).

4 Discussion

The present study aimed at exploring the influence that different input modalities and, specifically, gestural training, could have on the acquisition of morphological awareness (MA) in the learning of Spanish as a foreign language. The analysis of the data obtained provided no significant results as far as input type or condition is concerned. Thus, we cannot claim that the gesture group outperformed the other groups after the training.

A possible reason for the lack of significant differences between the gesture group and the other groups might have been the length of the treatment, since only three training sessions that lasted for 3 min each might not be enough for the benefits of gesture to emerge. Several other studies also claim that, in order for language development to occur, it is crucial that L2 learners have access to a considerable amount of input (Konishi et al., 2014; Matusevych et al., 2017). Indeed, previous studies that showed an advantage of gesture over other forms of input (i.e., Goldin-Meadow et al., 1999; Andrä et al., 2020) included longer training and larger exposure to gesture among their particiants. Thus, greater amount of exposure to multimodal gestural input might add to the efficacy of gesture as a teaching method for the foreign language classroom. While the exploratory nature of the present study could not confirm this, further research could provide stronger evidence.

Furthermore, from a psycholinguistic perspective, the limitations of the present study do not allow a deep analysis of the participants' processing of the trained items across the different experimental conditions. Thus, the present data provide little evidence as to how exactly different participants approached the trained words. It might be the case that some participants put more cognitive effort than others to work out the decomposition rules of the trained items. Previous studies on textual enhancement (e.g., Winke, 2013; Loewen and Inceoglu, 2016; Leow and Martin, 2018) have shown increased attention on the target L2 items among participants in enhanced input conditions, yet more noticing did not lead to better learning of the target items among those participants. According to Leow et al. (2019), this might be due to participants' low-level processing of the trained items. A replication of the present study using eye-tracking methodology might shed some light on the above-mentioned processing issues and the depth at which participants at different input type conditions analyse the trained items.

Despite the fact that the gesture group did not outperform the other experimental groups after training, a statistically significant main effect of time indicated improvement from pre- to post-test among the gesture group, while no such effect was found in the other conditions. Thus, the use of gesture might have a potentially beneficial effect for the development of morphological awareness in a second language, if provided more intensively. A future study with a larger

TABLE 1 Descriptive statistics of pre- and post-tests for the four training conditions.

		Derivation		Decomposition	
Condition	N	Pre-test *M* (SD)	Post-test *M* (SD)	Pre-test *M* (SD)	Post-test *M* (SD)
Control	10	22.2 (4.26)	21.2 (6.81)	9.4 (6.55)	12.4 (6.89)
Audiovisual	8	22.25 (2.71)	23.5 (4.86)	11.62 (5.85)	12.5 (4.62)
Gesture	10	22.8 (5.09)	24.8 (4.82)	11.6 (5.31)	16.3 (4.78)
Visual	10	23.6 (4.88)	26 (4.42)	14.7 (4.11)	14.9 (3.57)

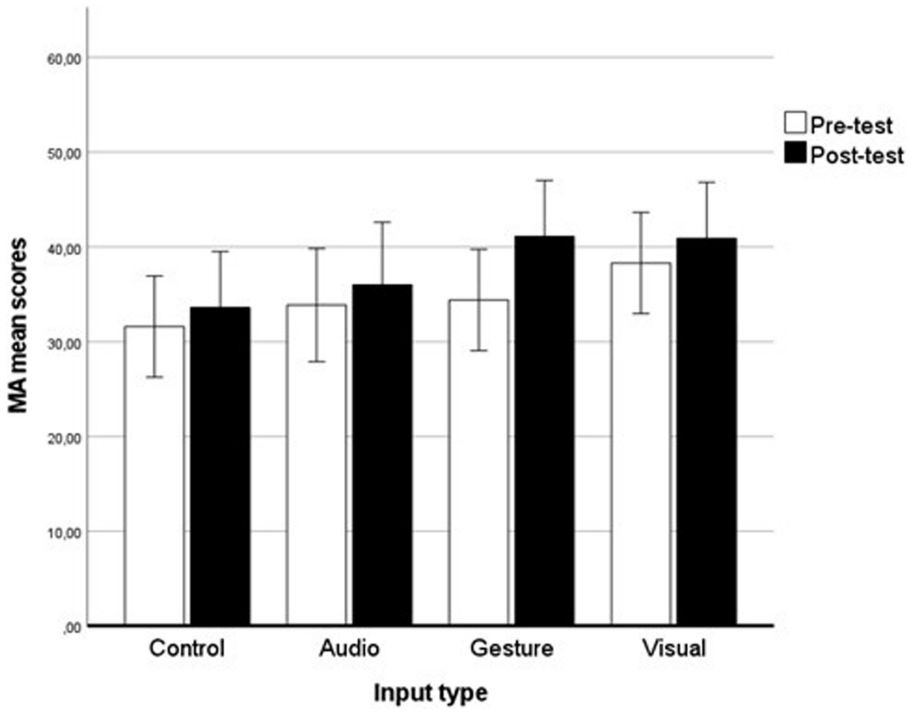

FIGURE 2
Mean total scores of MA (derivation and decomposition) across training conditions.

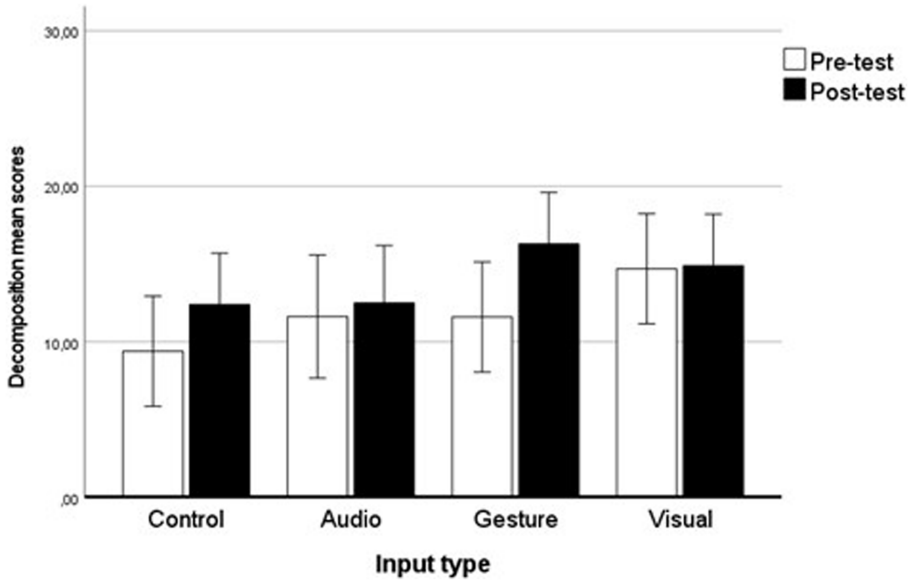

FIGURE 3
Mean scores of decomposition subtest across training conditions.

sample and a longer and more intensive training might confirm this tendency.

Further analyses on both MA subcomponents (i.e., derivation and decomposition) also found no main effect for input type, nor time or the interaction between time and input type in the case of derivation. Descriptive statistics revealed relatively high scores among the four groups of participants in the derivation pre-test already, leading to little room for improvement at post-test scores. Providing accurate measures of our dependent variable was one of the challenges of the present study, since all previous existing tests to measure morphological awareness in Spanish are meant for L1 speakers (García and González, 2006; González-Sánchez et al., 2018) and were not appropriate for L2 speakers with low proficiency level. Thus, we call for the need to create a more suitable tool to measure morphological

awareness in L2 Spanish, perhaps using items with a lower morphological transparency index or with greater orthographic modifications (Goodwin et al., 2011), which would probably eliminate the possible ceiling effects of our present adapted test. Another possible explanation for these high scores in the derivation pre-test might lie in the participants' level of MA in their L1, and the possibility of transfer from L1 to L2. Unfortunately, participants' MA in their L1 was not measured in the present study. Further research should consider MA in the L1 alongside MA in the L2 and confirm this.

Regarding the decomposition subtest, our data showed an advantage of the gesture group over the audiovisual and the visually-enhanced group in terms of decomposition. Thus, the gesture group appeared to outperform these other two groups in terms of MA gains after training. However, no such difference was found between the gesture group and the control condition. One of the possible reasons for these unexpected results might lie in the low scores that the control group obtained in the decomposition pre-test, which gave them bigger chances for improvement at post-test. While descriptive data did not reveal any potential outlier among this group, the overall pre-test mean of the group was relatively lower than that obtained by the other groups. Unfortunately, these data were collected still under post-pandemic restrictions and the researchers had no direct access to participants at the pre-test session. Even if the class teacher was given detailed information regarding the test procedure, it might have been the case that some of the participants did not understand the decomposition task at first and became better at it later. If this study were to be replicated, we would suggest providing clearer instructions to participants on the task as well as some practice items at the beginning. This should help participants become familiar with the task and it would also strengthen the validity of the test. Furthermore, as mentioned earlier, a bigger sample should allow the removal of potential outliers for a better analysis.

Further research should also explore the role of L2 proficiency level on the development of morphological awareness after training, since lower or higher proficiency learners might benefit differently from the training of this skill. Additionally, as mentioned earlier, given that morphological awareness in the L1 might not be necessarily transferred directly to the L2 (Vernice and Pagliarini, 2018), future studies should consider participants' morphological awareness in their L1 to find out whether the ability to transfer this linguistic skill to the L2 would be determined by the participants' level of proficiency in the second language, by the level of morphological awareness in their L1 (Saiegh-Haddad and Geva, 2007), or by a combination of both factors.

5 Conclusion

The present study points out towards a potential positive effect of the use of gesture as a working tool for the development of morphological awareness in a second language. With this study, new issues have arisen about the work of morphological awareness in Spanish as a foreign language in particular, and in L2 learning in general. The exploratory nature of this pilot study did not allow for a full confimation of the benefits of gesture for the training of morphological awareness. However, given the tendency of improvement shown in the data, we call for the need of further research to explore the role of gesture in morphological training. Further studies with a bigger sample and improved measurement tools should allow to confirm the impact of gesture on MA development. Furthermore, the addition of delayed post-test in the design would also provide evidence of the lasting effects of the use of gesture for language instruction.

Data availability statement

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

Ethics statement

Ethical approval was not required for the study involving human samples 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

SF: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. MA: Investigation, Methodology, Writing – original draft.

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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.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2024.1370898/full#supplementary-material

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Visual attention and phonological processing in children with developmental language disorder

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Introduction: Developmental Language Disorder (DLD) is a neurobiological condition characterized by insufficient language and communication development, with no underlying physical, sensory, or cognitive explanations. A prominent feature among children with DLD is their struggle with phonological processing, a pivotal skill for later reading proficiency. Recent research suggests that children with DLD may also exhibit impairments in various non-linguistic cognitive abilities, including memory, attention, and perception. Of particular importance is visual attention, which plays a critical role in integrating visual perceptual information with diverse cognitive and linguistic processes.

Objective: To characterize visual attention during phonological processing tasks in Colombian children with DLD.

Methodology: This study employed a cross-sectional descriptive experimental design involving 20 children diagnosed with Developmental Language Disorder (DLD) and 20 children without language difficulties. All participants underwent language, vocabulary, and phonological awareness tests. Additionally, an experimental task utilizing the eye-tracking method was designed and administered to measure phonological processing with phonological and lexical distractors.

Results: Children with DLD exhibited diminished performance on phonological awareness tasks, as evidenced by their lower scores. This was further supported by the experimental phonological processing task, where an interference effect was observed in the presence of lexical distractors for word recognition, but not with phonological distractors.

Conclusion: Children with DLD demonstrated deficiencies in both phonological awareness and visual attention skills during linguistic and phonological processing tasks. They also exhibit reduced sensitivity in identifying phonological relations such as rhyme. The study discusses these findings along with their clinical implications, emphasizing the importance of assessing online processing abilities in children with DLD and considering the influence of other cognitive abilities on their linguistic performance.

KEYWORDS

developmental language disorder, phonological awareness, visual attention, eyetracking, phonological processing

1 Introduction

Developmental Language Disorder (DLD) is a neurodevelopmental disorder that begins in early childhood and often persists into adulthood. Children with DLD have significant difficulties learning, understanding, and using spoken language. DLD is one of the most common neurodevelopmental disorders, with an approximate prevalence of 7% (Norbury et al., 2016).

DLD is characterized by poor language development without a physical, sensory, or cognitive explanation (Leonard, 2014). The main difficulties of this pathology are found in the language component, coexisting with alterations in the phonological domain (Catts and Kamhi, 2005) and in the semantic lexical organization (Sheng and McGregor, 2010).

Although the primary and almost exclusive difficulty in DLD is specifically linguistic in nature, recent studies have found that children with this diagnosis also have non-linguistic problems, such as difficulties in rhythmic and musical processing (Guarnera et al., 2013; Przybylski et al., 2013), executive functioning (Pauls and Archibald, 2016), behavior (Özcebeet et al., 2020), and deficits in visual-attentional skills (Dispaldro et al., 2013). Although the nature of DLD is still unclear, Ullman and Pierpont's (2005) thesis on procedural deficits in DLD opens an interesting avenue of research, as it hypothesizes an abnormal development of interconnected brain structures involved in learning and executing motor and cognitive skills, which could explain the variability of performance in children with DLD in different cognitive functions beyond language. This suggests, as described by Kapa and Plante (2015) that general domain deficits could cause the language difficulties observed in children with DLD.

Visual attention is one such function that is particularly relevant in DLD due to its intrinsic relationship with reading, where it is essential for word processing. It is currently known that there is a high comorbidity between language and reading disorders, with more than 50% of children with DLD having dyslexia and vice versa (Marshall et al., 2010). While attributing causality from one factor to the other is a matter of debate (McCardle et al., 2001; Catts and Kamhi, 2005), it has been suggested that phonological processing and visual attention may be affected in both conditions (Ehrhorn et al., 2021). Several theories of dyslexia and DLD suggest that, for example, phonological deficits of various types, when present in both disorders, play a key role in this overlap (Messaoud-Galusi and Marshall, 2010), recently demonstrating how language difficulties affect reading and the mediating role of phonological awareness (Catts and Kamhi, 2005).

Phonological awareness in children with DLD has been extensively studied across languages, but little is known about visuo-attentional performance in these children. Dispaldro and Corradi (2015) found that performance on visual attention tasks was significantly different from that of controls, suggesting that visuo-attentional processing may enable phonological processing. Other research has helped to clarify the role of visual attention in this population, as it is a skill that appears to be a critical component of working memory (Wais et al., 2012; Henry and Botting, 2017). For example, Finneran et al. (2009) found that children with DLD were slower than controls on visuospatial orientation tasks and less accurate on visual and auditory sustained attention tasks. Montgomery (2008) describes both anatomical-brain and behavioral differences in visual and auditory attention in children with DLD compared to their peers, with attentional processing being a critical component in DLD (Finneran et al., 2009).

The present study aims to characterize visual attention during phonological processing tasks in children with DLD, which, according to hypotheses on the causality of DLD, may have general domain limitations that cause the difficulties observed in the linguistic component (Kapa and Plante, 2015). As described by Dispaldro and Corradi (2015), these general domain difficulties lead to inadequate information processing with both linguistic and non-linguistic stimuli.

The approach of assessing by observing eye movements is emerging as an online research method that allows for the investigation of visuo-attentional and phonological processing (Bellocchi et al., 2013). Previous work, such as that of Desroches et al. (2006), suggests that the assessment of phonological processing using eye tracking is promising, based on the hypothesis that eye movements are linked to lexical processing, so that fixations on a target over time reflect the lexical activation of a word. These authors observed that eye movements in auditory word recognition are altered when the task involves knowledge of suprasegmental language skills (rhymes). These findings are at odds with conventional assessment and suggest that approaches and methods of assessment play a fundamental role in the study of phonological, visual, and auditory processing.

Considering that some research has proposed that visual processing seems to play an important initial role that precedes and enables phonological processing (Sargiani et al., 2015), and given that it is clear that DLD is associated with a deficit in phonological processing; the present study aims to identify the performance of visual attention in a task involving phonological processing in children with DLD in a transparent orthographic language such as Spanish, as measured by eye-tracking, in order to identify how children with DLD process this type of information.

2 Methodology

2.1 Participants

This cross-sectional correlational study involved 40 Colombian Spanish-speaking children aged 4–8. The study group consisted of 20 children with DLD, while the control group included 20 children without language difficulties. All participants attended school. To ensure similarity, the control group was selected to match the study group in terms of age and gender, resulting in a ratio of 15 boys to 5 girls in both groups. The sociodemographic data of the participants are shown in Table 1.

TABLE 1 Participant characterization.

	DLD group ($n = 20$)	Control group ($n = 20$)	Mann–Whitney U	p-value	Z
Age	6.5	6.5	200	1.00	0.000
Gender			200	1.00	0.00
Male	14	14			
Female	6	6			
SES			170	0.42	−0.92
Low	5	5			
Medium	9	12			
High	5	3			

Individuals included in the study group were diagnosed with language difficulties and their contacts were provided by schools and therapists. The inclusion criteria required that none of the children had other conditions such as autism, hearing loss, or intellectual disability that could explain the language impairments. Each participant underwent a language assessment battery to confirm the presence of difficulties in this specific area. In addition, a nonverbal intelligence assessment was administered to rule out any associated cognitive difficulties (Table 2).

2.2 Instruments and materials

Clinical Evaluation of Language Fundamentals CELF-Core Language Score.

The core language score is a measure of general language ability, informing clinical judgments regarding the existence or non-existence of language impairments, and determining the necessity for specialized educational interventions.

Two versions of the CELF have been administered: CELF Preschool 2 (Wiig et al., 2009) and CELF-4 (Semel et al., 2006), depending on the age of the children assessed. The former was used to assess children between the ages of 3 and 6.0 years (Sentence Comprehension, Word Structure Formulated Sentences, Recalling Sentences), while the latter was used for children older than 6.1 years (Word Classes, Formulated Sentences, Recalling Sentences, Semantic Relationships).

K-BIT 2—Kaufman Brief Intelligence Test, Second Edition (Kaufman and Kaufman, 1997).

In the present study, only the Nonverbal Scale was used, which focuses on the ability to make visual analogies and understand relationships, was used to determine whether there were severe cognitive impairments preventing the children from participating in the study.

Hispanic-American adaptation of the Peabody Picture Vocabulary Test (Dunn and Dunn, 1986), also known as *Test de Vocabulario en Imágenes Peabody* (TVIP).

The main purpose of this test is to assess an individual's level of receptive vocabulary and vocabulary acquisition. Its secondary purpose is the detection of difficulties in verbal skills to evaluate cognitive processes. This test has been widely used in scientific research.

Phonological Processing Assessment Test—PROFON (Lara-Diaz et al., 2011).

This test was used to assess the components of phonological processing at the level of phonological awareness, phonological memory and phonological naming. The measure of phonological awareness includes three levels: syllabic, intrasyllabic and phonemic. At the syllabic level, tasks included: initial syllable omission, final syllable omission, middle syllable omission, initial syllable substitution, final syllable substitution, and middle syllable substitution. At the intrasyllabic level, tasks included: onset deletion, rhyme deletion, rhyme substitution, rhyme substitution, rhyme pairing, phoneme deletion, and comparison judgment. At the phonemic level, tasks included: initial sound identification, final sound identification, segmentation synthesis, common words, non-words, segmentation analysis, backward words, and word play.

Eye Tracker Tobii TX 300.

The Eye Tracker is designed to measure eye movement and provide response times, visual fixations, and visual fixation counts of participants in real time as they perform a specific task.

The TX300 eye tracker consists of a 23″ detachable monitor. It has a sampling rate of 300 Hz and allows free head movement.

2.3 Procedures

A descriptive, cross-sectional, quasi-experimental study was conducted. The study had three main phases, which are described below:

Phase I: Search and selection of children: Participants were sought through direct contact with various professionals (speech therapists, occupational therapists, special educators, teachers, and psychologists), in addition to collaboration with educational institutions that allowed the selection of children who reported a language impairment. The final selection was made by means of inclusion–exclusion criteria. Participants who confirmed their availability to visit the facilities of the National University in order to apply the tests with the eye-tracking equipment were selected.

Phase II: Application of linguistic and cognitive tests: First, the informed consent form was signed by the parents and/or guardians and assented to by the minor. Two evaluation sessions of 45–60 min were held, during which the order of administration of the tests was randomized, a code was given to the participants to identify the envelope containing the tests, and the same code was used to identify the voice recordings made. Depending on the availability of the parents, the professionals conducted the tests at educational institutions, the children's homes or at the Center for Human Communication of the Faculty of Medicine of the National University of Colombia. All the tests previously described were applied and the indications of each of them were followed.

Phase III: The experimental phase consisted of assessing visual performance during the auditory recognition of images, with and without phonological distractors. Stimuli consisted of high-frequency bisyllabic words. The stimuli were tested with a group of children between the ages of 4 and 8 to determine the familiarity of the target words and their relationship to the image used. For the rhyme distractors, a pre-rhyme judgment was conducted with children of the same ages who did not participate in the study.

TABLE 2 Nonverbal cognition and language.

	DLD group ($n = 20$)	Control group ($n = 20$)	Mann–Whitney U	p-value	Z	1-β	d
KBIT	94.85 (7.809)	96.25 (8.77)	183.5	0.65	−0.448	0.98	0.31
CELF Core language	76.90 (7.52)*	103.85 (10.45)	0.50	0.000	−5.406	1.00	2.96

Standard deviation in parentheses, *$p < 0.05$.

During this phase, the children were introduced to the visual stimuli and asked to name each one. Adjustments were made and the name was checked to ensure it was correct, otherwise the participant was given feedback and the list was checked again at the end.

Twelve groups of four pictures were presented, with which the children performed an auditory–visual word identification task in which the phonological relation was manipulated with a target word, that is, with cohort or rhyming distractors.

The stimuli were presented on a 23″ screen at a distance of 50–60 cm with a resolution of 1,920 × 1,080 pixels (Figure 1).

The auditory stimuli consisted of bisyllabic words, in each presentation the children were given 3,000 ms to look at the pictures before hearing the instruction "look at the red dot" followed by the instruction "now look at (target word)." In order to provide no prior cue to the target word, neither the 3rd person direct complement atonic pronouns (*la,lo,el*) nor the corresponding indefinite articles (*un, una*) were used.

The Tobii TX300 eye tracker (version 3.2.1) was used to record eye movements at 300 Hz. Only data with a reliability percentage of more than 60% of the oculomotor recordings were taken into account.

Participants were seated in a fixed chair with an additional adjustable seat so that their eyes could reach a distance of 60 cm in front of the computer screen at a 90° angle to the screen. The background screen color was set to white. The calibration system was automated and a total of 9 points were scored. The calibration stimulus was a red dot on a white background.

In each screen, four images were presented, one of which was the target item and the others were three distractor images. The following types of distractors were used in the stimulus manipulation: (1) Pictures that were phonologically unrelated (baseline), (2) A distractor that rhymed with the target word (rhyme), (3) A distractor that began the same as the target word, with the same syllabic structure (cohort), (4) Two distractors, one cohort and one rhyming. Each target is delineated as an area of interest, and the Tobii Studio software identifies how the gaze is fixated on each of these areas. All data provided by the eye tracker were recorded. The time elapsed in milliseconds from the appearance of the stimulus to the first fixation in the area of interest, the number of visual fixations in the area of interest, and the time spent looking at the area are calculated, indicating the attention devoted to each stimulus. Through the

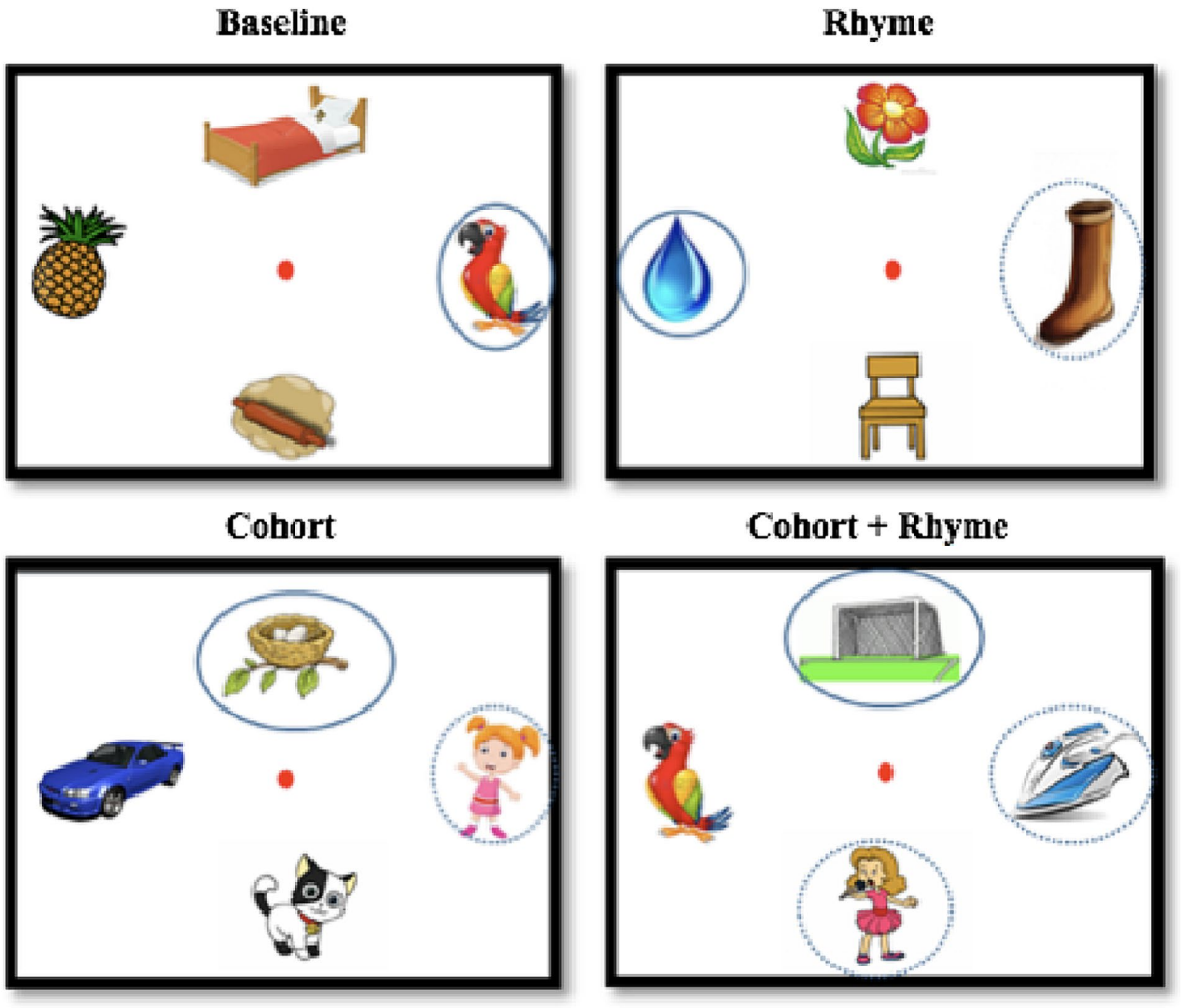

FIGURE 1
Example stimuli.

software, heat maps were also generated, visually indicating the concentration of fixations.

2.4 Data analysis

The data were recorded in the respective formats of the tests administered, and then the appropriate changes were made to the scalar scores and/or percentages as needed. Both the above-mentioned data and the data recorded by the eye tracker were transcribed into a database in the Microsoft Excel program.

Subsequently, an analysis was carried out using the computer package SPSS, version 17, where the appropriate descriptive statistics were calculated. Non-parametric analyses were performed, given the nature and size of the sample and the impossibility of assuming normality of the data.

The nonparametric Mann–Whitney U Test for independent samples was used to compare the means between the two groups for the different tests administered, with a significance level of 0.05. The effect size was calculated by Cohen's d using G*Power 3.1 statistical software (Faul et al., 2007). The d values are typically quantified as small (0.2), medium (0.5), and large (0.8) (Cohen, 1988).

The mean of the average fixations in the areas of interest (AOIs) of the correct item in each stimulus on eye tracking were calculated (Baseline, Cohort, Rhyme and Cohort + Rhyme). Measurements with a reliability of less than 60% were excluded because the evaluation was carried out on children; only data with a reliability of at least 70% were taken into account.

3 Results

The Mann–Whitney U analysis revealed significant differences between the groups in most of the domains evaluated, except for age and cognitive variables. The DLD group obtained lower scores in the areas of language, vocabulary, and phonological awareness (Table 3).

The non-parametric Friedman test was employed to examine whether there is an effect of condition for each of the groups (control and DLD).

For the control group, an effect of condition was found, specifically at baseline and cohort condition ($p = 0.013$), as well as for the pair of rhyme condition with cohort + rhyme condition ($p = 0.006$).

For the group with the disorder, there was no difference between baseline and rhyme condition ($p = 0.346$), but there was a difference for the baseline measurement condition and cohort ($p = 0.016$), and cohort + rhyme and rhyme condition ($p = 0.01$).

These results suggest that control children are sensitive to cohort and rhyme interference effects, which results in longer fixation latencies in the presence of these distractors. In contrast to the control group, the findings above indicate that children in the DLD group do not show differences in fixation times between baseline and rhyme, but they do show differences between baseline and cohort. This would indicate an interference effect when the words begin the same, but not when the words rhyme for children with DLD.

As mentioned above, the children were recorded by the eye tracker, which provides a record of eye movements through various modalities including heat maps (report that graphically establishes, in color scales, the portions in which greater visual fixations are made) and the areas of interest (AOIs) of the participants when looking at each item. Below are some of the heat maps and areas of interest that show the difference between the groups:

Figure 2 shows the heat map recorded by the control (A) and DLD (B) groups when faced with the visual recognition task with both cohort and rhyme distractors. It reveals a clustering of fixations on both distractors for the control group and on the cohort distractor for the DLD group. It is important to note that a higher density of fixations represents a greater cognitive effort in recognizing the target word.

In the same way, the following figure shows the performance for the same demand when only one phonological distractor is presented, i.e., Rhyme. In support of the above statistical data, Figure 3 shows how the phonological distractor presents higher concentrations of fixation duration (heat map) (B and D) and higher fixation amplitude in the area of interest in both the distractor and the target word (areas of interest maps) (A and C) in the control children compared to the children in the DLD group.

4 Discussion

This study compared the performance of visual attention in word recognition tasks when presented with phonological and lexical distractors to characterize the performance of children with developmental language disorders and controls. Previous studies indicate that phonological processing allows to encode information from the outside, to represent and manipulate it, to transform these representations, to create networks between them and to store them and to access them later (Betourne and Friel-Patti, 2003). Therefore, phonological processing is one of the components responsible for the preservation of language-based information.

Phonological processing skills are typically assessed through metalinguistic tasks such as phonetic discrimination, minimal pairs,

TABLE 3 Vocabulary and phonological awareness.

	DLD group ($n = 20$)	Control group ($n = 20$)	Mann–Whitney U	p-value	Z	1-β	d
TVIP	44.45 (15.95)*	64.55 (13.49)	58.5	0.000	−3.830	0.98	1.36
Syllabic PA	6.40 (3.13)*	11.75 (3.09)	51.5	0.000	−4.039	0.99	1.72
Inter-syllabic PA	4.20 (2.08)*	11.70 (3.96)	17.5	0.000	−4.972	0.99	2.37
Phonemic PA	3.25 (1.52)*	7.20 (2.06)	32	0.000	−4.583	0.99	2.18
Phonological awareness (PA)	13.80 (4.09)*	30.65 (8.47)	20.0	0.000	−4.876	1.00	2.53

TVIP: Peabody Test. Standard deviation in parentheses, *$p < 0.05$.

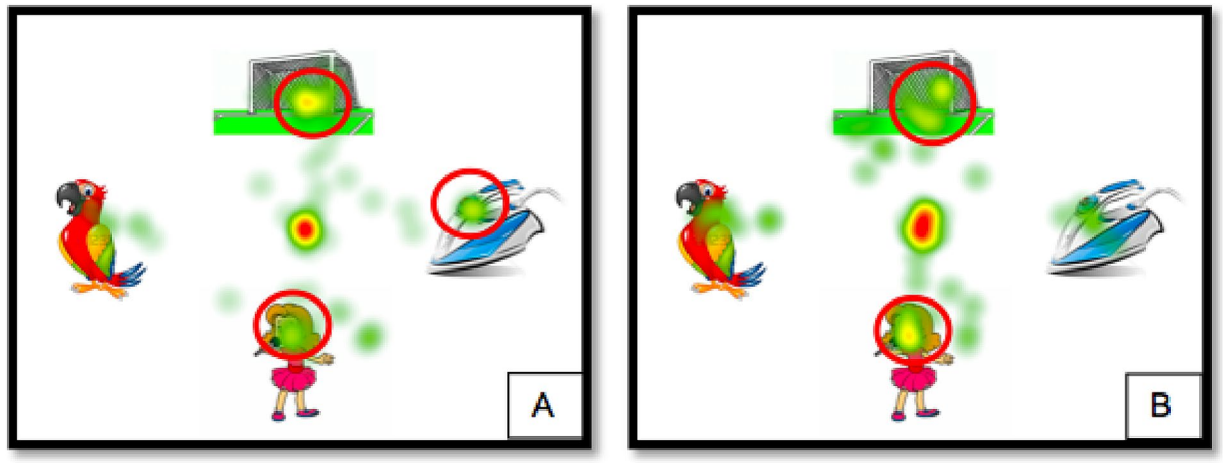

FIGURE 2
Cohort + Rhyme distractors. Item with target word *Cancha*, with two distractors: Cohort (*Canta*) + Rhyme (*Plancha*). Control Group **(A)** DLD Group **(B)**.

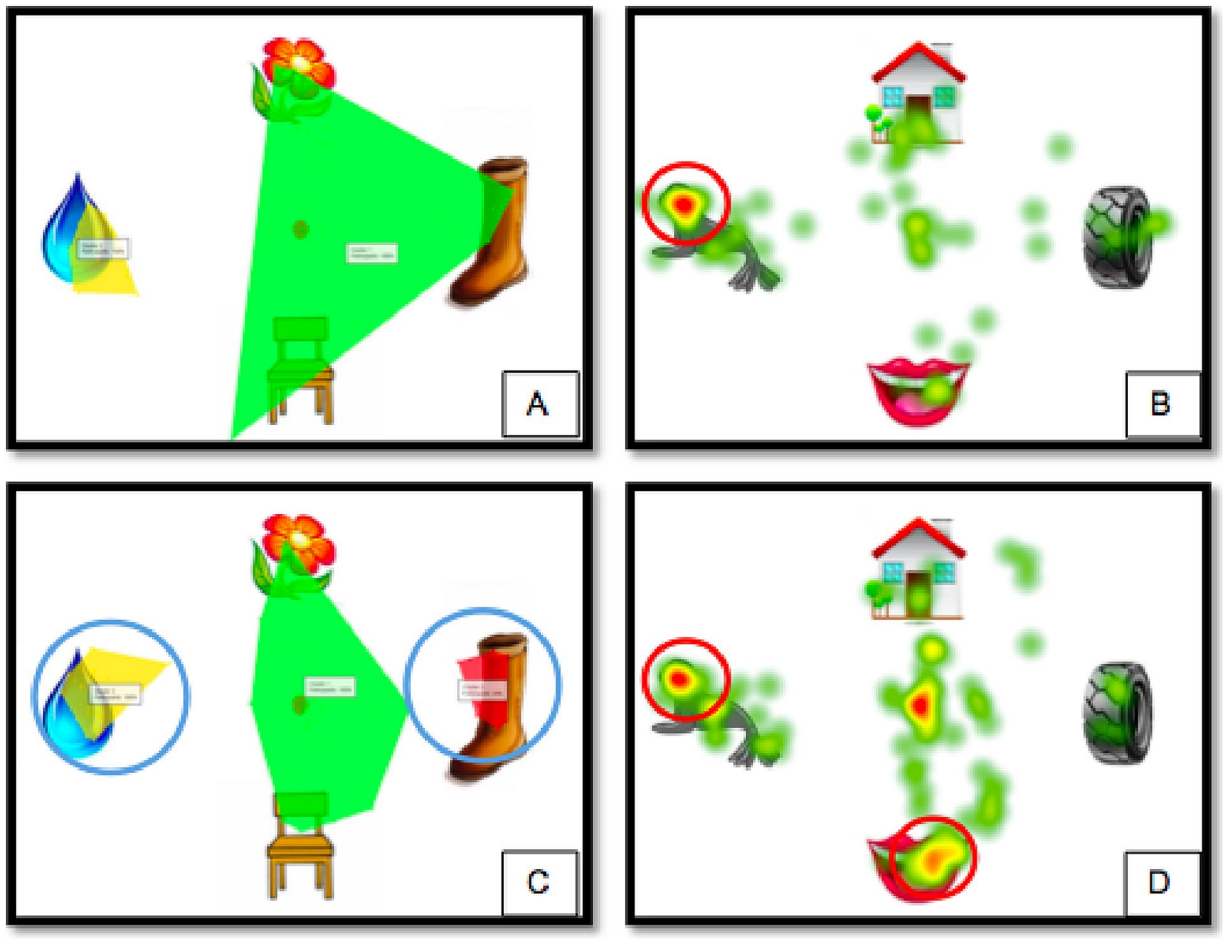

FIGURE 3
Rhyme distractor. Items with rhyme distractor. DLD Group **(A,B)** y Control Group **(C,D)**; Heat Maps with target word *Foca* and rhyme distractor *Boca*: **(B,D)**, Areas of interest with target word *Gota* and rhyme distractor *Bota* **(A,C)**.

phonological memory, omission, substitution and addition, syllabic and phonemic. These tasks are vulnerable to attentional and working memory processes and have an off-line approach that omits much important information at the perceptual, representational, productive and metaphonological levels. Thus, a visual assessment, as in the experiment presented above, could provide different information

depending on the modality of presentation. Thus, a direct relationship between the cognitive deficit and the conduct disorder is postulated by the phonological theory.

According to the hypothesis that DLD has general and not specific domain limitations, it can be said that this phenomenon is due to the fact that they have an insufficiency in processing different cognitive resources, which would determine how much work can be done in a period of time. As a consequence, the difficulty in processing resources leads to inadequate information processing with both linguistic and non-linguistic stimuli (Dispaldro and Corradi, 2015). Consequently, processing limitations have been identified in terms of speed and capacity, with working memory and processing speed being the most studied.

Bellocchi et al. (2013) mention that the assessment approach by observing eye movements is valuable in relation to cognitive processing, as it increases the knowledge of visual-attentional processing in reading. Through real-time monitoring of spoken language processing, eyetracking has effectively shown that both groups and rhymes contend during recognition. Furthermore, these effects have been observed even without visually presented competitors by adjusting the neighborhood size of targets (Magnuson et al., 2003, 2007). In this sense, the research by Desroches et al. (2006) proposes a new approach to phonological assessment using eye tracking, based on the hypothesis that eye motions are linked to lexical processing, such that fixating on a target over time reflects the lexical activation of a word.

The results of the eye tracker task indicate that under normal circumstances, auditory word recognition in children with DLD does not show significant differences compared to the control group. Both groups showed similar eye movement speeds when presented with stimuli without any type of distractor (baseline), suggesting that the ability to identify isolated words is equivalent in both groups. In addition, both groups (DLD and Control) showed a slowness of fixation on the target stimulus when presented with a lexical distractor, i.e., Cohort, indicating that both groups were sensitive to this factor. Although the DLD group has lower scores on the TVIP test, it is likely that they may experience difficulties in the semantic component of language, But in this case, their performance is similar to that of the controls.

However, the control group displayed a slower response when presented with a phonological distractor, i.e., rhyme, in contrast to the DLD group, which showed the same level of performance as in the baseline test. This suggests that children with DLD can perceive the segmented information of words and rely on the retrieval of lexical information, as proposed by the model of speech perception (McClelland and Elman, 1986); but they are much less sensitive to identifying the phonological relationship, as is the case with rhyme, which may be related to the DLD group shows lower performance in phonological processing.

Although the control group also exhibited slower recognition in the presence of a rhyme distractor, the DLD group did not. This observation implies that DLD children possess the ability to perceive detailed segmental information about words, enabling them to quickly identify spoken words. However, they demonstrate significantly less sensitivity to higher-order rhyming relationships among words. This finding indicating that typically developing children naturally categorize auditory stimuli based on both segmental and suprasegmental properties, whereas children with DLD tend to prioritize segmental information. These results are similar to previous studies (Allopenna et al., 1998) and support other studies indicating that typically developing children naturally categorize auditory stimuli based on both segmental and suprasegmental properties, confirming that children with language disorders are less sensitive to phonological aspects of language (Aguilar-Mediavilla et al., 2002; Vandewalle et al., 2012; Buiza et al., 2016).

Consistent with the hypothesis presented in this study, the deficiencies in phonological processing did not interfere with visual attention for the recognition of the target word. However, it was thought that there would be a similar behavior with the cohort distractors, since it refers to a task of initial sound identification; yet, the TRACE model suggests that the cohort is a lexical facilitator (McClelland and Elman, 1986).

On the other hand, evidence shows that children with DLD fail to identify initial sounds in words on traditional tests; however, on the eye-tracker task, when presented with the cohort distractors, they show the same performance as children in the control group. It is possible that their problems in identifying initial sounds in words are due to difficulties in the explicit application of phonological knowledge, rather than an online processing deficit. If this is the case, it is possible that the metaphonological problems are adjacent to the phonological processing deficits that actually play a causal role in language difficulties, especially in DLD.

The findings regarding phonological processing with visual attention tasks suggest the relevance of using the eye tracker in diagnosis and assessment during treatment, as it is able to detect subtle processing deficits that cannot be detected by offline methods, such as traditional phonological awareness tests.

4.1 Clinical implications

This research contributes significantly to both the clinical and educational fields. It highlights that children with Developmental Language Disorder (DLD) often exhibit deficits primarily in the phonological component, which consequently affects the semantic component and visual attention. These deficits are also reflected in their performance on standardized language tests. As a result, this study underscores the importance of a differential diagnosis. Such a diagnosis not only identifies the disorder, which has a higher incidence than previously assumed, but also allows for subcategorization and the development of methodological strategies for detection, treatment, and mitigation in affected children. This approach will facilitate the creation of diverse models for diagnosis, treatment, school evaluation, and curriculum support.

Studying online processing in children enables us to delve deeper into cognitive processing. This is particularly crucial as many nuances occurring within milliseconds during complex language processing tend to be overlooked in typical tasks.

4.2 Limitations

Despite the prevalence of Developmental Language Disorder (DLD) in the Colombian population, the recruitment process for this research proved to be quite complex. Twenty children from both the

DLD and Control groups were excluded from the study due to difficulties encountered by parents and guardians in transporting them to the laboratory.

It is crucial to emphasize that the results presented here pertain solely to the sample involved in this study. Due to the limited number of participants, no generalizations can be made.

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 Faculty of Medicine, Universidad Nacional de Colombia. 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. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

ML-D: Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. JB: Investigation, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. YA: Conceptualization, Investigation, Writing – original draft, 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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Multilingual use assessment questionnaire: a proposal for assessing language and literacy experience

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The linguistic profile of multilingual individuals can vary significantly due to diversity in linguistic experience. This poses challenges for language researchers, educators, and clinical practitioners. We developed a Multilingual Use Assessment Questionnaire (MUAQ) to capture the heterogeneous nature of multilinguals profiles integrating three dimensions: self-assessment of language(s) competence, language(s) use for mental operations, and language(s) use in different contexts. The questionnaire was administered to bilingual Catalan/Spanish children and adults across three educational levels: elementary school (year 6), secondary school (year 10), and university level. The application of the MUAQ revealed that Catalan/Spanish bilinguals displayed variations in their self-assessed proficiency based on the type of linguistic activity required by each language. While high bilingual competence was concentrated in oral comprehension, production skills exhibited lower bilingual competence and a strong asymmetry between languages emerged in writing. Also, more pronounced preferences for one language were observed for Thinking and Counting. Whereas Catalan (the language of schooling) was more frequently preferred for Counting, a more multilingual approach was observed for Thinking. A significant heterogeneity was also evident in the language(s) used in different contexts, with each third of the study population demonstrating distinct patterns of linguistic behavior depending on the context. An Exploratory Factor Analysis (EFA) identified two key dimensions (linguistic competence skills and languages involved in mental operations) that accounted for a substantial portion of the variance, while the third dimension (language use in different contexts) bifurcated into situational/communicative vs. personal contexts. These results endorse multidimensional approaches for a comprehensive understanding of multilingualism.

KEYWORDS

bilingual children, multilingualism, linguistic profile, assessment tool, questionnaire, Spanish-Catalan bilinguals, self-reported linguistic competence

1 Introduction

Approximately half of the global population possesses some degree of multilingualism[1], residing in environments where they interact with and utilize two or more languages (Grosjean, 2010; Westby, 2014). The linguistic makeup of multilingual speakers can vary significantly. Various factors such as belonging to a literate or an illiterate community [with or without standardized language(s)], age of language acquisition, method of learning (e.g., formal instruction or immersion), extent and quality of exposure to different languages, and usage patterns across different communicative settings with diverse interlocutors contribute to this diversity. These varied language experiences can influence the formation of multilinguals' identities as well as their cognitive and neural development (Marian and Hayakawa, 2021).

Multilingual individuals may have different preferences for their primary language of comfort and assess their communicative competence differently for different language skills (e.g., listening, speaking, reading, writing). Furthermore, their linguistic behavior can vary depending on the context, i.e., at school, with friends, or during leisure activities like watching TV. The variations in language competence, the array of usage patterns across different contexts, as well as the combinations of languages used, result in a vast diversity of linguistic profiles. This diversity poses challenges not only for language researchers but also for educators and clinical practitioners (Nieva et al., 2020). Without adequate means of capturing this diversity and identifying which factors are crucial to describe the linguistic condition of participants in research, students, or language therapy users, both the scope of research findings and decisions about the language(s) of assessment and intervention would be on shaky ground.

The goal of this study is to develop an assessment tool that captures the diversity of multilingual individuals in linguistic abilities and patterns of use across a variety of contexts. Our aim is to provide a comprehensive and realistic evaluation that goes beyond the oversimplified monolingual versus bilingual categorization which is often used in studies involving multilingual populations.

Researchers have advocated for precise methods for assessing the linguistic profile of bilinguals to capture and quantify individual experiences, as well as to identify which of these experiences are more or less likely to have effects on language and cognition (Marian and Hayakawa, 2021; De Cat et al., 2023; Rothman et al., 2023). Having appropriate tools to assess individual multilingual experiences is crucial for understanding issues such as the impact of multilingualism on neurocognition, language processing, language acquisition, and educational outcomes (Rothman et al., 2023). Additionally, it will aid in distinguishing the potential effects of multilingualism on language development from developmental language disorders, thus preventing misdiagnoses (Gagarina et al., 2016; Tsimpli et al., 2016).

Proposals for quantitative and qualitative proxies for multilingual language profiles should move away from dichotomous labeling of language profiles (monolingual vs. multilingual, simultaneous vs. sequential, etc.) that fail to capture the complexities and nuances of multilingual experiences. Such labeling may, in fact, be responsible for the contradictory results obtained concerning some central issues, such as the phantom-like appearance of cognitive effects of bilingualism (Leivada et al., 2021), or the identification of developmental delay(s) in bilingual children (Thordardottir, 2017). To acknowledge the differences between these labels does not suffice to overcome the deterministic variation underlying each label and across them: many multilingual individuals transcend these labels themselves (Rothman et al., 2023). Multilingualism needs to be conceptualized like a continuum or spectrum [e.g., Marian and Hayakawa (2021) and Rothman et al. (2023)]. The advantages and feasibility of a bilingualism quotient construct, that is, a valid and generalizable index of multilingual experience, have been supported in previous studies [e.g., Marian and Hayakawa (2021)].

In addition, the multidimensional multifaceted nature of bilingualism calls for identifying the components which are relevant to multilingual profiles to develop research approaches where these components are related to specific linguistic and cognitive outcomes (Rothman et al., 2023). For instance, self-evaluated multilingual competence is identified as positively impacting text length in text production in elementary and secondary school children (Tolchinsky et al., 2022); self-reported amount of Spanish used for academic writing in Spanish-English bilinguals accounted for differences in short-term memory tasks (Smith and Briggs Baffoe-Djan, 2019). However, there is still no consensus as to which components of the bilingual profile must be measured. Studies would greatly benefit from a greater transparency regarding both the components used for defining multilingual participants' profiles and the measures used to operationalize them (Marian and Hayakawa, 2021; De Cat et al., 2023). A recent review noted substantial variation in the documentation of key dimensions of bilingualism, such as language skills and activities performed in each language, among others (Kašćelan et al., 2022). In fact, divergent approaches to the multidimensional nature of multilingualism are considered partly responsible for the mentioned conflicting results (Valian, 2015).

The need for tools that measure multilingualism as a multidimensional factor becomes especially relevant in sociolinguistic situations like the one in Catalonia, the context of our study, where two official languages, Catalan, and Spanish, coexist and none of them is a minority language (Serrat et al., 2021). While Catalan is the main language of schooling, both languages are widely used, and there is virtually no monolingual Catalan population (Camus and Aparici, 2020; Tolchinsky et al., 2022). Catalonia has also a large immigrant population with various native languages (Institut d'Estadística de Catalunya (IDESCAT), 2019).

A recent systematic review identified 48 questionnaires for assessing linguistic profiles and/or documenting bilingual experience [see Kašćelan et al. (2022)]. Some of these questionnaires have been used in research on language development and cognitive performance, whether to characterize multilingual populations, to look for correlations between linguistic condition and the cognitive effects of multilingualism, or to investigate differences in the learning trajectories between monolingual and bilingual children. They have also been used to gather information on individuals' language dominance, or to make decisions about language(s) of assessment or intervention in clinical practice.

Among them, the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian et al., 2007), for adults with a literacy level of secondary school in, at least, one of the languages; the Bilingual

1 The terms multilingual and bilingual will be used here irrespective of the number of languages used by the speakers.

Language Profile (BLP; Gertken et al., 2014), for children and adults with a minimum schooling level of secondary school; or The Language Exposure Assessment Tool (LEAT; De Anda et al., 2016), a parental questionnaire for children aged 17 to 40 months, are available in Spanish (and the first two in Catalan). Although they have inspired our own questionnaire, none of them matched the age range and/or the particular sociolinguistic context of our own research.

We aimed to construct a valid and reliable tool to obtain a more precise characterization of potential predictors of the individual differences observed in primary and secondary school children and adults, considering the complexity of the multilingual condition of our participants. We align with Rothman et al. (2023) on the convenience of having more than one measure at disposal. Different instruments may be designed to best capture distinct but complementary features of multilingual experiences and make them suitable for different questions, contexts, or specific age groups. In doing so, we advocate for a continuous rather than categorical view of multilingualism whereby not only should these dynamic factors be identified, but also the extent to which they help define an individual's multilingual profile.

We posit that speakers-writers' linguistic profile is among the factors influencing both learning trajectories and the quality of discourse. To this end, we developed a questionnaire to gather information about home literacy practices, family SES, language(s) use in different contexts, and self-assessment of language competence. We aimed to move beyond the monolingual/bilingual dichotomy, which does not entirely capture the complexities of the sociolinguistic situation in our studies, and to identify those dimensions of the linguistic profile relevant to multilingual contexts, ultimately contributing to the definition of multilingualism.

2 Methods

Our aim was to develop a multidimensional scale for assessing the linguistic profile of speakers integrating various dimensions: self-assessment of language/s competence, language(s) use for mental operations, and language(s) use in different contexts. This involved creating a survey questionnaire with specific items to measure these dimensions which was administered to bilingual Catalan/Spanish students across three educational levels: elementary school (year 6), secondary school (year 10), and university level.[2] Analysis of the responses allowed us to assess the questions' correspondence and internal structure of each dimension (dichotomous or graded), and the relationships among dimensions (correlated or unrelated).

2.1 Instrument structure and scoring

The survey questionnaire comprised three blocks of questions. The first block collected participants' demographic characteristics and asked basic questions about the languages spoken, while the second one addressed their literacy practices. The third block, focus of this study, embraced three sets of questions hypothesized to measure different aspects of linguistic condition.

The first set assessed language competence in four linguistic skills through self-report. Participants rated their competence in speaking, oral comprehension, writing, and reading in a particular language on a 4-point scale (1 = *no gaire bé* 'not well', 2 = *regular* 'average', 3 = *bé* 'well', 4 = *molt bé* 'very well'). The same questions were asked for Catalan, Spanish and, if applicable, for a third language.

The second set evaluated language(s) use for two mental operations, i.e., frequency of use of a particular language for Thinking and Counting. These parallel questions were scored in a 4-point scale (0 = never, 1 = rarely, 2 = frequently, 3 = always) for Spanish, Catalan and, when applicable, for a third language.

The third set examined language use across various contexts. Participants indicated the language(s) they use in different situations (e.g., with family, friends, for watching TV), using a 7-point scale: 1 = always in Catalan, 2 = more in Catalan than in Spanish, 3 = in Catalan as well as in Spanish, 4 = more in Spanish than in Catalan, 5 = always in Spanish, 6 = more in another language than in Catalan or Spanish, and 7 = always in another language.

A fourth set of questions about language use in distance communication contexts (e.g., emails, social networks) was excluded from further analysis due to limited responses.

2.2 Data collection

A total of 268 Catalan students from three educational levels participated in the study: 69 from elementary school ($M = 11.6$), 123 from secondary school ($M = 15.8$), and 73 university students ($M = 21.1$). For 35.6% of the students Spanish is their home language, followed by 31.18% for whom Catalan is their home language and 23.1% for whom both Catalan and Spanish are. Less than 5.3% of the students reported other languages in addition to Catalan and Spanish, and 4.1% reported only another home language (See Supplementary Table S1).

Participants were evenly split regarding their comfort language choice. Catalan, either alone or followed by Spanish or another language, was preferred by 45.45% of the sample while 43.93% opted for Spanish, either alone or followed by Catalan or another language. Other languages were chosen as primary comfort language by 10.60% of the sample. The preference for Catalan tended to decrease from 66% in elementary school to 31.7% in secondary school, with an increase to 48.6% in university.

2.3 Analytical strategy

Responses to the survey questions were analyzed. A rescaling procedure combining the extent of use and command of Spanish, Catalan, and another language was applied to create ordinal scales for self-assessed linguistic skills, language(s) used for mental operations and language(s) use in different contexts. Exploratory factor analysis (EFA) was conducted to explore the structure of the linguistic profile emerging from the three dimensions measured. Subsequently, the correlations among these were examined to opt for the most parsimonious integration. In what follows, we present the scaling criteria and results for each set of questions.

2 The MUAQ questionnaire is available in Spanish and Catalan, for children and for adults. It is at disposal upon request to the first author (Melina.Aparici@uab.cat).

3 Results

3.1 Self-assessment of language competence in different linguistic skills

A scale was developed based on responses to questions about language competence in different skills for Spanish, Catalan, and another language, separately. For the analysis, categories 1 and 2 (1 = *no gaire bé* 'not well', 2 = *regular* 'average') were combined due to less than 5% of answers. Only 16% (43 participants) of the whole sample declared to know another language besides Catalan and Spanish. The following final ordinal scale included five categories for speaking, oral comprehension, reading, writing.

If participants assessed their own competence in Spanish and Catalan as 'not well', they received the lowest value (1). In contrast, if respondents assigned 'very well' for both languages, they got the highest value of self-assessed competence in both languages (4). For the intermediate values, there were different combinations, such as 'well' in one language and 'not well' in the other one (2), or 'very well' in one language and 'well' in the other one (3). The fifth value was assigned to cases who also reported 'well' or 'very well' in a third language (5). Therefore, the lower values represent a self-feeling of low competence in one or more skills in both (1) or in one language (2). The higher values indicate relatively good (3) or very good (4) self-reported competence in one skill in both languages. The highest value (5) indicates competence in three languages.

Table 1 shows the percentage for each value of the scale in the four linguistic skills. Oral comprehension shows the highest rate of high competence in the two languages. In contrast, production skills, i.e., Speaking and Writing, in this order, show the highest rate of intermediate bilingual competence. However, Writing also displays the highest rate of self-perceived low competence in the two languages. Overall, rates are much lower for those values indicating low or monolingual competence than for those representing bilingual or high bilingual competence: nearly half the sample manifested good competence in the two languages, though not to the highest extent, and altogether, almost three-quarters of the sample self-reported as bilingual to some extent. The students who self-evaluate their competence in three languages as 'well' and 'very well' did so for Oral comprehension (9.9%) and less for Speaking, Reading, or Writing.

3.2 Language use for performing mental operations

A second scale was developed for assessing the frequency to which participants reported to think and count in one or more languages. Each question was asked for Spanish, for Catalan, and for another language, and responses were scored from 0 (never) to 3 (always).

The differing extent of use of the languages at stake for mental operations indicates that almost half of the sample thinks and counts always in one language, be it Spanish or Catalan (see frequencies of use in Table 2). The other half of the sample seems to behave bilingually in this respect, i.e., answering either 'frequently' or 'rarely' to the questions. In addition, as a group, our participants hardly ever use any other language for Counting, but around 20% do it for Thinking. However, these frequency data do not allow us to observe the language preferences in the same individual, that is, to what extent they use one or more languages for performing mental operations.

A rescaling procedure allows us to approach this issue. We assessed the combined value of each pair of languages (e.g., Spanish-Catalan, Spanish-Other, Catalan-Other) to distinguish between participants who report Counting or Thinking most frequently in one language from those who rather report performing these operations in more languages. A final mean across the three pairs was scaled from 1 to 6, where up to 3 means frequent use of one language, and from 3 up to 6 means frequent use of two or more languages. This scale was rescaled into a 1–3 range.

In notation $(\Sigma\ (Ri + Rj))/3$, R = Rate for $i \neq j$ and i,j are languages (Spanish, Catalan, Other), such that there are three possible pairs. In words, we added the score(s) of a pair of languages in, for example, Thinking and divided the result by three; this yields the extent to which one or more languages are used for this operation. If the value is lower than three, it means that only one language is most frequently used. Based on this procedure we developed a scale for participants' use of languages for each mental operation.

The means for the created scale indicate that participants' multilingual use is significantly more frequent [t (259) = 7.30, p = <0.001] for Thinking (1.59, SD = 0.46) than for Counting (1.40, SD = 0.36). However, participants do not appear to use more than one language indistinctly for Thinking and Counting, but rather they have a preferred language for each operation (Supplementary Table S3).

TABLE 1 Percentage and (frequency) in each value of the scale of self-assessed competence in four linguistic skills.

	Speaking	Oral comprehension	Reading	Writing
1. Low competence	1.5% (4)	0.8% (2)	2.7% (7)	8.7% (23)
2. Monolingual competence	9.8% (26)	1.1% (3)	5.7% (15)	20.5% (54)
3. Bilingual competence	53.4% (141)	20.2% (53)	46.2% (122)	48.5% (128)
4. High bilingual competence	32.2% (85)	68.1% (179)	40.9% (108)	21.6% (57)
5. Competence in three languages	3.0% (8)	9.9% (26)	4.5% (12)	0.8% (2)
Mean	3.25	3.85	3.39	2.85
SD	0.73	0.63	0.78	0.88

Mean = 3.34; SD = 0.61; alpha = 0.807.

TABLE 2 Percentages and (frequencies) of use of languages for mental operations ($n = 264$).

	Spanish	Catalan	Another language
Thinking			
0. Never	7.8% (20)	15.8% (15)	46.1% (105)
1. Rarely	24.9% (64)	21.6% (56)	35.5% (81)
2. Frequently	27.2% (70)	24.7% (64)	14.5% (33)
3. Always	40.1% (103)	47.9% (124)	3.9% (9)
Counting			
0. Never	9.6% (25)	12.4% (32)	74.1% (163)
1. Rarely	20.8% (54)	22.8% (59)	20.9% (46)
2. Frequently	23.1% (60)	24.3% (63)	3.6% (8)
3. Always	46.5% (121)	40.5% (105)	1.4% (3)

TABLE 3 Percentages and (frequencies) of bilingual behavior in various situations according to the language use scale ($n = 264$).

	At home	At school, with friends	Out of school, with friends	For reading	For watching TV
1. Monolingual use	54.2% (143)	40.9% (108)	49.2% (130)	26.9% (71)	8.0% (21)
2. Mid-level bilingual use	31.8% (84)	41.7% (110)	34.8% (92)	39.8% (105)	59.8% (158)
3. Balanced bilingual	13.8% (37)	17.4% (46)	15.9% (42)	33.3% (88)	32.2% (85)

3.3 Language use in different contexts

A third scale was developed for participants' linguistic behavior in several contexts of use: at home, at school and out of school with friends, when reading books, and when watching TV shows, movies, or series. In any of these contexts, participants may exhibit monolingual to balanced bilingual behavior. If the languages at stake are reported to be used to the same extent in a certain context ("Catalan as Spanish"), the rank in bilingual use is the highest (code 3), while always using one language in that context regardless of which one ("Always Catalan" or "Always Spanish") represents the lowest rank in bilingual use (code 1). If both languages are used in different degrees ("More Catalan than Spanish," "More Spanish than Catalan," or "More in another language"), a mid-level rank is assigned (code 2).

When we ranked language choice in particular contexts, half of the participants appeared as monolingual language users (see the percentage of participants' behavior by situation in Table 3). Participants do not use the two languages indistinctly but rather use only one language in a given situation (and maybe the other language in another situation). When it comes to reading, though, only a quarter of the sample does resort to only one language. The other half of the sample behave bilingually by situation, either to some extent (using both languages, but one more than the other, in a given situation), or in a balanced manner (using both languages to the same extent in a given situation), except for the home context, where most participants tend to use only one language. However, less than 20 percent behave as balanced bilinguals within the same situation, except for reading, where more participants report using both languages to the same degree.

To validate the scale, we performed a cluster analysis (k-means, $k = 3$) that resulted in assigning respondents to a preferred cluster, that is, a preferred combination of situations in which they behave multilingually (Supplementary Figure S1). The results show three groups of similar size, based on the values in five situational measurements ranked on a scale from 1 to 3. Except for TV watching that had high bilingual use of language in the three groups, although significantly higher in group 3, each group showed a more bilingual behavior in one situation than in the others. Group 1 ($n = 73$) had a more bilingual use of languages at school with friends, whereas group 2 ($n = 100$) showed more bilingual behavior in reading, though less than for TV watching, and group 3 ($n = 91$) behaved more multilingually in reading and at home. A complementary analysis of variance across the five situational variables resulted in a significant group-difference in all five bilingual measures.

3.4 An integrative characterization of linguistic condition

A final integrative exploratory factor model (EFA) was performed to explore the structure of linguistic condition emerging from the three dimensions measured. We attempted to test whether the obtained measurements could be approached as one representative scale or require a separate consideration of the different measured dimensions.

EFA results (Supplementary material, Table 4) highlighted four factors. Factor 1 covered the component skills of linguistic competence and factor 2 related to the language(s) involved in mental operations. These two factors map the differentiation that motivated two different sets of the survey questions. In contrast, factor 3 only covered a subset of contextual uses of language, the more situational/communicative contexts of use –with friends at school and out of school – while factor 4 related to the more personal contexts –at home, for reading, for watching TV. The

TABLE 4 Factor analysis results for six questions; Factor loadings and descriptives.

	Factor 1	Factor 2
Reading	0.81	−0.01
Speaking	0.69	0.07
Oral comprehension	0.68	−0.04
Writing	0.62	−0.01
Counting	−0.06	0.79
Thinking	0.07	0.64
Mean	0.74	0.50
SD	0.18	0.12
Reliability	0.784	0.658
Eigenvalue	2.56	1.43
Percent of shared variance	42.63%	23.76%

distinction between communicative uses of language (factor 3) and more personal uses (factor 4) emerged from the EFA. However, as four factors, the model performed poorly. The two factors that point at communicative and personal contexts of use contributed only a small part (5.74 and 3.77%, respectively) out of the total shared variance (eigenvalue lower than 1) and showed low internal consistencies as expressed in the reliabilities.

Only a separate consideration of factors 1 and 2 (component skills of linguistic competence and language(s) involved in mental operations) leaving apart the uses of language in communicative and more personal contexts (factors 3 and 4) increased the explanatory power of the analysis. Table 4 shows that these two factors (that embrace six questions) obtained an eigenvalue higher than 1. Factor 1 accounted for 43% of the variance while factor 2 accounted for 24% of the variance in the definition of linguistic condition.

Despite their low explanatory power, the four factors provide a meaningful and interpretable empirical arrangement of the survey's theoretical grounds. Low internal consistencies are understandable given that items are independent of each other while sharing theoretical ground.

Nevertheless, to determine how integrated the four factors in shaping participants' linguistic condition are, we calculated the correlations among them, where each factor was calculated as the mean across its relevant items (Supplementary Table S5). Correlation results showed that only language(s) used for Thinking and Counting are relatively highly correlated ($r = 0.51$).

4 Discussion

The starting point of this study was the acknowledgment that the linguistic makeup of multilingual individuals can vary significantly due to multiple factors such as the age at which they acquired languages, exposure to languages, and usage patterns across different contexts. Given the complexity and diversity inherent in multilingual experiences, there is a need to develop assessment tools that move beyond dichotomic, simplifying categorizations, aiming to capture the nuanced nature of multilingual profiles.

The Multilingual Use Assessment Questionnaire (MUAQ) was conceived to address this need by identifying dimensions crucial for defining the profiles of multilingual individuals. We detailed the measures and rescaling procedures employed to operationalize each dimension, thus facilitating the mapping of their internal structure and the relationships among dimensions (Marian and Hayakawa, 2021; Rothman et al., 2023).

Drawing from existing research [e.g., Kašćelan et al. (2022) and De Cat et al. (2023)], we posited that self-evaluated competence in receptive and productive skills (speaking, oral comprehension, reading, and writing), and the language(s) utilized for mental operations and in specific contexts with particular interlocutors are pivotal components of multilingualism.

The application of the MUAQ revealed that answers to basic questions about home and preferred language(s) offer limited insights into the linguistic profiles of our study population and/or sociolinguistic context, Catalonia, where there is no majority language (Serrat et al., 2021). In our study, every participant is bilingual to some extent; responses regarding their language of comfort and languages spoken at home were evenly divided between Spanish, Catalan, and both languages. However, responses to more specific questions proved to be more illuminating in capturing the nuances of the linguistic profile, particularly among Catalan bilingual students.

It was through an analysis of participants' self-evaluated competence across different skills in Spanish, Catalan, and a third language that we discerned a concentration of high bilingual competence in oral comprehension, whereas production skills exhibited lower bilingual competence. Notably, a stronger sense of proficiency asymmetry between languages emerged in writing. Bilinguals displayed variations in their self-assessed proficiency levels based on the type of linguistic activity required by each language (Grosjean, 2008; Dewaele, 2011).

Consistent with Dewaele (2011), we observed more pronounced preferences for one language when bilinguals were asked to indicate their language preferences for Thinking and Counting. These mental operations appeared to reveal varying degrees of bilingualism, with Catalan (the language of schooling) being more frequently preferred for Counting and a more multilingual approach observed for Thinking.

Furthermore, a significant heterogeneity was evident in participants' responses regarding the language(s) used in different contexts, with each third of the study population demonstrating distinct patterns of linguistic behaviors depending on the context. One third had more bilingual use of languages at school with friends, another showed more bilingual behavior in reading and TV watching, and the last third behaved more monolingually with friends at school and out of school but multilingually at home, in reading, and in watching TV. These findings confirmed that multilingualism is not a unified construct (Kremin and Byers-Heinlein, 2021). Nevertheless, we explored whether this heterogeneity demanded separate consideration of the different measured dimensions.

The results of the EFA underscored the multidimensionality of multilingualism. While two hypothesized dimensions (linguistic competence skills and languages involved in mental operations) accounted for a substantial portion of the variance, the third dimension (language use in different contexts) bifurcated into situational/communicative vs. personal contexts. In this arrangement, factors of the linguistic condition pertaining to aspects that are more individual by nature exhibited higher explanatory power than those relating to the use of languages in specific contexts, which revealed a previously unanticipated distinction among contexts of use. This reaffirms the elusive and context-specific nature of differences in language use (Dewaele, 2011).

While a comprehensive consideration of multidimensionality slightly diminished explanatory power, it provided a meaningful and interpretable empirical framework grounded in the theoretical underpinnings of the survey. It emphasized the strong independence of different indicators, as evidenced by the lack of correlation among them, thus supporting multidimensional approaches that contribute to a comprehensive understanding of the multilingualism construct.

This report has primarily focused on delineating the development of a multidimensional scale for assessing the linguistic profile of bilingual Catalan/Spanish speakers by integrating various hypothesized dimensions. The linguistic profile generated by the questionnaire responses would assist educators and clinicians in recognizing the distinctive heterogeneity of multilingual knowledge. In other words, the term "bilingual" encompasses a diversity of competences and patterns of language use. Therefore, there is a need for tools that prevent us from drawing conclusions about competence levels based solely on observations in isolated contexts or abilities. This way, in cases of significant performance imbalances between contexts or skills, educational or therapeutic interventions could be better guided. Future endeavors will concentrate on elucidating the relationships between speakers' language and literacy experiences and the characteristics of their linguistic profiles.

Data availability statement

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

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/ participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

MA: Writing – review & editing, Writing – original draft, Investigation, Conceptualization. ER: Writing – review & editing, Methodology, Investigation. LT: Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization.

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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.

Publisher's note

Supplementary material

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Lexical-semantic processing in preschoolers with Developmental Language Disorder: an eye tracking study

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This study examined lexical-semantic processing in children with Developmental Language Disorder (DLD) during visually situated comprehension of real-time spoken words. Existing evidence suggests that children with DLD may experience challenges in lexical access and retrieval, as well as greater lexical competition compared to their peers with Typical Development (TD). However, the specific nature of these difficulties remains unclear. Using eye-tracking methodology, the study investigated the real-time comprehension of semantic relationships in children with DLD and their age-matched peers. The results revealed that, for relatively frequent nouns, both groups demonstrated similar comprehension of semantic relationships. Both groups favored the semantic competitor when it appeared with an unrelated visual referent. In turn, when the semantic competitor appeared with the visual referent of the spoken word, both groups disregarded the competitor. This finding shows that, although children with DLD usually present a relatively impoverished vocabulary, frequent nouns may not pose greater difficulties for them. While the temporal course of preference for the competitor or the referent was similar between the two groups, numerical, though non-significant, differences in the extension of the clusters were observed. In summary, this research demonstrates that monolingual preschoolers with DLD exhibit similar lexical access to frequent words compared to their peers with TD. Future studies should investigate the performance of children with DLD on less frequent words to provide a comprehensive understanding of their lexical-semantic abilities.

KEYWORDS

semantic processing, lexical retrieval, Developmental Language Disorder, semantic competition, eye tracking

Introduction

Developmental Language Disorder (DLD) is a condition that impacts approximately 7% of the general population (Tomblin et al., 1997; Norbury et al., 2016). This condition shows a high degree of heritability, influenced by complex interactions between genetic and environmental factors (Mountford et al., 2022). Children with DLD experience linguistic difficulties that are not attributed to any known biomedical cause and have a significant impact on their daily functioning, often leading to a poor prognosis (Bishop et al., 2017). These linguistic challenges can be manifested in one or more language components, such as

morphology, syntax, semantics, pragmatics, and narrative discourse (Bishop et al., 2017). The severity of these challenges varies widely among individuals (Ardanouy et al., 2023).

Despite the wide range of linguistic profiles of this condition, children with DLD often present deficits at the lexical-semantic level, as evidenced in several studies (Kail et al., 1984; McGregor et al., 2002; Andreu et al., 2012a). One of the earliest indicators of their lexical difficulties is a delay in early word acquisition (LaParo et al., 2004; Rice et al., 2008). Later, during both preschool and school years, children with Typical Development (TD) exhibit a faster lexical development compared to their peers with DLD (Dollaghan, 1987; Rice et al., 1990; Mainela-Arnold et al., 2010; Jones and Brandt, 2018; Dosi and Gavriilidou, 2020). This is probably explained by their difficulties in learning new words [see Jackson et al. (2021) and Marshall (2014), for reviews on the topic], which leads to smaller vocabulary size (i.e., number of words known) and lower vocabulary depth (i.e., how well they know those words, including its meanings and usage) compared to their age-matched peers with TD.

Besides the deficit in vocabulary size in children with DLD, they also exhibit difficulties in handling lexical-semantic information (McGregor and Appel, 2002; Sheng and McGregor, 2010; Drljan and Vuković, 2019). At the lexical level, children with DLD often require more time to accurately retrieve names in comparison to their peers when identifying objects (e.g., Leonard et al., 1983; Katz et al., 1992; Lahey and Edwards, 1996; see Haebig et al., 2019; Leonard et al., 2019 for more recent and related research). Furthermore, they tend to exhibit a higher frequency of naming errors in various contexts, including object and action naming, and story retelling when compared to their peers with TD (McGregor, 1997; Messer and Dockrell, 2006; Andreu et al., 2012b). For example, children with DLD display reduced naming accuracy for both nouns and verbs, with a notably higher rate of naming errors within the DLD population than observed in children with TD (Messer and Dockrell, 2006; Andreu et al., 2012b). These findings have led to the proposal of a lexical retrieval deficit in children with DLD.

At the semantic level, challenges for children with DLD are twofold: First, they show difficulties in forming semantic representations of concepts and, second, in establishing connections between words. Regarding semantic representations, research has consistently demonstrated that, unlike their peers with TD, children with DLD struggle to define both concrete (McGregor et al., 2002) and abstract concepts (Ponari et al., 2018). Concerning their lexical-semantic networks, children with DLD show sparser connections between words and lower levels of semantic organization (Sheng and McGregor, 2010; Drljan and Vuković, 2019). This has been demonstrated mainly through association tasks requiring verbal response. For instance, Sheng and McGregor (2010) showed that children with DLD produced fewer semantic responses, more clang associations (connections between words based on sound rather than meaning), and more errors compared to age and expressive vocabulary matched peers. More recently, using a similar word association task, Drljan and Vuković (2019) found that both preschool-aged (5–6 years) and school-aged (7–8 years) children with DLD display significantly fewer mature associations (paradigmatic and syntagmatic) and more immature ones (phonological, unrelated, echolalic, or omissions) than children with TD, showing a similar trajectory but a marked, delay especially in the early school years, in their semantic development. Similarly, Alt et al. (2004) examined the ability of children with DLD to establish new semantic links using a learning task involving artificial objects and actions. Their findings revealed that these children were less adept at forming new semantic connections compared to children with TD.

As shown earlier in this introduction, most of what we know about semantic representation in children with DLD comes from studies using production tasks, like naming, word definition tasks and semantic association tasks eliciting verbal responses. These studies infer lexical and semantic processing based on these verbal responses, focusing on the outcome rather than the underlying processes. In turn, our understanding of lexical retrieval and semantic processing in children with DLD during online processing remains limited. There are, nonetheless, a few studies using online tasks that have shown a deficit in lexical retrieval and semantic processing in children with DLD (e.g., McMurray et al., 2010; Andreu et al., 2012a; Helo et al., 2022). Andreu et al. (2012a), using an eye-tracking technique demonstrated a delay in the retrieval of lexical information in children with DLD compared with TD children. Specifically, children were slower than their age-matched peers in directing their gaze towards the visual referent of words (nouns or verbs) when they were named. Interestingly, no differences in the time course of gaze preference were observed when both groups were exposed to an attractive but unnamed object (red circle), discarding a general processing speed issue.

Lexical retrieval has also been studied using competition tasks. This involves presenting a word alongside an image of its referent as well as images of competing objects. In typical populations, hearing a word (e.g., "car") generates a higher percentage of looks toward the referent but also, with a lower degree, to phonological (e.g., "carrot") and semantically related objects (e.g., truck) compared to unrelated objects (e.g., glasses; Mirman and Magnuson, 2009). These tasks have also been used to study clinical populations. For instance, McMurray et al. (2010) investigated lexical retrieval by examining phonological competition in four groups of adolescents: one with DLD, another with cognitive impairments, a third group with both cognitive and language impairments, and a group of TD children. Participants were presented with spoken words alongside images of the word referent and two phonological competitors (cohort and rhyme competitors). The results indicated that adolescents with DLD and those with cognitive and language impairments exhibited a lower visual preference for the word's referent. Also, they observed that children with language impairment directed more gazes toward cohort and rhyme competitors compared to their same-age peers without language difficulties. The authors interpreted these results as suggesting that the deficit in the retrieval process for children with language impairment, implies that the difficulties in retrieving word information may be related to an inability to inhibit phonological information.

In a more recent study, Helo et al. (2022) examined the processes of lexical retrieval and semantic connections between words in children with DLD by using a lexical competition task involving familiar words. To investigate this, they conducted four eye-tracking experiments in children with and without DLD assessing real-time competition when hearing a spoken word presented together with a visual (shape) and either a phonological or semantic competitor. The timing of the visual stimulus presentation before the spoken word varied (simultaneously or 3 s of previewing). The fourth experiment assessed exclusively semantic

processing with 3 s of previewing of visual stimuli. The results of the three first experiments revealed that children with DLD experienced greater challenges than their age-matched peers in retrieving shape information during word recognition. Results from the fourth experiment (pure semantic task) indicated that both groups exhibited a preference for the semantic competitor over an unrelated object. However, when analyzing the timing and duration of this preference, distinct differences between groups emerged regarding the extent and strength of the semantic competition effect. The TD group showed a much larger semantic competition effect, suggesting a relatively weaker connection between words in children with DLD.

In summary, the reviewed evidence in children with DLD indicate that although there is extensive evidence of lexical-semantic difficulties among these children in tasks such as naming and semantic association tasks, our understanding of these challenges in real-time language processing is still limited. Similarly, evidence from online tasks shows that children with DLD face challenges in both lexical retrieval and establishing semantic connections when processing spoken words. Specifically, results from online word recognition tasks have shown that children with DLD experience a delay in matching spoken words with their referents, which may be indicative of slower lexical information retrieval (Andreu et al., 2012a). Furthermore, evidence from lexical competition tasks suggests that children with DLD encounter more pronounced interference from phonological competitors compared to their TD peers, suggesting difficulties in processing lexical-phonological information (see McMurray et al., 2010). Interestingly, the evidence also showed that while both children with DLD and TD children exhibit a semantic competition effect, this effect is shorter in children with DLD, even with familiar words. This finding suggests difficulties at the semantic level, specifically indicating weaker connections between words (Helo et al., 2022).

This study aims to extend the previous investigation in lexical retrieval and semantic connections in preschoolers with DLD by focusing on semantic competition, rather than phonological competition as in McMurray et al. (2010) and employing a more demanding task than that presented in Helo et al. (2022). By doing so, we aim to bridge the gap between knowledge in the online processing of lexical semantic information, using an online methodology to investigate how these children retrieve word information and process semantic relationships during real-time language comprehension. Concretely, we will explore whether children with DLD experience increased semantic competition when accessing a familiar word without prior time to explore the visual field.

The present study

The primary objective of our study is to determine whether children with DLD present difficulties processing lexical-semantic information in a semantic competition task. To do so, an eye-tracking experiment was implemented in which monolingual preschool participants (one group with DLD and one with TD) heard a spoken word (e.g., "car") that appeared simultaneously with a visual context, allowing only a limited time for exploring the visual scene. This experiment was carried out under two different conditions: (a) Target condition where the referent of the spoken word appeared together with a semantically related object (e.g., truck; semantic competitor) and (b) Competitor condition where a semantic competitor appeared with a distractor (e.g., glasses).

If children with DLD can retrieve semantic information as fast and accurately as children with TD, we should observe a preference for semantic-related objects in the visual context. Alternatively, if children with DLD in our sample have difficulties retrieving lexical information, we should observe a late and/or lower preference, compared to the control group, for the target and the semantic competitor both in those trials where the semantic competitor appears with the target and in those where it appears with the distractor.

Methods

Participants

The final sample consisted of 20 monolingual participants who were native Spanish speakers with DLD (6 girls and 14 boys, 5;9 years, min = 5;1, max = 6;6), and 20 monolingual participants who were native Spanish speakers with TD (6 girls and 14 boys, average age = 5;9 years, min = 5;1, max = 6;7). All children had normal hearing, as determined by audiometric screening, nonverbal cognitive abilities within the normal range, measured by Raven's Colored Progressive Matrices (scores at or above the 25th percentile considered normal). Normal or corrected-to-normal vision, and no history of neurological or other conditions impacting language development, based on teacher reports. Children in the TD group met the same criteria, with the exception of the history of language difficulties.

Selection of participants

Our study involved participants diagnosed with DLD, selected from students enrolled in integration programs for children with this disorder in their respective educational institutions. These students had received an initial diagnosis from speech therapists at their schools, following the criteria set by Chile's Ministry of Education (Decree 170). This diagnostic process included the Test for the Evaluation of Phonological Simplification Processes (TEPROSIF-R; Pavez et al., 2008; Cronbach's alpha = 0.90) and the Allen Toronto's Exploratory Test of Spanish Grammar (Pavez, 2003), which measures grammatical skills through both expressive (Cronbach's alpha = 0.77) and receptive (Cronbach's alpha = 0.83) components. Typically, we observed diverse performance profiles among children with DLD. However, to be diagnosed with this disorder, encountering challenges in grammar is a critical criterion. Consequently, every child identified with DLD in the present study exhibited grammar skill deficits, falling below the expected level—specifically two standard deviations beneath the established Chilean norms—on either the expressive or receptive components of the Toronto Exploratory Test of Spanish Grammar. This assessment tool has been validated for its efficacy in distinguishing between children with DLD and those with TD in terms of grammatical abilities within a Chilean context, as shown by Pavez (2003). Besides, comprehensive medical, pedagogical, and psycho-pedagogical assessments were conducted to exclude any additional disorders affecting language development.

In addition, our research team independently evaluated each participant, focusing on language structure elements like grammar and lexical-semantic abilities. This assessment used the Spanish

TABLE 1 Participants' means in Raven and CELF-4 subtests (with standard deviation, SD) for the corresponding pairwise contrasts (Welch two sample *t*-test, two-tailed).

CELF-subtests	DLD (Raw scores)	TD (Raw scores)	*t*-value	*p*-value
Formulated sentences subtest	1.94 (1.77 SD)	–	–	–
Word structure subtests	12.44 (4.07 SD)	–	–	–
CELF–expressive vocabulary	16.3 (4.34 SD)	–	–	–
Word classes subtests	11.79 (5.48 SD)	–	–	–
CELF–expressive vocabulary	16.3 (4.34 SD)	28.9 (8.66 SD)	−5.91	< 0.001
Raven scores	15.85 (4.13 SD)	17.65 (3.73 SD)	−1.41	0.17

adaptation of the Clinical Evaluation of Language Fundamentals (CELF-4; Semel et al., 2003), a benchmark test for linguistic evaluation in children with DLD (Aguado et al., 2015). We administered four CELF-4 subtests: Formulated Sentences, Word Structure, Expressive Vocabulary, and Word Classes. The first two subtests assessed grammatical skills, while the latter two focused on lexical-semantic skills. Participants who scored below the 16th percentile on any subtest were identified as low performing. This evaluation confirmed that all participants with a prior DLD diagnosis had grammatical challenges, and some also had semantic difficulties. The control group, TD children, were matched by age and socio-economic status. Their evaluation also included the Expressive Vocabulary subtest of CELF-4.

All participants underwent additional testing: audiometry to exclude hearing issues (thresholds at or below 20 dB) and Raven's Progressive Matrices to rule out cognitive impairments (no significant differences between groups were found in Raven's test scores, see Table 1). Importantly, based on the reports from teachers at their respective schools, we confirmed that both the DLD and TD groups had no history of neurological or social problems.

Apparatus

During the experiment, participants' gaze was monitored through an EyeLink 1,000 Plus eye tracking system (SR Research, Ontario, Canada). The experiment was implemented with a sampling rate of 500 Hz in remote mode (instead of head-stabilized), as it is usual for studied with children. The images were presented on a high-precision 24-inch monitor (BenQ XL2430). Auditory stimuli were presented through headphones at a moderate volume.

Materials and experimental design

For the experimental task, 20 auditory stimuli and 60 images of familiar objects belonging to 6 common categories (toys, fruits and vegetables, animals, furniture, means of transport, and school supplies) were used. The auditory stimuli consisted of Spanish words referring to 20 of these familiar objects, which were recorded by a female native Spanish speaker. Consequently, the images included 20 referents corresponding to the 20 auditory stimuli, 20 images representing semantic competitors of these referents, and finally, 20 images of objects unrelated to the objects referred to by the auditory stimuli. Table 2 presents the complete set of auditory and visual stimuli used in the experiment.

TABLE 2 Set of materials used in the experiment.

Spoken word and visual target	Semantic competitor	Distractor picture
auto (car)	camión (truck)	lentes (lenses)
betarraga (beet)	pepino (cucumber)	cuadro (picture)
buque (ship)	bote (boat)	gorro (cap)
camioneta (pickup truck)	taxi (cab)	anillo (ring)
chancho (pig)	vaca (cow)	monedero (purse)
coliflor (cauliflower)	cebolla (onion)	guitarra (guitar)
conejo (rabbit)	ratón (mouse)	estuche (case)
durazno (peach)	pera (pear)	violín (violin)
flecha (arrow)	espada (sword)	goma (rubber)
frutilla (strawberry)	melón (melon)	calcetín (sock)
león (lion)	hipopótamo (hippopotamus)	lápiz (pencil)
lobo (wolf)	canguro (kangaroo)	pantalón (pants)
martillo (hammer)	pala (shovel)	flauta (flute)
mesa (table)	cama (bed)	zapato (shoe)
monopatín (skateboard)	bicicleta (bicycle)	polera (shirt)
peluche (plush toy)	muñeca (doll)	bufanda (scarf)
refrigerador (refrigerator)	cocina (kitchen)	domino (domino)
regla (ruler)	destacador (highlighter)	camisa (shirt)
resbalín (slide)	columpio (swing)	piano (piano)
tenedor (fork)	cuchara (spoon)	reloj (watch)

The images of these objects were always presented in pairs, which gave rise to the two experimental conditions of the study depending on their combination. The Competitor-Target (CT) condition presented an object to which the spoken word referred more than its semantic competitor, while the Competitor-Distractor (CD) condition presented an object unrelated to the spoken word in addition to a semantic competitor for that word. Using a Latin square, these experimental conditions, plus the relative position of each object (left or right), were crossed in four experimental lists so that each participant was presented with the same number of repetitions in each experimental condition, with an equal number of referents on the left and right. At the same time, each spoken word appeared in each experimental condition in some list. In summary, the experimental design can be described as a one-factor design with two levels within-participant, within-item.

Procedure

All participants sat comfortably ≈60 cm from the computer screen in a room at their school. Before starting the experiment, 5 points of the eye-tracking system were calibrated and validated. Each child completed an experimental list with a total of 20 trials presented in random order. In each trial, a fixation point was presented in the center of the screen. Once the participant fixated on the central point, the experimenter manually activated the trial. Once the trial started, a cross appeared in the same place where the fixation point had been, and the imperative "Look!" was heard 1,500 ms after the start of the trial. The cross remained in the center for another 1,500 ms, after which the experimental materials (i.e., two images and one spoken word) were presented simultaneously. The images remained on the screen for another 3,000 ms. Once the repetition was completed, the fixation point that allowed the experimenter to start the next trial appeared again on the screen. Participants' eye movements were recorded in each trial. There was no verbal communication with the children while the images were on the screen, but if necessary, the experimenter spoke to the children between repetitions to encourage them to continue. The experiment lasted approximately 5 min. Figure 1 shows a schematic representation of an experimental repetition in the CT condition.

Data analysis

Prior to statistical analysis, the Data Viewer software (SR Research) was used to create two areas of interest and extract a report with the duration and location of each fixation that occurred during each repetition. These areas of interest corresponded to the location and size of the objects presented in the visual context. The time window extended from the beginning of the critical spoken word to the end of the test. Subsequently, we used R Project software (R Core Team, 2018) to isolate each millisecond of the time window of interest and assign a value of 1 each time the participant's gaze fell within one of the areas of interest and a value of 0 each time the participant's gaze fell outside the areas of interest. Using the same software, these data were aggregated into 50 ms time windows for each participant, each item, and each area of interest. Finally, we calculated the average of the proportion of fixations to each area of interest, experimental condition, and group, along with the 95% confidence intervals (adjusted for within-participant designs, see Morey, 2008). Figure 2 provides an overview of the results, revealing the timing and magnitude of the participants' visual preference for the images in the visual context.

To corroborate the confidence intervals, we used a nonparametric analysis based on random permutations of experimental condition labels in clusters (see Barr et al., 2014; Kronmüller et al., 2017; Chan et al., 2018; Kronmüller and Noveck, 2019; Barzy et al., 2020). Before implementing this analysis, we calculated our dependent variable defined as the logarithmic transformation of the ratio between visual preference for the semantic competitor and the accompanying image (i.e., the referent in the CT condition and the distractor in the CD condition), which we will call log-ratio (Arai et al., 2007). This variable provides a unique index of the difference between the proportion of fixations between the two objects present at the same time in the visual context. Positive values of the log-ratio reflect a preference for the semantic competitors, while negative values represent a preference for the other object (i.e., the referent or distractor depending on the experimental condition).

After these transformations, we carried out a cluster analysis. The first stage of analysis consisted of identifying the initial clusters from

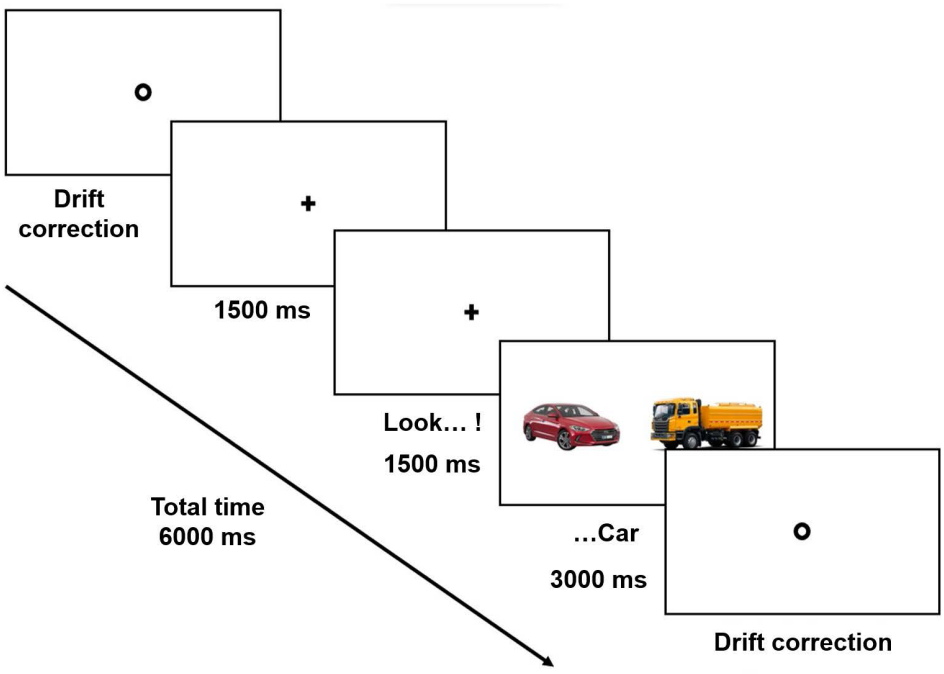

FIGURE 1
Schematic presentation of an experimental repetition in the CT condition.

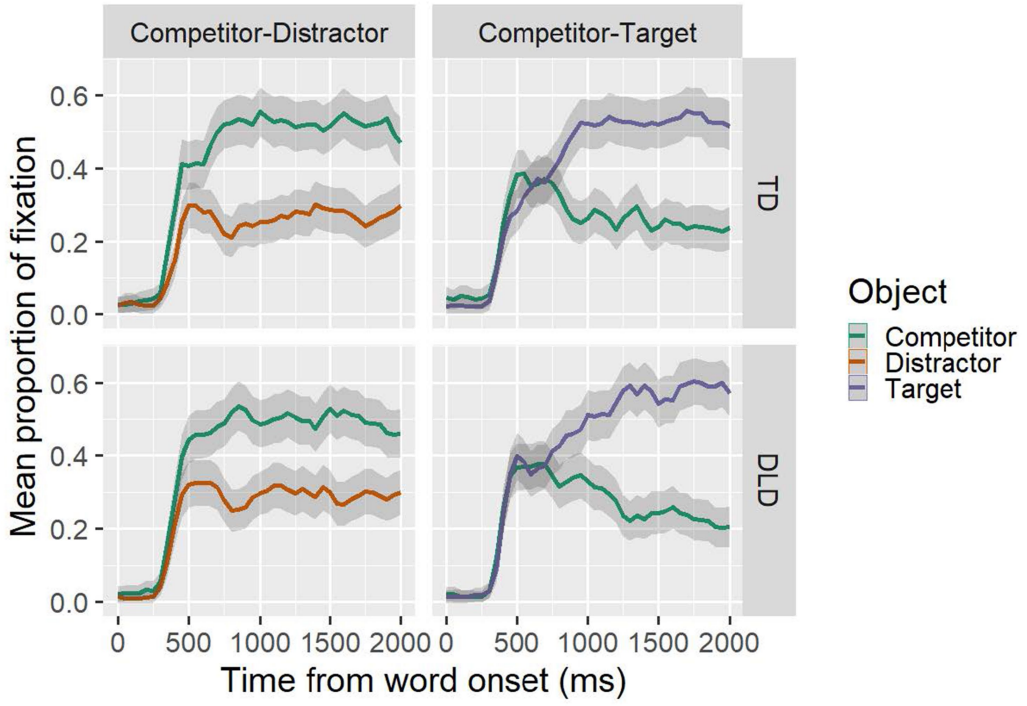

FIGURE 2
Temporal course of the average fixation proportion for each group in each experimental condition. The lines represent the different objects in the visual context, while the gray shaded area around each line represents the 95% confidence intervals (adjusted for within-participant designs).

the contrast between the group of children with TD and the control group of DLD (for each experimental condition), as well as the contrast between the log-ratio and a distribution equal to zero (i.e., without object preference) for each group independently (see Barzy et al., 2020; Guerra et al., 2021; Christou et al., 2022a,b; Coloma et al., 2024). Using the lmerTest R package (Kuznetsova et al., 2017), we determined statistical significance for each 50 ms time interval by performing a mixed-effects linear regression on our dependent variable with group (i.e., TD, DLD, or zero) as a fixed effect and random intercept for participants and items. This was done for each time window and experimental condition separately. Subsequently, time windows composed of at least three consecutive 50 ms intervals showing statistical significance ($p < 0.05$) were aggregated.

The second stage consisted of constructing null hypothesis distributions through permutations. We created three null hypothesis distributions of *t*-values: one by randomly permuting the group labels (i.e., TD and DLD), and two others by randomly permuting the TD label with the ZERO label (from a distribution with no preference) and the DLD label with the ZERO label. All permutations were based on 2000 simulations in which each 50 ms time window was contrasted with randomly permuted labels. After obtaining the *t*-distributions, these values were aggregated by cluster and randomization, and then the absolute largest summed *t*-value was identified for each simulation, and finally these values were summed for each cluster.

The statistical significance of each cluster was determined by calculating the proportion between the sums of the highest *t*-values in the random distributions, which were greater than the sum of the *t*-values obtained for each cluster in our data. Following Chan et al. (2018), we considered proportions below 0.025 to be significant.

Results

As can be seen in Figure 2, both groups preferred the semantic competitor in those repetitions in the CD condition and the visual referent in the repetitions in the CT condition. In this context, the cluster analysis did not detect significant differences between the groups (TD vs. DLD). In contrast, the clusters identified based on the contrast between each of the experimental groups and the zero distribution (TD vs. ZERO; DLD vs. ZERO) for each experimental condition appeared as significant.

Table 3 presents the experimental condition, the contrast, duration, observed sum of t values, and *p*-values for these clusters.

As shown in Figure 3, participants from both groups quickly directed their gaze toward the semantic competitor shortly after the start of the spoken word in the CD condition. Specifically, 500 ms after the word onset for the TD participant group, and 600 ms for the DLD participant group. Similarly, both groups discarded the semantic competitor when presented in combination with the visual referent of the spoken word. Around 850 ms after the word onset, TD participants unequivocally directed their gaze towards the visual referent of the word, while the DLD participants preferred the visual referent after 1,000 ms from the word onset. Finally, as clearly shown in Figure 3, there were no significant differences between groups (TD vs. DLD) in the preference for the semantic competitor in any of the experimental conditions.

Discussion

The aim of the present study was to investigate whether children with DLD experience difficulties in processing lexical-semantic

information. To do so, children were engaged in a semantic competition task that involved the real-time comprehension of spoken words in a visually situated context while their eye movements were recorded. Spoken words were presented simultaneously as the visual objects appeared on the screen, providing children with limited time for visual exploration before processing the spoken word. Our results indicate a pattern of lexical access to frequent words and evidence a competition effect in preschoolers with DLD that is very similar to their peers with TD. These results contrast with existing evidence using production tasks (McGregor, 1997; McGregor et al., 2002; Messer and Dockrell, 2006; Ponari et al., 2018), where differences in lexical retrieval and semantic processing have been reported.

Specifically, our findings reveal that when interacting with relatively frequent words and objects, children with DLD shift their attention away from the semantic competitor and focus on the named object as TD children do, suggesting no significant difficulties in lexical retrieval processing. This observation contrasts with the findings of Andreu et al. (2012a), who reported a slower pace in matching spoken words with their visual referents in children with DLD compared with their age matched peers. However, it is important to notice that this difference was more pronounced for verbs than for nouns in their study. Given that our study involved very familiar nouns only, it is plausible that this familiarity facilitated word retrieval processing in children with DLD.

Furthermore, both groups demonstrated a preference for the semantic competitor while disregarding the unrelated object, exhibiting no statistically significant differences in the real-time activation of semantic relationships. These findings suggest that lexical-semantic processing of familiar words is preserved in children with DLD. However, these results contrast with the findings from Helo et al. (2022), who reported a shorter semantic competition effect in children with DLD compared to their age-matched peers, suggesting a weaker connection between semantically associated words in this group. In Helo et al. (2022), the visual objects were presented 3 seconds before the spoken word, whereas in the present study, the presentation of visual stimuli and the spoken word was simultaneous. This simultaneous presentation was designed to increase task difficulty compared to Helo et al. (2022), as it gave children no prior time to activate the semantic information of the objects on the screen. Despite this, the results show that children with DLD exhibit a pattern similar to TD children. Although this result might initially seem counterintuitive, previous research has demonstrated that differences between children with and without DLD are more apparent in easier tasks compared to more difficult ones (see Christou et al., 2022a). When presented with more challenging visual world tasks, both groups of children (TD and DLD) may require additional time or show increased uncertainty in identifying the relevant visual target, potentially masking group differences. Conversely, in easier visual world tasks, it is possible that only the DLD group falls behind.

It is important to notice that even though the temporal course of preference for the competitor and the referent were almost identical in both groups, minimal differences were observed (see Table 3). Children with DLD look slightly earlier at the semantic competitor (100 ms earlier) when it was presented with an unrelated object, and they look slightly later to the target (150 ms later) when it was presented with a semantic competitor. It is known that semantic competition is related to the activation and inhibition of lexical candidates (Rumelhart and McClelland, 1982). Thus, these two small

TABLE 3 Results of the cluster analysis.

Experimental condition	Contrast	Starts	Ends	*t* value	*p*-value
Competitor-Distractor (CD)	TD vs. ZERO	600	2000	105.58	<0.001
Competitor-Distractor (CD)	DLD vs. ZERO	500	2000	91.37	<0.001
Competitor-Target (CT)	TD vs. ZERO	850	2000	−104.10	<0.001
Competitor-Target (CT)	DLD vs. ZERO	1,000	2000	−109.96	<0.001

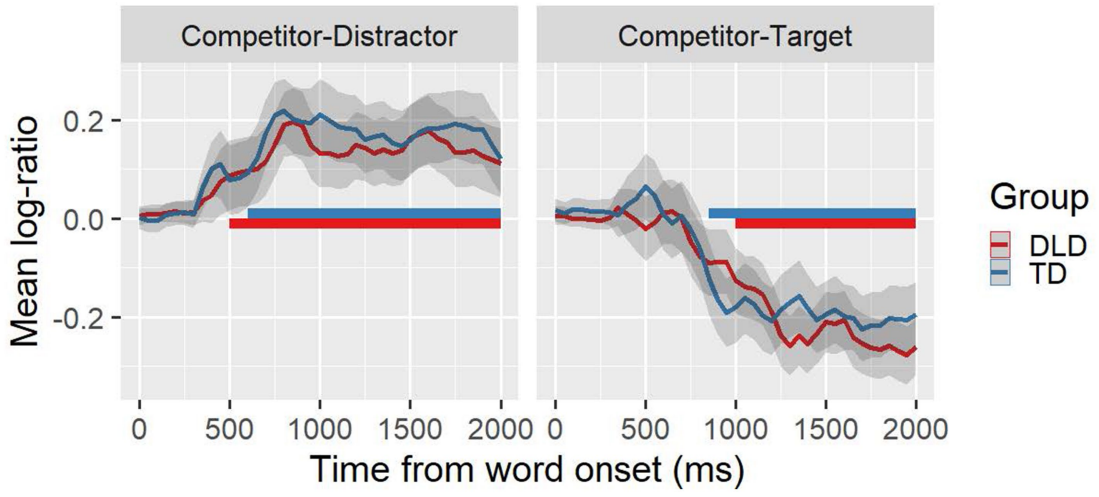

FIGURE 3
Temporal course of the average log-ratio (diverging lines) and extent of significant clusters (horizontal bars) for each group in each experimental condition. The lines of different colors represent the groups (TD, DLD), while the gray shaded area around each line represents the 95% confidence intervals (corrected for within-participant designs). The horizontal bars represent the extent of the clusters identified as significant.

differences could be linked to a greater lexical-semantic competition effect in participants with DLD similar to the greater phonological and semantic competition effect observed by McMurray et al. (2010) and Helo et al. (2022), respectively. Indeed, existing research has previously suggested that children with DLD are characterized by inhibitory inefficiency (Larson et al., 2020). A recent meta-analysis (Pauls and Archibald, 2016) demonstrated that children with DLD have inhibition difficulties, even though the severity of these difficulties depends on each child's profile (Dispaldro et al., 2013). Such inhibitory deficit might allow irrelevant information to occupy working memory making processing less efficient and slower (see Marton et al., 2007). Previous work on young TD children (Marchman and Fernald, 2008) suggest that less efficient processing demand more extensive exposure to words to achieve comparable levels of representational depth, leading to slower vocabulary growth and weaker phonological and lexical relationships. Thus, these difficulties may be interconnected and potentially underlie the lower lexical skills observed in this population. However, since these differences were small and their direct contrast appeared not to be significant, further investigation is needed to corroborate this assumption.

Our study offers valuable insights into lexical-semantic competition in preschoolers with DLD but also presents several limitations. The relatively small, monolingual Spanish-speaking sample may limit the generalizability of our findings to other linguistic groups or bilingual populations. Additionally, focusing exclusively on high-frequency nouns might not fully represent the diverse lexical challenges faced by children with DLD, particularly with less frequent words or different parts of speech, such as verbs.

In sum, the results of this research show that lexical access to frequent words is as developed in monolingual preschoolers with DLD as in their TD peers, suggesting that semantic difficulties in this population are less severe in comprehension than production. Future research should confirm if this is the case for less frequent words. Regarding lexical competition, and without forgetting the absence of significant differences between the groups, children with DLD show a temporal course that suggests greater lexical-semantic competition, which could be related to the inhibition difficulties previously reported in this population. As a take-home message, our results contribute to a growing body of evidence suggesting that while children with DLD face challenges in linguistic abilities, they may be more resilient than previously understood.

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, Facultad de Medicina. 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

EG: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. CC: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. AH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Software, Visualization, Writing – original draft, 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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Who spoke that language? Assessing early face-language associations in monolingual and bilingual infants

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Introduction: In bilingual communities, knowing the language each speaker uses may support language separation and, later, guide language use in a context-appropriate manner. Previous research has shown that infants begin to form primary associations between the face and the language used by a speaker around the age of 3 months. However, there is still a limited understanding of how robust these associations are and whether they are influenced by the linguistic background of the infant. To answer these questions, this study explores monolingual and bilingual infants' ability to form face-language associations throughout the first year of life.

Methods: A group of 4-, 6-, and 10-month-old Spanish and/or Catalan monolingual and bilingual infants were tested in an eye-tracking preferential-looking paradigm (N=156). After the infants were familiarized with videos of a Catalan and a Spanish speaker, they were tested in two types of test trials with different task demands. First, a Silent test trial assessed primary face-language associations by measuring infants' visual preference for the speakers based on the language they had previously used. Then, two Language test trials assessed more robust face-language associations by measuring infants' ability to match the face of each speaker with their corresponding language.

Results: When measuring primary face-language associations, both monolingual and bilingual infants exhibited language-based preferences according to their specific exposure to the languages. Interestingly, this preference varied with age, with a transition from an initial familiarity preference to a novelty preference in older infants. Four-month-old infants showed a preference for the speaker who used their native/dominant language, while 10-month-old infants preferred the speaker who used their non-native/non-dominant language. When measuring more robust face-language associations, infants did not demonstrate signs of consistently matching the faces of the speakers with the language they had previously used, regardless of age or linguistic background.

Discussion: Overall, the results indicate that while both monolingual and bilingual infants before the first year of life can form primary face-language associations, these associations remain fragile as infants seemed unable to maintain them when tested in a more demanding task.

KEYWORDS

infant bilingualism, speaker perception, face-language associations, native language preference, preferential looking

1 Introduction

Infants growing up in bilingual contexts face the challenge of learning two languages simultaneously. To succeed, they need to form separate linguistic representations for each of their languages and learn to use them appropriately according to the social context. Learning which language a speaker uses may become a useful strategy during bilingual language acquisition, since a speaker's identity could serve as an additional cue to further support language separation (Kandhadai et al., 2014). Furthermore, it may also serve as the basis for selecting and using the appropriate language with different speakers, thus maximizing children's communicative skills and improving their social interactions. At the age of two, bilingual children start modulating their language use depending on the language most commonly spoken by the person they are interacting with (Lanza, 1992; Genesee et al., 1995, 1996; Nicoladis and Genesee, 1996; Nicoladis, 1998). These findings suggest that at that age, bilingual children are already aware of the languages used by specific speakers. However, little is known about the age at which bilingual infants start associating a speaker with the language they use.

Early in development, infants detect the audiovisual correspondence between the auditory and visual information provided by a speaker (Kuhl and Meltzoff, 1982; Patterson and Werker, 2003). This enables the formation of audiovisual associations, such as those between speakers' facial features and the specific characteristics of their voices. For instance, newborns show a preference for their mother's face, but only after being simultaneously exposed to both her face and voice (Sai, 2005). To develop this visual preference with such limited exposure to the face, infants need to have formed a face-voice association, most likely prompted by the high familiarity with their mother's voice acquired during pregnancy. After a few months, infants are able to match their parents' faces with their corresponding voices (Spelke and Owsley, 1979).

Additional studies on these audiovisual associations have focused on infants' ability to learn face-voice pairings of unfamiliar speakers (Brookes et al., 2001; Bahrick et al., 2005). In both studies, infants were habituated with two different face-voice pairings and then presented with test trials where the pairings had been switched. Infants that were 3, 4, and 6 months old, but not 2 months old, detected a change in the face-voice combinations, implying they had learned the associations. Interestingly, the study by Bahrick et al. (2005) included a subsequent preferential-looking test phase where they assessed infants' ability to match the faces of the habituation speakers with their corresponding voices after a 10-min break. To succeed in this task, infants needed to be able to retain the previously learned face-voice pairings and use this knowledge to guide their looking behavior as the voices played in the background. Due to the increased cognitive demands of this second test, only 6-month-old infants looked preferentially to the correct face when listening to its corresponding voice.

However, more recent studies have found it difficult to replicate these promising findings with unfamiliar speakers. For example, Fecher et al. (2019) found that 16- to 17-month-old infants only looked at the face corresponding to the voice being played when the face-voice pairings differed in gender. Using pairings from different genders simplifies the task by increasing the discriminability between the faces and voices. Furthermore, infants at this age are expected to have already formed audiovisual categories for each gender based on their experience with males and females (Hillairet de Boisferon et al., 2015; Richoz et al., 2017). This makes it difficult to determine whether infants have truly learned the specific audiovisual characteristics of each speaker, or if the face-voice matching is based on gender. Conclusive evidence of infants associating faces and voices of unfamiliar speakers of the same gender is not found until 24 months of age (Orena et al., 2022).

Altogether, these results suggest a gradual maturation of face-voice associations throughout development (Fecher et al., 2019). Tasks with low demands, such as measuring infants' ability to detect changes in face-voice pairings, can be solved at an early age by forming primary associations between the acoustic and visual properties of speakers. In contrast, tasks with higher demands, such as measuring infants' ability to match speakers' faces with their corresponding voices, require more robust face-voice associations as infants must encode, store in memory, and then retrieve the pairings. Accordingly, these associations do not consistently appear until the second year of life.

Languages themselves can be considered an important feature of a speaker's identity and be associated with certain physical attributes, such as those related to race (Uttley et al., 2013; May et al., 2019). This suggests that infants may also be able to form audiovisual associations between the specific attributes of speakers' faces and the languages they use. For face-language associations to take place, infants must first be able to discriminate between languages and between faces.

Studies have already demonstrated that language discrimination is present from birth, as newborns from both monolingual and bilingual environments are able to acoustically discriminate between two languages when they belong to different rhythmic categories (Nazzi et al., 1998; Byers-Heinlein et al., 2010). Furthermore, newborns from monolingual mothers show recognition and preference for their native language (Moon et al., 1993; Byers-Heinlein et al., 2010), while those from bilingual mothers show no preference between their languages despite being able to discriminate them (Byers-Heinlein et al., 2010). The auditory discrimination between languages that belong to the same rhythmic class does not appear until around 4 to 5 months of age for monolingual infants, as long as one of the compared languages is their native one (Bosch and Sebastián-Gallés, 1997; Nazzi et al., 2000). Data from bilingual infants learning two rhythmically similar languages, such as Spanish and Catalan, also reveals that the ability to discriminate between them develops at a similar age (Bosch and Sebastián-Gallés, 2001) or even slightly earlier, by 3 months of age, for Basque-Spanish bilingual infants (Molnar et al., 2014).

Regarding face discrimination, 3-month-old infants are able to discriminate own-race and other-race faces, but the ability to discriminate other-race faces declines with age and is no longer present in 9-month-old infants (Kelly et al., 2007). Similarly, 3-month-old infants discriminate adult and infant faces, while 9-month-old infants are only able to discriminate adult faces (Macchi Cassia et al., 2014). In both cases, older infants' ability to discriminate faces of a certain social category depends on the presence of that specific category in their visual environment. By 3 months of age, infants can discriminate between two female faces (Barrera and Maurer, 1981), and a few months later, they show evidence of discriminating both male and female faces (Righi et al., 2014).

When considering both aspects together, research revealed that language influences face perception and discrimination (de Boisferon et al., 2021; Clerc et al., 2022). Furthermore, Kinzler et al. (2007) found

that infants can develop visual preferences for the faces of speakers based on the language they had previously used. In this study, monolingual infants were familiarized with videos of two speakers, one speaking the infants' native language and the other using an unfamiliar language. The test phase consisted of a preferential-looking paradigm where infants were presented with static side-by-side pictures of both speakers in silence. Five- to six-month-old monolingual infants showed a visual preference for the speaker that had previously spoken in their native language. A recent study by Colomer et al. (2023) replicated and extended those findings. They found that the preference for speakers of the native language is present even earlier, in 3- to 6-month-old monolingual infants. However, this preference seems to disappear later in life, as 8- to 11-month-old infants no longer preferred looking at the native language speaker (Colomer et al., 2023). Similar developmental patterns have been observed when exploring visual preferences for other speaker characteristics, such as gender (Quinn et al., 2002; Liu et al., 2015a) and race (Liu et al., 2015b; Fassbender et al., 2016). In both cases, young infants showed a preference for the attributes that were more present in their environment, and therefore more familiar to them. In older infants, this familiarity preference started to fade. Interestingly, in the case of race, 9-month-old infants not only stopped showing a visual preference for own-race faces but also started preferring to look at other-race faces (Liu et al., 2015b; Fassbender et al., 2016). The shift from a familiarity to a novelty preference suggests a more exploratory behavior in older infants.

Although the studies by Kinzler et al. (2007) and Colomer et al. (2023) focus on how language influences speaker perception and infants' social cognition, they provide evidence of early face-language associations. As there is no pre-existing relationship between the physical appearance of a speaker and the language they use, infants must have formed some type of association between the auditory aspects of the language and the face of the speaker in order to express a language-based visual preference. However, these studies do not allow researchers to assess the robustness of the association and retention of the face-language pairings. Infants could show a preference for native-language speakers because they have learned what language each speaker uses, or more simply, because they have classified the speaker as "familiar" based on the language they used. Although these previous studies indicate the formation of at least primary face-language associations, it remains to be seen whether more robust face-language associations can also be formed during these early stages of development.

Recent research has aimed to directly explore the association between languages and speakers in 5-, 12-, and 18-month-old infants (Schott et al., 2023). The goal of the study was to determine when the ability to associate a speaker with a language emerges and whether the ability is modulated by linguistic background. Bilingual experience has been reported to enhance speaker processing abilities when linguistic information is involved. Studies in 9-month-old infants revealed that both monolinguals and bilinguals were able to detect a change in face-voice pairings when the language used was their native language (Fecher and Johnson, 2022), but only bilinguals succeeded when tested in a foreign language (Fecher and Johnson, 2019, 2022). Furthermore, bilingual infants could benefit more from learning which language speakers use, as it may further support language separation. Accordingly, Schott et al. (2023) tested monolingual (exposed either to French or English) and bilingual infants (exposed to both French and English). The task consisted of a familiarization-switch procedure with two conditions. In the auditory-only condition, participants only heard the speakers, while in the audiovisual condition, participants saw and heard the speakers. First, infants were familiarized with the two speakers, one speaking English and the other French. Then, they assessed language-speaker associations by testing whether they detected a change in the pairings when the speakers used the opposite language. Regardless of age, linguistic background, or condition, infants showed no signs of detecting changes in the speaker-language pairings, providing no evidence of the formation of associations between speakers and the language they used. However, as the authors pointed out, the null results could be partially due to the selected familiarization-switch paradigm, which may not be the most suitable for assessing this ability in infants growing up in a bilingual community. Given that these infants might be accustomed to speakers switching between two languages, they may not react to changes in speaker-language pairings regardless of whether they had detected the change. If that is the case, the familiarization-switch paradigm could fail to reflect infants' ability to form face-language associations.

In summary, while previous research has shown that monolingual infants begin to establish primary face-language associations around the age of 3 months, there is still a limited understanding of how robust these associations are and whether they are influenced by the linguistic background of the infant.

The current study investigates these questions by exploring the development of both primary and more robust face-language associations in monolingual and bilingual infants throughout the first year of life. For this purpose, 4-, 6-, and 10-month-old monolingual (exposed either to Catalan or Spanish) and bilingual infants (exposed to both Catalan and Spanish) were recruited and tested in a preferential-looking paradigm. After being familiarized with two speakers, one speaking Spanish and the other Catalan, infants were tested on two types of test trials with different task demands: the Silent test trial and the Language test trials.

In the Silent test trial, infants were presented with side-by-side static pictures of the speakers with no sound. The aim was to assess primary face-language associations by measuring infants' visual preference for the speakers depending on the language they had previously used, as in Colomer et al. (2023) and Kinzler et al. (2007). If infants' looking behavior is influenced by the language used by the speakers, then they must have established some form of association between the languages and the physical appearance of the speakers. Both monolingual and bilingual infants were expected to be able to form primary face-language associations early on. Based on the previously mentioned studies, 4- and 6-month-old monolinguals were expected to show a preference for the native language speaker. This preference was also expected to disappear by 10 months of age, as previously reported by Colomer et al. (2023). Crucially, no study to date has explored bilingual infants' preference for speakers using one or the other of their languages. Therefore, the predictions regarding bilingual infants were less clear. One possibility was for bilingual infants to behave similarly to monolinguals and show a preference for the speaker of their dominant language (i.e., the language they are more exposed to). Alternatively, they could show no preference for either speaker since both languages were familiar and native to them, regardless of their ability to form primary face-language associations.

In the Language test trials, infants were presented with the same side-by-side static pictures of the speakers while an audio recording played simultaneously, one trial in Catalan and the other in Spanish. The aim was to assess more robust face-language associations by measuring infants' ability to match the speakers' faces with their corresponding languages. If infants look longer at the speaker who used the language being played in the background, then they must have retained the previously learned face-language pairings. This task has higher demands, as infants need to encode and store the two face-language pairings in their memory, and then retrieve them when they hear the languages. Due to the increased difficulty of these trials, only 10-month-old infants were expected to solve the task. In addition, bilingual infants were expected to outperform monolingual infants and show robust face-language associations earlier. Due to their richer and more complex sociolinguistic environment, bilingual infants may benefit more from associating languages with speakers and may use this strategy to promote language separation during their dual language acquisition. This could be especially important for bilingual infants learning two similar languages, as they face a bigger challenge discriminating their languages. Moreover, research suggests that exposure to two languages may promote adaptative attentional control mechanisms (D'Souza and D'Souza, 2021), which could further enhance bilingual infants' performance in this experimental task.

2 Materials and methods

2.1 Participants

The final sample consisted of 156 infants aged 4, 6, or 10 months living in Catalonia, Spain. All participants were full-term babies with normal birth weight and no reported developmental delays or hearing or vision problems. Infants were learning Catalan and/or Spanish and were classified as monolingual or bilingual based on their language exposure, measured using the Language Exposure Assessment Tool (LEAT) (DeAnda et al., 2016). Infants with more than 10% exposure to a language other than Catalan or Spanish were excluded. For monolingual consideration, infants must have been exposed predominantly to one of the languages or have had less than 20% exposure to the other. For bilingual consideration, infants' relative exposure to the two languages must have ranged between 50–50% and 25–75%.

Following previous studies on this topic (Kinzler et al., 2007; Colomer et al., 2023), as well as general recommendations for infant studies (Oakes, 2017), sample sizes between 20 and 32 participants per age and linguistic group were targeted. In the 4-month-old group ($N = 56$, age range = 3.4–4.6 months, mean age = 4.2 months, SD = 0.3), 32 were monolingual (mean L1 = 94%, SD = 7.0, 12 Catalan dominant) and 24 were bilingual (mean L1 = 61.8%, SD = 8.3, 10 Catalan dominant). In the 6-month-old group ($N = 50$, age range = 5.5–7.8 months, mean age = 6.5 months, SD = 0.5), 27 were monolingual (mean L1 = 96.7%, SD = 6.2, 8 Catalan dominant) and 23 were bilingual (mean L1 = 63.5%, SD = 8.5, 10 Catalan dominant). In the 10-month-old group ($N = 50$, age range = 8.7–11.9 months, mean age = 10.3 months, SD = 0.9), 27 were monolingual (mean L1 = 89%, SD = 8.4, 17 Catalan dominant) and 23 were bilingual (mean L1 = 59%, SD = 7.5, 12 Catalan dominant).

Sixty-two additional infants were tested but excluded because of preterm birth (9), fussiness or excessive crying (27), exposure to a language other than Spanish or Catalan (12), or not providing enough data in the test trials (14, see Data Preprocessing below).

2.2 Stimuli

Familiarization stimuli consisted of 10-s videos of a female uttering a monologue in an infant-directed (ID) manner. In half of the videos, a native speaker of Catalan was recorded, and in the other half, a native speaker of Spanish. Both speakers were Caucasian and had dark hair with a similar hairstyle (see Figure 1).

The Silent test trial consisted of one 8-s trial presenting two side-by-side static images of the speakers from familiarization in silence. The Language test trials consisted of two 8-s trials showing the same static images, but this time accompanied by a voice recording playing simultaneously, one trial in Catalan and the other in Spanish. These audio clips were extracted from the familiarization stimuli.

2.3 Procedure

Infants were seated in an infant seat in a sound-attenuated and dimly lit room, approximately 60 cm in front of a 17″ computer monitor. Infants' eye movements were recorded at a sampling rate of 60 Hz using the Tobii X120 standalone eye tracker (Tobii Technology AB, Danderyd, Sweden). Stimuli were presented on the monitor using the Tobii Studio software (version 2.0.8). The Tobii eye tracker's five-point calibration routine was used to calibrate each participant's gaze. Once calibration was successfully completed, the familiarization phase started. Infants were exposed to a total of eight 10-s videos, 4 in Catalan and 4 in Spanish. The videos were presented in a language-alternated order and the starting language was counterbalanced across infants. Familiarization was followed by the test phase. Infants were first presented with the Silent test trial in which they watched one 8-s trial with side-by-side pictures of the speakers in silence. Immediately after, they were presented with the Language test trials, in which they watched two 8-s trials with side-by-side pictures of the speakers while a voice recording played in the background, one trial in Spanish and the other in Catalan. The order of appearance of the languages was counterbalanced across participants. During the test phase, the side in which each speaker appeared was consistent for each participant but counterbalanced across participants. See Figure 1 for a visual representation of the experimental task.

In the test trials, the eye-tracker monitored the infants' gaze at three areas of interest (AOI), one for the face of each speaker and one for the entire screen. The proportion of total looking time (PTLT) toward each of the speakers was then computed by dividing the time infants spent looking at each speaker's face by the time they spent looking at the screen during each trial.

2.4 Data preprocessing

In the test phase, trials where infants contributed less than 20% of total looking time were excluded, as in Frank et al. (2012) and Birulés et al. (2019). Participants were required to provide data from at least

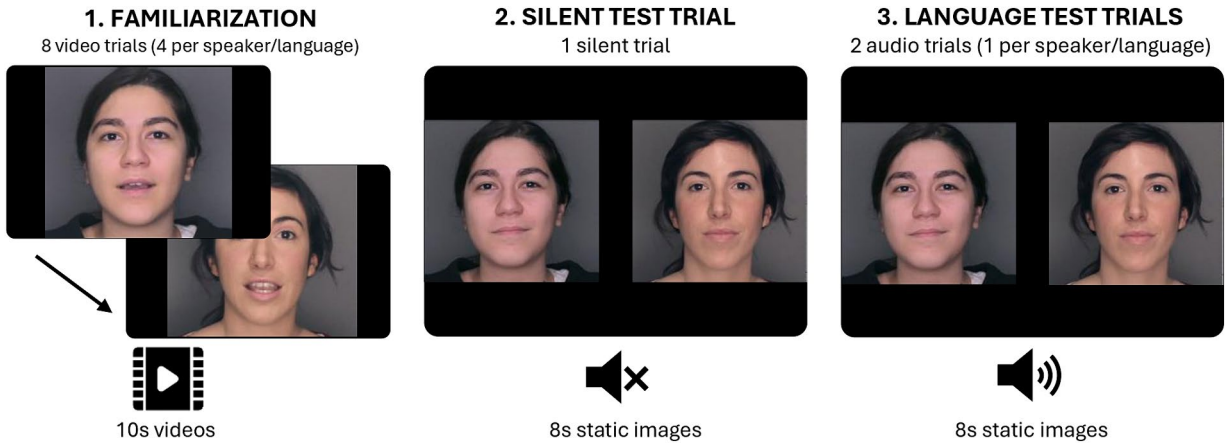

FIGURE 1
Schematic representation of the three phases in the experimental task: Familiarization, Silent test trial, and Language test trials.

the Silent test trial. For the Language test trials to be included, participants had to provide data for both trials, one in each language.

In the Silent test trial, the speakers were labeled according to infants' language exposure. For monolingual infants, they were labeled as "native-language speaker" or "non-native-language speaker." However, for bilingual infants, both languages were native. Therefore, the speakers were labeled as "dominant-language speaker" or "non-dominant-language speaker" depending on whether the speakers used the language infants were most or least exposed to.

In the Language test trials, the speakers were labeled as "match speaker" and "mismatch speaker," depending on whether or not the voice recording matched the language they had used during familiarization. These trials were labeled according to infants' language exposure: "native trial" or "non-native trial" for monolingual infants, and "dominant trial" or "non-dominant trial" for bilingual infants.

2.5 Data analysis

All data analyses were conducted using R (R Core Team, 2020). To measure infants' formation of primary and more robust face-language associations, mixed-effects analyses were conducted separately for the Silent and the Language test trials. For each type of test trial, a mixed-effects ANOVA was performed using the "ezANOVA" function of the "ez" package (Lawrence, 2016). *Post-hoc* comparisons were performed using two-tailed paired *t*-tests.

For consistency reasons, the Silent test trial had the same duration as the Language test trials. In the Language test trials, infants needed to process the language of the recording, the two faces, and then recognize and show a preference for the speaker that previously used that language during familiarization. However, in the Silent test trial, infants did not need to process any auditory stimuli which may have required less time to visually process the two faces and show a preference toward one of the speakers. In fact, recent research has used 6-s test trials to measure visual preference for speakers of the native language (Colomer et al., 2023). To further assess potential differences in infants' behavior throughout the course of the test trials, the previous analysis was repeated for the first and the second half of each trial separately.

3 Results

3.1 Silent test trial

To assess primary face-language associations, infants' visual preference for the speakers based on the language they had previously used was analyzed, as in Kinzler et al. (2007) and Colomer et al. (2023) studies. The visual preference for the speakers was evaluated by a mixed-effects ANOVA with PTLT as the dependent variable. Speaker (Native/Dominant vs. Non-native/Non-dominant) was included as a within-subjects variable, and Linguistic Background (Monolingual vs. Bilingual) and Age (4, 6, and 10 months) as between-subjects variables.

The ANOVA revealed a nearly significant Speaker main effect ($F(1, 150) = 3.11$, $p = 0.08$) and Speaker × Age interaction ($F(2, 150) = 2.72$, $p = 0.07$). None of the other main effects or interactions approached significance (all $ps > 0.1$). As a group, infants showed a marginally significant preference for the speaker of the native/dominant language ($M = 0.50$, SD = 0.23) compared to the speaker of the non-native/non-dominant language ($M = 0.44$, SD = 0.24; $t(155) = 1.85$, $p = 0.07$). Based on the theoretical expectations and the nearly significant Speaker × Age interaction, the PTLT to each speaker was compared in each age group separately. Four-month-old infants looked significantly more at the speaker of their native/dominant language ($M = 0.55$, SD = 0.28) rather than at the speaker of their non-native/non-dominant language ($M = 0.39$, SD = 0.29; $t(55) = 2.05$, $p < 0.05$). No preference was observed in 6- and 10-month-old infants speakers ($t(49) = 1.37$, $p = 0.18$; $t(49) = -0.97$, $p = 0.34$, respectively).

To assess potential differences in infants' looking behavior throughout the course of the Silent test trial, the previous mixed-effects ANOVA was repeated for the first and the second half of the trial separately.

In the first half of the Silent test trial, a significant Speaker × Age interaction was found ($F(2,150) = 4.78$, $p < 0.01$). None of the other main effects or interactions were significant (all $ps > 0.1$). This interaction was further explored by comparing the PTLT to each speaker in each age group separately. Four-month-old infants preferred to look at the speaker that used their native/dominant language ($M = 0.54$, SD = 0.33), compared to the speaker that used their non-native/non-dominant language ($M = 0.36$, SD = 0.32;

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$t(55) = 2.18$, $p < 0.05$). Six-month-old infants looked similar at both the native/dominant ($M = 0.49$, SD = 0.28) and the non-native/non-dominant language speaker ($M = 0.44$, SD = 0.26; $t(49) = 0.63$, $p = 0.53$). Ten-month-old infants looked significantly more at the non-native/non-dominant language speaker ($M = 0.53$, SD = 0.22), compared to the native/dominant language speaker ($M = 0.40$, SD = 0.19; $t(49) = -2.40$, $p < 0.05$). These results are depicted in Figure 2. As indicated by the absence of a significant Linguistic Background main effect or its interactions, the obtained results did not differ between monolingual and bilingual infants (see Figure 3). When analyzing separately monolingual and bilingual infants at each age, four-month-old bilinguals showed a marginally significant visual preference for the speaker of their dominant language ($M = 0.57$, SD = 0.31), compared to the speaker of the non-dominant language ($M = 0.33$, SD = 0.29; $t(23) = 1.99$, $p = 0.06$). In addition, ten-month-old monolinguals showed a marginally significant visual preference for the speaker of their non-native language ($M = 0.55$, SD = 0.22), compared to the speaker of their native language ($M = 0.41$, SD = 0.22; $t(26) = -1.72$, $p = 0.09$).

In the second half of the Silent test trial, the ANOVA did not reveal any significant main effect or interaction (all $ps > 0.1$).

3.2 Language test trials

To assess robust face-language associations, infants' visual preference for the speakers was analyzed while a voice recording was playing simultaneously, one for each of the languages from familiarization. If infants had associated each speaker with the language they used, they should have looked longer at the corresponding speaker when the language was playing in the background. This was evaluated by a mixed-effects ANOVA with PTLT as the dependent variable. Speaker (Match vs. Mismatch) and Trial Language (Native/Dominant vs. Non-native/Non-dominant) were included as within-subjects variables, and Linguistic Background (Monolingual vs. Bilingual) and Age (4, 6, and 10 months) as between-subjects variables.

The ANOVA revealed a significant Speaker × Linguistic Background × Age triple interaction ($F(2,133) = 3.24$, $p < 0.05$). None of the other main effects or interactions were significant (all $ps > 0.1$). To better understand the triple interaction, both Language test trials were combined, and the Speaker × Linguistic Background interaction was assessed separately in each age group. The interaction was only significant at 4 months of age ($F(1,48) = 5.09$, $p < 0.05$). Four-month-old monolingual infants showed no preference for either the speaker matching the language of the recording ($M = 0.43$, SD = 0.11) or the speaker who used the opposite language ($M = 0.48$, SD = 0.13; $t(27) = -1.15$, $p = 0.26$), but four-month-old bilingual infants showed a marginally significant preference for the matching speaker ($M = 0.50$, SD = 0.18) compared to the mismatching speaker ($M = 0.39$, SD = 0.14; $t(21) = 1.89$, $p = 0.07$). See Figure 4.

To assess potential differences in infants' looking behavior throughout the course of the Language test trials, the previous mixed-effects ANOVA was repeated for the first and the second half of the trials separately.

In the first half of the Language test trials, a Speaker × Linguistic Background × Age triple interaction was observed again ($F(2,133) = 3.1$, $p < 0.05$). None of the other main effects or interactions were significant (all $ps > 0.1$). As before, both Language test trials were combined, and the Speaker × Linguistic Background interaction was assessed separately at each age. The interaction was not significant at any age, but approached significance at 6 months of age ($F(1,44) = 3.37$, $p = 0.07$). Six-month-old monolingual infants showed no preference for either the speaker matching the language of the recording ($M = 0.44$, SD = 0.14) or the speaker who used the opposite language ($M = 0.41$, SD = 0.15; $t(24) = 0.49$, $p = 0.63$), but 6-month-old bilingual

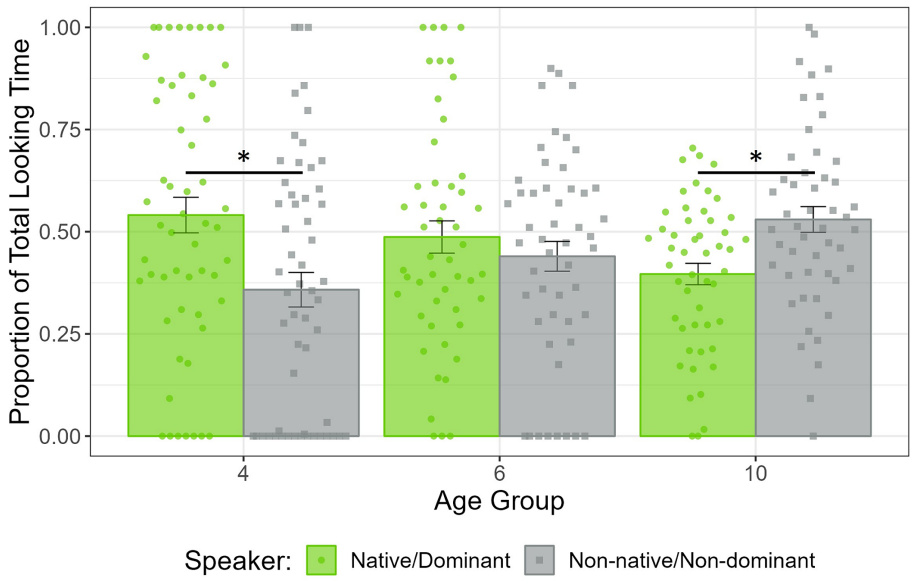

FIGURE 2
PTLT to the native/dominant and non-native/non-dominant speaker in the first half of the Silent test trial, in 4-, 6-, and 10-month-old infants. Dots represent individual PTLT values, and error bars the standard error (SE) of the group mean.

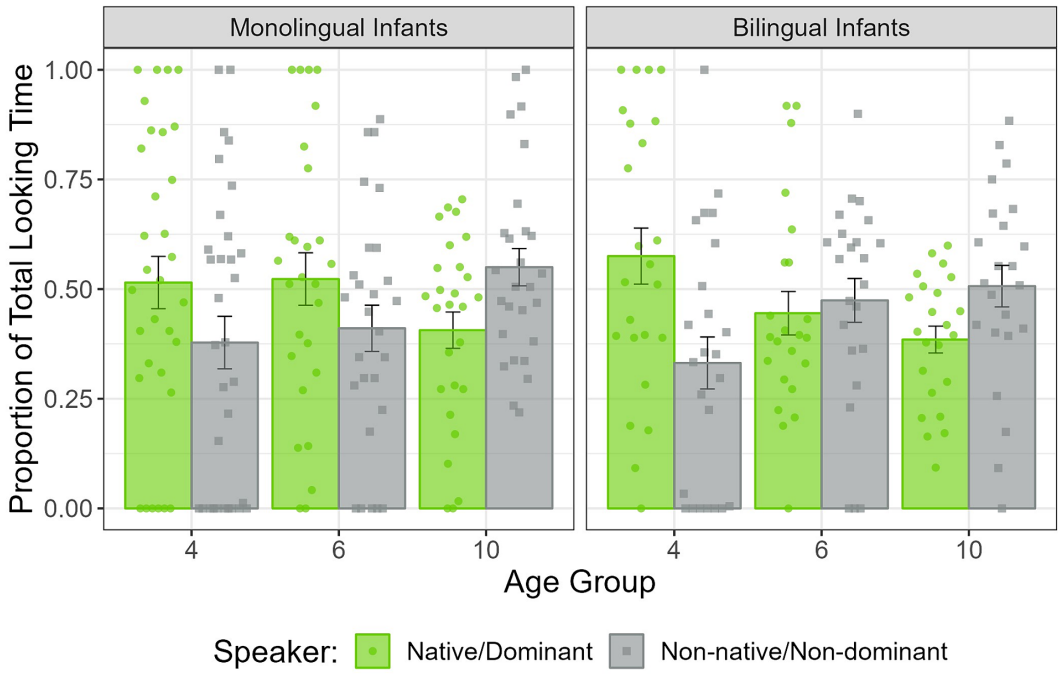

FIGURE 3
PTLT to the native/dominant and non-native/non-dominant speaker in the first half of the Silent test trial, in 4-, 6-, and 10-month-old monolingual and bilingual infants. Dots represent individual PTLT values, and error bars the standard error (SE) of the group mean.

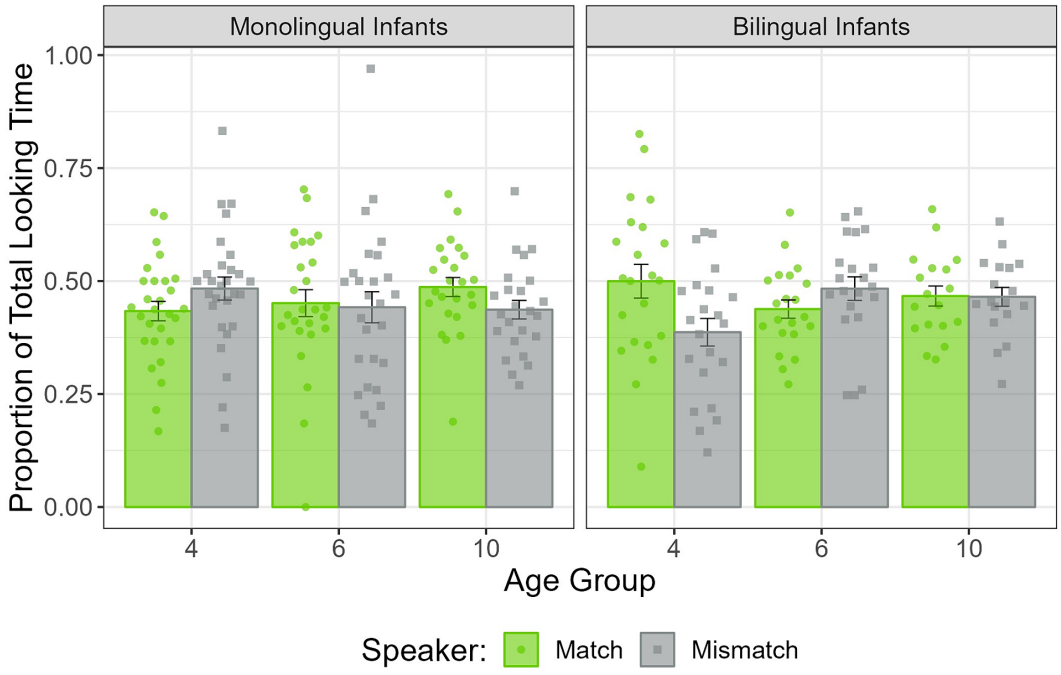

FIGURE 4
PTLT to the match and mismatch speaker in the Language test trials combined, in 4-, 6-, and 10-month-old monolingual and bilingual infants. Dots represent individual PTLT values, and error bars the standard error (SE) of the group mean.

infants showed a significant preference for the mismatching speaker ($M = 0.50$, SD = 0.14) compared to the matching speaker ($M = 0.39$, SD = 0.10; $t(20) = -2.21$, $p < 0.05$).

In the second half of the Language test trials, the Speaker × Linguistic Background × Age triple interaction approached significance ($F(2,126) = 2.42$, $p = 0.09$). None of the other main effects or interactions were significant (all $ps > 0.1$). After combining both Language test trials, we assessed the Speaker × Linguistic Background interaction at each age separately. The interaction was only significant at 4 months of age ($F(1,46) = 6.06$, $p < 0.05$). Four-month-old monolingual infants showed no preference for either the speaker matching the language of the recording ($M = 0.47$, SD = 0.17) or the speaker who used the opposite language ($M = 0.49$, SD = 0.18; $t(27) = -0.32$, $p = 0.75$), while four-month-old bilingual infants showed a marginally significant preference for the matching speaker ($M = 0.60$, SD = 0.20) compared to the mismatching speaker ($M = 0.37$, SD = 0.18; $t(19) = 2.77$, $p < 0.05$).

4 Discussion

The current study explored the formation of face-language associations during the first year of life in Catalan or Spanish monolingual and Catalan-Spanish bilingual infants. To assess the development of face-language associations, 4-, 6-, and 10-month-old infants from both linguistic backgrounds were tested in a preferential-looking paradigm. After familiarizing with videos of a Catalan and a Spanish speaker, infants were tested in two types of test trials with different task demands to measure both primary and robust face-language associations. In the Silent test trial, primary face-language associations were assessed by measuring infants' visual preference for the speakers depending on the language they had used during familiarization. In the Language test trials, robust face-language associations were assessed by measuring infants' ability to match the faces of the speakers with their corresponding languages. When measuring primary associations, both monolingual and bilingual infants exhibited language-based preferences. Interestingly, these preferences varied with age. While 4-month-old infants looked preferentially at the speaker of their native/dominant language, 10-month-old infants preferred the speaker of their non-native/non-dominant language. In contrast, when measuring more robust associations, infants were unable to consistently match the faces of the speakers with the language they had previously used, regardless of age or linguistic background. Overall, results indicate that both monolingual and bilingual infants can form primary face-language associations during the first year of life, but no evidence of more robust face-language associations was found since infants did not show signs of retaining the previously learned face-language pairings. Additional considerations are needed to provide a better interpretation of the data. In what follows, a more detailed discussion of the results obtained in each type of test trial is provided, as well as the present study's implications and limitations.

Results from the Silent test trial reveal that, during the first year of life, infants exhibit visual preferences for speakers depending on the language they previously used. These language-based preferences follow a developmental pattern transitioning from an initial familiarity preference toward a novelty preference in older infants. Consistent with previous research (Kinzler et al., 2007; Colomer et al., 2023), 4-month-old infants preferred to look at the speaker that used the language they were most exposed to. After the sixth month of life, this familiarity preference started to fade, likely due to infants gaining more experience with their languages (see also Colomer et al., 2023). Interestingly, the results show a second developmental change a few months later. Ten-month-old infants exhibited a novelty preference and looked predominantly at the speaker who used the language they were less exposed to. This reversed preference has been previously observed when assessing the development of visual preferences for own- and other-race faces (Liu et al., 2015b; Fassbender et al., 2016), but this is the first time it has been reported for language-based preferences. It should be noted that these results were more robust during the first half of the trial, implying that the language-based preferences were predominantly expressed at the beginning. The preferences diminished in the second half, suggesting infants may have shifted to more exploratory behavior and increased their attention to the face of the opposite speaker. This was more pronounced in older infants. The expression of language-based preferences evidences infants' ability to form primary face-language associations. Since there is no pre-existing relationship between a speaker's physical appearance and the language they use, infants must have formed some type of association between the auditory aspects of the language and the face of the speaker to express a visual preference.

Interestingly, no significant differences were observed between monolingual and bilingual infants at any age, indicating that both groups had comparable visual preferences during the Silent test trial. According to this, bilingual exposure does not seem to impact the expression of language-based preferences for speakers or enhance the formation of primary face-language associations. Both monolingual and bilingual infants exhibit the previously described familiarity to novelty preference transition. However, statistically, the preferences failed to reach significance when the groups were analyzed separately. Significant language-based preferences were expected in monolingual infants, based on previous research (Kinzler et al., 2007; Colomer et al., 2023) and the fact that they were regularly exposed to only one of the languages. However, all infants from this study lived in Catalonia, a bilingual community where Catalan and Spanish are co-official languages. This implies that monolingual infants may have accumulated some, even if limited, experience with the other language. This relative familiarity with both languages might have attenuated their preferences for the speakers compared to previous research, where monolingual infants had no exposure to the non-native language. Similarly, the absence of significant preferences in bilingual infants could be explained by their regular exposure to the languages used by the speakers. As bilingual infants are highly familiar with both languages, they might not have a strong preference for one speaker over the other. Nevertheless, 4-month-old bilinguals tended to look more at the speaker of their dominant language and 10-month-old bilinguals at the speaker of their non-dominant language. Crucially, this is the first evidence that, even if familiarity with both languages may attenuate the strength of the preference, bilingual infants also exhibit a language-based preference for speakers, according to the language that is most present in their environment. Another factor that might have influenced the expression of language-based preferences in both monolingual and bilingual infants is language proximity. The speakers in this study used two rhythmically and phonologically close languages (i.e., Catalan and Spanish) as opposed to two distant languages (i.e., English and Spanish or English and French). By using two

rhythmically and phonologically similar languages, the auditory differences between the languages tested were reduced in comparison to previous studies. Although both monolingual and bilingual infants should be able to discriminate between Catalan and Spanish at the ages tested (Bosch and Sebastián-Gallés, 1997, 2001), the similarities between the languages may have weakened the preference for one speaker over the other.

The findings of the Language test trials are less consistent. Four-month-old bilinguals had a marginally significant visual preference for the speaker matching the language of the recording, while no other group approached significance, regardless of age or linguistic background. Although this could be interpreted as a potential bilingual advantage, the fact that such a preference was not found in any of the older age groups makes this finding difficult to interpret. It is unlikely that bilingual infants form robust face-language associations when they are 4 months old but not when they are older. When separately analyzing each half of the Language test trials, it was found that during the first half, 6-month-old bilingual infants looked significantly longer at the speaker that did not match the language of the recordings. Since there is no clear reason for infants to look more at the speaker who used the opposite language from the one being played, these results should be interpreted with caution.

Altogether, infants did not show consistent signs of having retained the face-language pairings, providing no conclusive evidence of robust face-language associations during the first year of life. These results are in line with previous research, as Schott et al. (2023) also found no evidence of these associations even when testing 18-month-old infants. Taken together, these findings suggest that the ability to form robust audiovisual associations between the face and the language of unfamiliar speakers does not develop until later, after the first year of life. Although infants may learn and remember the language used by familiar speakers (i.e., their caregivers), these associations are most likely formed as a result of cumulative experience throughout the infants' lives. Short exposures to new speakers might not be enough for infants to retain the specific face-language pairings, at least at early developmental stages. In addition, bilingual experience was not found to modulate these associations in either study, regardless of learning close or distant languages.

Other factors may have influenced the results in the Language test trials and should also be considered. It is possible that infants' looking behavior in these trials was still guided by their individual language-based preference for the speakers, regardless of the language being played in the background. If infants had a persistent preference for a speaker, it could have impacted their performance in the task, thus concealing potentially retained face-language associations. Furthermore, the specific study design may have also affected face-language pairing retention. This task was based on a preferential-looking paradigm, similar to the tasks used by previous researchers to assess infants' face-voice matching abilities. However, results from those studies also reveal inconsistent findings. While some authors did not find significant face-voice matching until after the first year of life (Fecher et al., 2019; Orena et al., 2022), other authors found it as early as 6 months of age (Bahrick et al., 2005). These discrepancies could be attributed to design differences, such as the duration of the familiarization phase or the type of stimuli presented in the test phase. For example, Bahrick et al. (2005) used synchronized videos showing the speakers' whole face, while Fecher et al. (2019) and Orena et al. (2022) used synchronized videos where the speakers' mouth was occluded. The audiovisual correspondence between the auditory information and the mouth movement in Bahrick et al. (2005) could have increased infants' attention, facilitating face-voice matching. In the present study, static images of the speaker were used, which might have reduced infants' interest during the Language test trials. Additionally, infants' expectation of seeing the speakers' mouths moving when the audio recordings started playing in the background may have also affected their visual behavior. Lastly, the stimuli used may have not been easy to discriminate, as two similar languages and two female speakers with rather similar features were compared. Although the results from the Silent test trial indicate that infants successfully discriminated the languages and the speakers, the similarity between them might have increased the cognitive demands of the task, hindering the formation of more robust face-language associations. Testing two distant languages or two speakers with more salient distinctive features might facilitate the formation of these face-language associations.

In summary, this study provides evidence for infants' formation of primary audiovisual face-language associations during the first year of life, as they exhibit a preference for speakers based on the language they had previously used. Interestingly, regardless of linguistic background, 4-month-old infants showed a visual preference toward speakers of their native/dominant language, while 10-month-old infants preferred to look at speakers of their non-native/non-dominant language. However, conclusive evidence for more robust face-language associations was not found, regardless of age or linguistic background, as infants did not show signs of retaining the previously learned face-language pairings. According to these findings, both monolingual and bilingual infants in the first year of life appear to be aware of the languages spoken by those around them, which influence and guide their social interactions. However, they do not seem to be able to retain the specific language used by each speaker and actively use that information.

The current study makes a significant contribution to the field by extending previous findings in several ways. Firstly, results reveal a previously unidentified developmental pattern in language-based preferences for speakers, transitioning from an initial familiarity preference toward a novelty preference in older infants. In addition, these preferences have been examined for the first time when comparing speakers that used two rhythmically and phonologically close languages, and most importantly, including a group of bilingual infants who are native and familiar with both languages. Lastly, this study used a preferential-looking paradigm to explore robust face-language associations, in contrast to the familiarization-switch paradigm used in previous research, which appears to be a more appropriate experimental approach for investigating these associations in infants from bilingual communities.

A potential limitation of the current study is the use of a controlled, in-lab experimental task that does not fully replicate the natural situations in which infants interact with new speakers (see Birulés et al., 2023). While this approach is highly valuable for exploring the potential underlying mechanisms in face-language associations, future research could enhance ecological validity by designing experimental tasks that more closely mirror real-world interactions.

Data availability statement

The original contributions presented in the study are publicly available. This data can be found here: https://osf.io/jvtk9/.

Ethics statement

The studies involving humans were approved by the Bioethical committee of the University of Barcelona. 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. Written informed consent was obtained from the individual(s) for the publication of any identifiable images or data included in this article.

Author contributions

LM: Writing – original draft, Writing – review & editing, Data curation, Formal analysis, Investigation. JB: Investigation, Writing – review & editing, Conceptualization, Software. LB: Funding acquisition, Project administration, Supervision, Writing – review & editing, Resources. FP: Funding acquisition, Project administration, Supervision, Writing – review & editing, Conceptualization, Resources.

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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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The use of technology-assisted intervention in vocabulary learning for children with autism spectrum disorder: a systematic review

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Introduction: Children with autism spectrum disorder may show delays in vocabulary development. Technology-based interventions could facilitate the teaching of different vocabulary skills; however, it is still not clear whether technology represents an added value.

Methods: The current review preregistered in PROSPERO evaluates the efficacy of technology-based interventions in vocabulary learning for children with autism spectrum disorder. We selected articles published in the period 2006–2022 from five databases.

Results: The results identified two group studies, one within subject design, nine single-case studies and one randomized controlled design in participants aged 0–16 years who had used technological devices to learn vocabulary. Overall, five of the 13 studies showed positive results of using technology-assisted intervention, six described mixed results, one described negative result, and one described no differences in technology-assisted intervention. The studies are divided into the categories of efficacy of technology and comparison between technology and non-technology.

Discussion: In summary, technology, such as tablets and computers, might be useful tools to improve vocabulary skills in certain children with ASD. However, the various degrees of impact found in the studies we reviewed indicate that personalized assessments, acknowledgment of previous experiences, and awareness of the context of usage are essential. The contrast with nontechnological approaches highlights the necessity for more detailed studies to pinpoint the precise conditions under which technology-based interventions can offer the most advantages.

Systematic review registration: [https://clinicaltrials.gov/], identifier [CRD42021238758].

KEYWORDS

autism spectrum disorder, technology, intervention, vocabulary, systematic review

Introduction

Children with autism spectrum disorder (ASD) typically have impaired verbal and nonverbal communication (American Psychiatric Association, 2013). Some children with ASD present a delay in language acquisition compared to typically developing children (Landa, 2007; Lauritsen, 2013). According to Tager-Flusberg and Kasari (2013), half of the population with autism do not develop useful speech by the age of three and they may develop fluent speech after the age of 4 years. Ellis Weismer et al. (2010) and Wodka et al. (2013) evaluated children with ASD and found that only 3% of the population had normal levels of language compared to typically developing children; the rest of the sample with ASD presented delays in language acquisition. Furthermore, specifically for vocabulary development, studies have shown that children with ASD have lower levels of expressive and/or receptive vocabulary compared to the typical population (Kwok et al., 2015; Belteki et al., 2022). A weakness in receptive language has been found very early in the development of children with ASD (Ellis Weismer et al., 2010). For receptive vocabulary, some children with ASD may have relatively significant deficits, even when expressive language appears to be moderately intact (Davis et al., 2016). Furthermore, Ellis Weismer et al. (2021) found that toddlers with ASD aged 24–36 months had significantly higher expressive language age-equivalent scores than receptive language age-equivalent scores on two different assessment measures. Regarding expressive language, in a study by Smith et al. (2007) including children with ASD and children without ASD, expressive vocabulary was evaluated at specific points in life, reporting that children with ASD showed lower expressive vocabulary and delays in first utterances compared to those with typical language development.

Methods for vocabulary learning in children with ASD

Many different types of intervention methods have been developed to optimize language development, including vocabulary, in children with ASD, although the evidence base for their impact on vocabulary acquisition is varied and still in need of further research (Donolato et al., 2023). Methods vary in how explicit the goals of the intervention are for the participants. They range from incidental and implicit methods grounded in more developmental constructive theories to explicit instruction, in which words are modeled and their learning specifically reinforced. In between, hybrid approaches attempt to provide this explicit structure in naturalistic or quasi-naturalistic communicative situations.

Explicit methods used in autism include, among others, the picture exchange communication system (PECS) and many applied behavior analysis (ABA) approaches (Rhea, 2008; Will et al., 2018). PECS uses pictures or symbols combined with behavioral strategies to teach the child how to use the images in a functional way to request what he or she desires. This method has shown promising results in facilitating communication in children with ASD (Bottema-Beutel et al., 2019). ABA (Fisher et al., 2013) has been extensively applied to vocabulary intervention. In ABA, each step is taught one by one, presenting specific models, and using prompts followed by reinforcement of appropriate responses. Discrete trial intervention (DTI), based on ABA, uses strategies such as shaping, prompting, prompt fading, and reinforcement.

Contemporary ABA approaches attempt to include these strategies in naturalistic situations, this improving generalization. They include what are known as milieu teaching methods, such as prompt-free training, incidental teaching, and mand-modeling (Rhea, 2008).

Social-pragmatic strategies focus on facilitating communication and language learning within meaningful communicative interactions led by the child. One of these methods and programs is the floor time or the developmental, individual-difference, relationship-based (DIR) model. The Hanen method or Pediatric Autism Communication Therapy (PACT) aims to train parents to optimize their communication strategies in these contexts.

Other language interventions focus on language precursors, such as joint attention and play (Kasari et al., 2012). These interventions focus on basic skills, such as functional communication, imitation, and basic receptive and expressive language learning skills (Pelios et al., 2004).

Technology-based intervention in autism spectrum disorder

Assistive technology or technology-based intervention refers to the use of an electronic or digital device, application, or software that helps improve a specific skill (Syriopoulou-Delli and Gkiolnta, 2020). The implementation of technology-based interventions in the field of the education of atypical pupils is considered an increasing trend in many countries. This intervention has gained recognition among teachers, parents, and practitioners (Qahmash, 2018). The technology-based intervention seeks to train many skills, such as social communication, face recognition, academic skills, vocabulary (Massaro and Bosseler, 2006), and communication skills (Gevarter et al., 2020).

Many researchers and clinicians have noted the benefits and advantages of technology-based intervention specifically for people with ASD (Grynszpan et al., 2014) for various reasons.

Firstly, technologies such as mobile phones and tablets are relatively affordable and socially valued (Light and McNaughton, 2012). Second, mobile phone and computer-based interventions (CBI), also known in the literature as computer-assisted intervention (CAI) or computer-assisted learning (CAL), can assist children in expanding their attention span and increasing motivation (Novack et al., 2019). These interventions can also aid in automated practice and feedback, and can be easily programmed. Another valuable component is the potential to present multiple sources of information, such as text, sound, and images, in parallel. Massaro and Boessler (2003) tested this in a study in which all students showed an increase in identification accuracy once training was implemented. Additionally, the children generalized the learned vocabulary to new instances of vocabulary items. Third, tablets can be attractive for young learners, providing opportunities for self-initiation or prompting the child with few stimuli (Stockall and Dennis, 2014). Fourth, mobile technologies could increase interaction and participation within a learning environment and, more importantly, facilitate the learning process (Qahmash, 2018). Fifth, students with ASD learn from visual media and pictures are

one of the first supports used to acquire language. Technology makes visual images more accessible to students with ASD (Odunukwe, 2019). Despite these alleged advantages, empirical evidence on whether technology-based intervention for vocabulary learning is more beneficial than using methods without the use of technology has not been reviewed systematically and therefore an overall perspective of the state of current research is lacking (Goldsmith and Leblanc, 2004).

Previous reviews

Over the past 10 years, some systematic reviews and studies have contributed to achieving a picture of the value of the different technological methods used for the intervention to help children with ASD improve different abilities. Previous systematic reviews have evaluated technologies used as intervention tools for language and literacy, social skills, and emotion recognition with technology-based interventions.

The first systematic review was conducted by Ramdoss et al. (2011). The authors evaluated CBI to teach communication skills to children with ASD in studies from 1990. The systematic review produced 10 studies. However, due to the variety of literacy skills targeted for instruction in different studies and the heterogeneity of participants, according to the authors, it was not possible to draw a conclusion regarding the effectiveness of CBI in teaching literacy skills to students with ASD.

Another systematic review on this type of intervention in the autism population is the one carried out by Fletcher-Watson (2014). The aim of the review was to identify common characteristics of different interventions and to review a consistent research model using technology. The information was extracted on how technologies were designed, implemented and evaluated to define best practices. Fletcher-Watson (2014) collected evidence over more than four decades of research. The search was conducted in 2011 and 2013, and a final list of 52 studies was reviewed. The CBI approach appeared to show an advantage over traditional teaching methods in academic learning, social skills, and life skills development.

Later, Grynszpan et al. (2014) conducted another systematic review and meta-analysis to assess innovative technology interventions for children with ASD. These authors evaluated the efficacy of studies using pre-post-intervention designs between January 1990 and December 2011. Twenty-two articles were found. Their results demonstrated an overall significant effect size for the controlled studies and a similar effect size for the randomized control studies. According to Grynszpan et al. (2014), the significant effect size might support the efficacy of innovative technology. However, the authors pointed out some differences between the studies, such as the characteristics of the participants, the procedure, and the methodological approaches.

Another systematic review, by Aljameel et al. (2018), reviewed different technologies and different contexts and evaluation methods that were used to improve emotion recognition, social skills, and language skills for children with ASD aged 10–16. Nineteen articles were reviewed (from 2005 to the end of 2015). The results indicated that the children showed sufficient progress in learning within the CBI paradigm. However, according to the authors, future research must demonstrate the effectiveness of technologies by using a larger number of participants and indicating differences in functional abilities of children diagnosed with ASD.

The systematic review carried out by Valencia et al. (2019) evaluated how the use of technology contributes to the education of people with ASD, what user experience and accessibility elements or methods were considered when analyzing the impact of technology on people with ASD, and what game elements were considered when using gamification or serious games in education. They examined 94 studies published between January 2009 and June 2019 focusing on those conducted in an educational context or focused on teaching. The results showed that technology was useful in promoting constant learning for people with ASD.

Lastly, the meta-analysis conducted by Sandgreen et al. (2021) to review digital interventions in the treatment of people with ASD of any age found 19 articles (prior to June 2019). The review presents the different technological devices used, the skills targeted, and the effect size of interventions, and concludes that computer programs constitute the technological solution most frequently used, the skills targeted, social skills, and effect size was positive, however, small. This study faced challenges in drawing conclusions due to significant variations in effect sizes and concerns about the risk of bias. In conclusion, this systematic review and meta-analysis considers that the digital intervention for people with ASD is currently too heterogeneous, making comparison with other approaches difficult.

To our knowledge, although these systematic reviews provide extensive overviews of the field, none of the systematic reviews specifically assess vocabulary learning. Previous meta-analyses and systematic reviews have evaluated only the use of the digital intervention to assess other skills for people with ASD (Sandgreen et al., 2021).

The present review aims to (a) assess the level of evidence in studies aimed at evaluating the effectiveness of technology-based interventions used in children and adolescents with ASD, specifically focusing on interventions that target receptive and expressive vocabulary acquisition. Additionally, it aims to (b) review the conclusions of studies which set out to compare the effectiveness of technology-based intervention methods with teaching methods without technology in this same population.

Methods

The present review uses a narrative approach, conducted to provide an overview of studies that involved the use of digital devices (that is, CBI, robots, and tablets) that focused on expressive and receptive vocabulary interventions for children with ASD. This protocol was registered with the PROSPERO International Prospective Register of Systematic Reviews (CRD42021238758).

Study characteristics

Eligible studies met the following criteria: participants with ASD, published in English during the period of 2006–2022, participants between 0 and 16 years of age, and intervention using technology that has been designed to improve vocabulary skills (i.e., using any type of technological device for the intervention, such as tablets, computers, robots, etc.). Studies that used technology to improve oral

communication that do not specifically include vocabulary were excluded.

Interventions with children with ASD included in this review could be performed by any practitioner and directly by specialists themselves or through parents, teachers, or teaching assistants. Additionally, these interventions were implemented in various settings, such as homes, schools, clinics, or private practices.

Comparison groups

Studies with and without a comparison group were included. Control groups included no treatment, treatment as usual, or other treatment, with or without digital technology. Children subjected to intervention (or experimental group) included those receiving therapy through any digital device. Both comparison groups involved children with ASD.

Information sources

The databases used to obtain studies for this review were: Education Resources Information Centre (ERIC), MEDLINE, PsycINFO, PubMed, SCOPUS, and Web of Science (WOS). The search strategy was first developed in WOS and then adapted to the other databases. Keyword fields in all five databases were searched using Boolean terms (Autis* OR Asperger OR ASD) AND (Intervention OR instruction OR teaching OR therapy OR training OR treatment OR learn*) AND (language OR vocabulary OR literacy OR lexicon OR communication) AND (technology OR machine OR 'computer assisted' OR computer assisted OR multimedia OR digital OR 'robot assisted' OR robot assisted).

Study selection and data extraction

The study selection was carried out in three stages by one of the authors and the precision was verified by another. For this review, the study selection and screening adhered to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Figure 1).

Stage 1: Searches were conducted in March–April 2021 and updated in September 2022 using the six databases. For further screening, all citations were exported to Rayyan software (Ouzzani et al., 2016) which was also utilized to remove duplicates.

Stage 2: After Stage 1, all papers underwent screening based on title and abstract. Two independent reviewers double screened all articles according to inclusion and exclusion criteria, as well as intervention information. An overall agreement of 80% was achieved before resolving the discrepancies.

Stage 3: Articles obtained in the previous stage underwent a second round of screening by two independent reviewers based on full text. This stage aimed to include articles specifically focused on: (a) vocabulary learning, (b) population with ASD, and (c) technology-based intervention. Overall agreement was reached through consensus between the two independent reviewers.

Data extraction

From studies that met the inclusion criteria, we extracted data on participant characteristics, diagnosis, research design, type of intervention used, settings, software used, language, diagnostic measures, main outcomes, and secondary outcomes.

Methodological quality

We evaluated methodological quality using the Sterne et al. (2019). Five characteristics were used for the evaluation: randomization process, evaluation of the effects of the intervention, missing outcome data, measurement of the outcome and selection of the reported results (low, medium, or high risk). For single-case designs, Kratochwill et al. (2010) criteria (WWC) were used: (i) the independent variable must be systematically manipulated, (ii) the outcome variable must be measured systematically, and (iii) the study must include at least three attempts to demonstrate an intervention effect. Based on the results of each of these criteria, each study was classified as *Meets without Reservation, Meets with Reservations, or does not meet WWC Single-Case Design Standards*. The evaluation was carried out by the same two authors and the results were discussed until agreement was reached.

Results

To answer the research questions of this review, the studies were divided into two groups. The first group refers to studies that explored the efficacy of technology-based intervention itself (without comparison), and the second group refers to studies that compared technology-based intervention and nontechnology-based interventions. The studies we found in the second group only compared gain scores or were designed to measure time to success. Their analyses or designs, therefore, did not allow them to be added to the first group, and thus both categories of studies were mutually exclusive.

Study selection

After applying each of the filters described in the study selection criteria, a total of 13 studies published were obtained within the period of 2006–2022 were obtained. Figure 1 includes the systematic process for identification, screening, eligibility, and inclusion of the studies using the adapted version of the PRISMA flow diagram (Page et al., 2021). The excluded studies did not provide a vocabulary intervention ($n = 76$), the objective was to acquire oral language in general without vocabulary measures ($n = 48$), they only taught symbols and sight words ($n = 9$), they did not describe an intervention ($n = 52$), only evaluated the attitude or perspective of caregivers concerning technology-based intervention ($n = 10$), the technology used was eye tracking ($n = 2$), the intervention included video modeling ($n = 11$), or lastly, the age and diagnosis did not match with the inclusion criteria of this systematic review ($n = 4$).

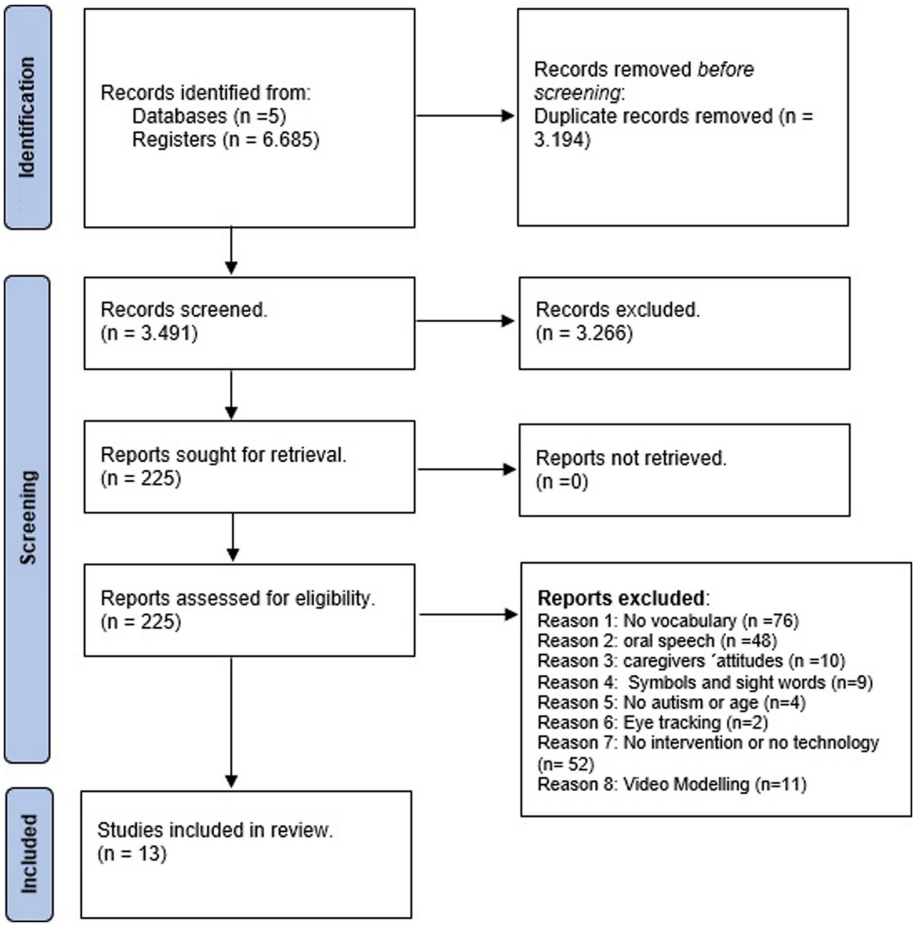

FIGURE 1
The systematic process of identification, screening, eligibility, and inclusion of the studies. The diagram is an adapted version of the PRISMA flow diagram (Page et al., 2021).

Characteristics of the studies

Of the 13 studies evaluated, nine used a single-case design (Mulholland et al., 2008; Kagohara et al., 2010; Ganz et al., 2014, 2015; Chebli et al., 2017, 2019; McKissick et al., 2018; Khowaja and Salim, 2019; Pellegrino et al., 2020), and four were group studies (Whalen et al., 2010; Allen et al., 2015; Novack et al., 2019; Pellecchia et al., 2020). The ages of the participants in the different interventions are found in Table 1. The duration of the vocabulary intervention is presented in Table 2. The duration of the different studies varies: nine studies held the sessions 3–5 days a week, one study 3 h for 4 weeks, one study 4 sessions one per week, and two studies did not provide information about duration.

Regarding the diagnosis of autism in the 13 studies, in seven studies the diagnosis had been carried out with a specialist using different standardized diagnostic scales [e.g., Autism Spectrum Rating Scale (ASRS), Childhood Autism Rating Scale (CARS), Gilliam Autism Rating Scale (GARS)] (Table 3). Four studies did not specify the diagnostic process of the participants and two studies described the diagnosis as applied by a pediatrician or diagnostic specialist (without indication of instruments).

Regarding the technological devices used to teach vocabulary, their variety was very limited and consisted only of computers and tablets.

Five studies used computers (Whalen et al., 2010; Pellecchia et al., 2020) used a software called TeachTown Basic for implementing CBI; Khowaja and Salim (2019) also included computer to teach vocabulary by listening to verbal instruction given by the computer; McKissick et al. (2018) used explicit and video-based instructional slides in the computer to teach vocabulary, and Mulholland et al. (2008) used a software named Team Up with Timo as a tutor.

Eight studies used a tablet device to teach vocabulary. Three studies used an Android device and five iOS devices. The use of the tablet to teach vocabulary varied among studies: Two used an app designed by the research team, three showed images to teach vocabulary, one used a PECS app, one used an app called Camp Discovery app, and the last one used the iCommunicate app.

TABLE 1 Key elements of the studies reviewed.

Author single-case studies	Number of participants; ages in years	Gender (M, F)	Aim of the study	Technological device	Instructional content	Main results
Ganz et al. (2014)	3, Ages: 8,9,14	Both (2: M, 1: F)	Investigates the effects of a visual script delivered using the iPad on the use of verbs and nouns.	*Tablet*	Treatment Condition: The same for baseline and intervention. Baseline: The researcher showed a 45 s video and asked the participants "what is happening?," and no prompts or cues were given. Intervention: Tablet was turned on and placed next to the child a 45 s. video was shown to participants followed by researchers' question "what is happening." The child had 10 s to point out the correct answer. Nontreatment condition: Same as for treatment but the iPad was turned off.	Two of the three participants demonstrated significant increases in the use of nouns and verbs. The participants demonstrated a generalization of the use of nouns and verbs provided by parents or teachers.
Chebli et al. (2019)	7, age: 5–9 years	Both (5: M, 2: F)	Compare the effectiveness of tablet-delivered to instructor-delivered teaching and evaluate generalization of concepts taught to 3-dimensional representations. Assess maintenance of correct response and compare nonresponding across modalities	*Tablet*	Baseline and teaching on tablet condition: 3 Images were presented on screen. Generalization: Instructor presented 5 real objects. A digital voice named the word, and the child was required to choose the image associated with the concept by selecting it on the screen. Baseline and teaching on instructor condition: Instructor presented 3 images on paper. Generalization: Instructor presented 5 real objects.	Five participants showed better maintenance learnt with the instructor, and the results of two participants were the same in both conditions. Nine out of fourteen concepts were generalized more rapidly after the instructor delivered them. Five participants showed better maintenance of the concepts learnt with the instructor and, for two participants, the same across modalities. Six out of seven participants showed lower levels of nonresponding during instructor-delivered and only 1 less nonresponding with the tablet condition.
Chebli et al. (2017)	5, age: 4–11 years	Both (2:M, 3: F)	Extend research on teaching one-word concepts by evaluating generalization to pictures and objects while minimizing trainer involvement to individuals with ASD.	*Tablet*	Baseline: Images were presented on the tablet with one image depicting the target concept and two distractors. The automated voice named the concept, and the child had to choose the image associated with the concepts by selecting it on screen. Training: Like the baseline session with prompts. No social reinforcement was used; only the preferred video was automatically used by the app. Generalization: Conducted by an experimenter and real objects.	Three out of five participants generalized on at least two concepts following tablet-based instructions. By integrating video reinforcement within the app to promote learnt independence, minimized trainer involvement. Two children were able to maintain correct response to these concepts for several weeks after training. Two of 5 children never showed generalization. After tablet-assisted condition.

(Continued)

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TABLE 1 (Continued)

Author single-case studies	Number of participants; ages in years	Gender (M, F)	Aim of the study	Technological device	Instructional content	Main results
Ganz et al. (2015)	1, age: 4	(1:M)	Determine whether the use of PECS-based communication instruction improves the receptive language identification of target words of one child with autism.	*Tablet*	Baseline: PECs app was muted. Objects and icons not verbally labeled. The icons in the PECS app were presented and the child had to choose the concept by touching the screen. Instruction phase: The sound was turned on.	No convincing evidence of a strong, clear functional relation between SGD intervention and receptive identification. The intervention appears to improve the responses levels for two of the target words. The participants did not make a connection between the spoken word and the image presented.
Kagohara et al. (2012), Study 2	2, age 13 and 17 (17-year-old data not considered)	(2:M)	Expand the participants vocabulary by teaching a set of 18 drawings presented in a commonly used picture book and using an iPad as the SGD.	*Tablet*	The pages with color line drawings when touched produced the corresponding speech output. Baseline: iPad and book placed on the table in front of the participant. The trainer pointed to one drawing and asked, "what is this?" Intervention: The same as in the baseline except that prompting was used if no correct answer within 10 s.	The two participants did not have correct responses during baseline. However, with the intervention, the performance increased above 85 and 100%. Acquiring a new and larger set of picture naming responses.
Pellegrino et al. (2020)	3, age: 4, 5, 5	(3:M)	Evaluate to what extent stimuli delivered via tablet versus flashcard increased and maintained receptive labeling in young children with ASD. In addition, participant preferences for stimuli delivery were assessed.	*Tablet*	Pre experiment: Stimuli presented by flashcards with the instruction "touch (stimulus). Teaching session: The general procedure was identical under all conditions; 3 stimuli were presented to teach receptive labeling in a discrete trial instruction format. Each of the 3 stimuli was presented 5 times in random order. Flashcard condition: The stimuli were on laminated cards; instructor manually rotated the order of the cards. Tablet condition: The stimuli were presented on a tablet; the instructor manually rotated the order of the stimuli.	Participants showed a preference to work under tablet conditions. One participant demonstrated preference for flashcards after 10 sessions. And the other two participants demonstrated preference for the tablet after 10 and 5 sessions. All participants demonstrated approximately equivalent performance in maintenance across conditions.
McKissick et al. (2018)	3, age: 14 and 13	Both (2:M,1: F)	Effect of CAI on the acquisition of grade-aligned science vocabulary. What are the students' and teachers' opinions on using the CAI package used to teach science vocabulary?	*Computer*	Probe slideshow: Consisted of 10 total slides. Five slides showed a picture of an amoeba and asked them to identify the target structure on a picture (what is the arrow pointing to?). Five slides asked them to fill in a statement regarding the function of the target structure. CAI intervention slideshow: Consisted of 31 slides. Included explicit instruction and video slides. CAI consisted of 31 slides. Including explicit instruction and video slides.	The three participants, the classroom teacher, and paraprofessionals agreed that the intervention was effective in teaching the targeted skills.
Novack et al. (2019)	28, Age: 3–8	Both (24:M, 4: F)	Investigate the effectiveness of Camp Discovery in teaching receptive language skills.	*Tablet*	Camp Discovery a mobile application incorporated modifies Discrete-Trial Training DTT, in which user is asked to identify a specific target with variations of instruction and variety of lessons.	Participants made a significant gain of a course of 4 weeks and maintained the acquires skills following 1 month.

(Continued)

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TABLE 1 (Continued)

Author single-case studies	Number of participants; ages in years	Gender (M, F)	Aim of the study	Technological device	Instructional content	Main results
Khowaja and Salim (2019)	5, Age: 6–10 years	(5:M)	Examine the effectiveness of the prototype SG "vocab builder" to improve the performance of learning vocabulary among children with autism.	*Computer*	Baseline: Questions are asked to identify the correct image of an item by showing three images, conducted to measure the current level of knowledge. Intervention: Each session corresponds to learning of one vocabulary item; once the participant saw and memorized all images associated with the item, they were asked to identify the current image of the item. Each day player played an activity game for 3 min.	The number of correct responses to receptively identify vocabulary items among children with ASD improved from baseline to intervention and was maintained at the end of week 1 and 2 after the withdrawal of the intervention. This shows that the prototype was effective in facilitating children with ASD to learn vocabulary.
Mulholland et al. (2008)	3, Age: 5–9 years	(3:M)	Effectiveness of teaming up with the Timo app to support expressive and receptive language development.	*Computer*	Virtual tutor called Timo. The tutor highlighted a picture and told the student its name. The program randomly moved the pictures around the screen and the tutor asked the student to click on the picture reflecting the word. As the student progressed through the lesson, the participant was asked to identify pictures by clicking on the one spoken by the tutor.	Three of the five students demonstrated improvement in language skills. It is not clear which of the participants who demonstrated improvement have autism.
Author group study	Number of participants; ages in years	Gender (M, F)	Aim of the study	Technological device	Instructional content	Main results
Pellecchia et al. (2020)	154, Ages: 5 to 9		The effectiveness of CAI designed to improve children's expressive and receptive language, cognitive, and academic skills was evaluated.	*Computer*	Computer lessons incorporate principles of ABA using a discrete trial format in which the student is provided with a specific instruction and selects the correct response. The program professes to have 5 levels of difficulty. Offline activities: Teachers provide interpersonal lessons by direct instruction following the same areas targeted in CAI activities. And administered at the beginning and end of the school year two measures as pre and post.	Showed an overall null effect for the Teach town: Basic program between groups (offline and computer lessons). The mean change score on DAS-II and BBCS scale were not statistically different between groups
Whalen et al. (2010)	47, 3–6		Assessed the effectiveness of Teach Town: basics in a randomized trial implemented in special education program	*Computer*	TeachTown:Basic a CAI program that includes computer lessons and natural environment activities using a discrete trial format where they receive reinforcement for correct responses. TeachTown Connection off-computer activities are lessons plans to implement in the natural environment for students to work on skills that are not targeted in the computer and enhance generalization of skills learned on the computer to the natural environment	The majority students demonstrated a significant progress in the software program by mastered lessons across the four learning domains than the control group. The standardized outcome measure were shown in changes of raw scored on PPVT-III and Brigance Inventory
Allen et al. (2015)	16, 4–16	(16:M)	Children with ASD are better able to learn new word-referent relations using an iPad or traditional picture book	*Tablet*	Stimuli were color photographs presented via picture books and tablet. Book condition: book placed in front of the child and experimenter turned the pages. iPad condition: children controlled their transition between pictured in both the experimenter directed the child's attention verbally or audio recording on iPad	The mapping test revealed that medium of presentation iPad or Book did not impact on extension of labels did not find an advantage for learning with iPad.

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TABLE 2 Method classification.

Single case studies	App or program used	Duration	Instructor	Setting
Ganz et al. (2014)	iCommunicate app	Each day for 3 days a week	Second author and occasionally first author	School and the home of the participant.
Chebli et al. (2019)	The Open-Source Discrete Trial Instructor app- developed by the research team.	6–12 sessions per day, 3 days a week.	First author	School
Chebli et al. (2017)	The Open-Source Discrete Trial Instructor app- developed by the research team.	4–8 sessions per day, 3 days a week.	First and second authors	School
Ganz et al. (2015)	PECS phase III app	Not specified	First and second authors	Autism clinic
Khowaja and Salim (2019)	SG prototype	5 weeks. 2–3 days a week	Not specified	Not specified
Mulholland et al. (2008)	Software Team up with Timo	3 days a week	First author	Not specified
Kagohara et al. (2012)	Book with pages with color line drawing and tablet	2–4 sessions per week. Each session lasted 15 min.	First author	School
Pellegrino et al. (2020)	Stimuli on tablet	3–5 days a week.	Instructor- not specified	Preschool
McKissick et al. (2018)	Slideshows	Not specified	Baseline: First and second observers, intervention: first author.	School of Special Education
Novack et al. (2019)	Camp discovery mobile application	3 h per week for 4 weeks	Research assistant	Participant's home or treatment center
Group studies	App or program used	Duration	Instructor	Setting
Pellecchia et al. (2020)	Teach town: basics	5 days per week. One year	Teacher	School
Whalen et al. (2010)	Teach town: basics	5 days per week. Three months	Teacher	School
Allen et al. (2015)	Stimuli on tablet and books	4 sessions for 4 weeks	Experimenter	School

Efficacy of technology-based interventions

Eight studies explored the use of technology-based interventions to teach vocabulary for children with ASD without a comparison to non-technological interventions.

Ganz et al. (2014) conducted a treatment study with a sample of three, 8–14 years old, a participant with very elevated levels of autism symptoms according to DSM-IV. In all three participants, social communication was characterized by difficulty in initiating and maintaining relationships and emotional regulation, and all three showed unusual behaviors that included repetitive speech and motor movements. Two students were able to imitate multiple-word phrases, used spontaneous speech rarely, and had difficulties to understand, the third participant spoke in three-word or longer phrases, and sometimes used spontaneous speech. In this study, participants had to answer what happened in a 45-s video using a tablet. The tablet was turned on and placed next to the child on the table. Least-to-most prompting was used when the students did not correctly answer the question "What is happening." The results were mixed, as two of the three participants who used spontaneous speech demonstrated a significant increase in the use of nouns and verbs, and the same two participants required less intrusive prompts over time, while the prompts of the third participants were consistent throughout the study. All three demonstrated a generalization of the use of nouns and verbs provided by a parent or teacher rather than by researchers.

Another study by Ganz et al. (2015) examined whether the use of a tablet with PECS-based communication instruction improved the receptive-language identification of target words. In this case, the tablet was used as a Speech Generating Device (SGD), that is, the tablet allows children to select a picture, symbol, letter, or word and reproduce it with voice. The study included only one 4-year-old participant, who had severe language disorders and an elevated level of autism according to the CASRS scale (Schopler et al., 2010). The participant communicated with single words, made eye contact, responded to simple demands with a gestural prompt, and had limited language skills. The multiple-baseline study consisted of different phases. In the first phase, the child had to touch an icon to reach an object using the PECS app; in this phase, the sound was muted and the objects and icons were not verbally labeled. In the second phase, the instruction phase, five icons on a PECS app were presented to the participant, sound was turned on, and if the participant touched an icon, it produced a recorded voice, then the researcher enticed the participant with two objects; if the participant selected an icon on the tablet, the researcher said "Take it." If the participant did not reach for the object that did not correspond to the icon, a four-step error-correction procedure was performed. Although there was no convincing evidence of a clear relation between the SGD intervention and receptive identification, the participant improved the response levels for two out of three target words and showed a higher mean level and an increasing trend from baseline to intervention. However, the participant was unable to make a connection between the spoken word and the image.

The study by Kagohara et al. (2012) used a tablet as a SGD to teach words for 18 colored drawings from a commonly used picture

TABLE 3 Sample classification.

Author single- case studies	Diagnosis	Scales used to assess diagnosis	Autism symptoms as reported in studies.
Ganz et al. (2014)	Autism and speech impairment	Autism Spectrum Rating Scale ASRS (Goldstein and Naglieri, 2009) DSM-TR-IV (American Psychiatric Association, 2000)	ASRS total: Elevated DSM-IV-TR: Very elevated
Chebli et al. (2019)	Autism	DSM-TR-IV (American Psychiatric Association, 2000) Childhood Autism Ratings Scale- 2 CARS-2 (Schopler et al., 2010) Adaptive Behavior Assessment System- Second Edition (Harrison and Oakland, 2003)	N = 3: Severe symptoms N = 3: Moderate mild symptoms N = 1: Mild symptoms
Chebli et al. (2017)	Autism	DSM-TR-IV (American Psychiatric Association, 2000) Childhood autism rating scale-second edition CARS-2 (Schopler et al., 2010)	N = 3: Mild to moderate N = 1: Mild symptoms N = 1: Severe symptoms
Ganz et al. (2015)	Autism	Autism Spectrum Rating Scale (Goldstein and Naglieri, 2009) DSM-TR-IV (American Psychiatric Association, 2000)	ASRS: Elevated DSM-IV-TR: Elevated
Pellegrino et al. (2020)	Autism	Diagnosis by a pediatrician or diagnostic specialist. Verbal Behavior Milestones Assessment and Placement Program	N = 1: Level 3 N = 2: Level 2
McKissick et al. (2018)	Autism	GARS Gilliam Autism Rating Scale (Gilliam, 1995)	N = 1: Require support N = 1: Require substantial support N = 1: Not specified
Khowaja and Salim (2019)	Autism	Not specified	Require support
Mulholland et al. (2008)	Autism	Not specified	Not specified
Kagohara et al. (2012)	Autism and severe intellectual disability; autism and obsessive-compulsive disorder	Vineland adaptive behaviors scales Vineland-II (Sparrow et al., 2005)	Not specified
Novack et al. (2019)	Autism	Vineland adaptive behaviors scales Vineland-II (Sparrow et al., 2005)	Not specified
Author group study	Diagnosis	Scales used to assess diagnosis	Autism symptoms as reported in studies
Pellecchia et al. (2020)	Autism	Autism Diagnostic Observation Scale, Second Edition (ADOS-2)	Not specified
Whalen et al. (2010)	Autism	CARS-2 (Schopler et al., 2010) Adaptive Behavior Assessment System-Second Edition (Harrison and Oakland, 2003)	Severely autistic
Allen et al. (2015)	Autism	Diagnosis from a qualified educational or clinical psychologist	Not specified

(N) Number of participants. DSM-TR-IV: Diagnostic and Statistical Manual of Mental Disorders.

vocabulary book for children. Two adolescents of 13 and 17 years of age participated in this study. They had an expressive language of less than 2.5 years, as determined by the results of the Vineland Adaptive Behavior Scales. According to the author, both participants rarely spoke and the speech was mainly inaudible without specific details of the described symptoms of autism. A tablet and a book were placed in front of each participant. The trainer asked a question while pointing at one line drawing from the book and asked the participant to use the tablet to give the correct answer. During the baseline, neither of the students made any correct responses; however, with intervention, their performance increased. Therefore, the multiple-probe design showed that the implementation of this type of instructional procedure increased the correct picture-naming responses and that the two participants had acquired a new set of picture-naming responses. But the follow-up sessions were relatively short and lacked generalization probes.

Chebli et al. (2017) used a tablet device to evaluate the effects of tablet-based instruction and generalization in five 4- to 11-year-old

children with ASD. An automated voice named the concept, and the child had to choose the image associated with the concept by touching the screen; the only reinforcer was a preferred video. The generalization was evaluated with five different untaught examples of the target concept. Two participants had mild to moderate ASD symptoms in CARS-2 and had no formal means of communication. A third participant had mild symptoms of ASD and spoke four- to five-word sentences with unclear pronunciation. The fourth participant had mild to moderate symptoms of ASD and the fifth participant had severe symptoms of ASD, both using one-word concepts to make simple requests. The authors of this study stated mixed results; only three of the five participants generalized in at least two concepts after tablet-assisted instruction, three of them had mild to moderate symptoms of ASD. The participant with severe ASD symptoms had the highest levels of nonresponses and required a greater number of prompts to do the task.

Novack et al. (2019) conducted a randomized controlled design with 28 participants aged 3–8 years. All participants were verbal. The purpose of this study was to investigate the effectiveness of Camp Discovery in teaching receptive language skills across a variety of domains to children with ASD. Camp Discovery is a mobile application that incorporates modified Discrete-Trial Training DTT procedures and other behavioral principals of ABA. To initiate treatment sessions, the researcher opened the tablet with Camp Discovery and instructed the participant to select one of the target lessons. Participants were randomly assigned to the immediate treatment (IT) group or the delayed treatment control (DTC) group; both benefited from the application. The IT group began interacting after the initial probe, whereas the DTC continued with treatment as usual with no manipulations; after 4 weeks both groups received a second probe. Following the second probe, the DTC group appeared to benefit from the treatment phase. Participants learned significantly more in the IT group than the DTC group. Participants made a significant gain in gameplay over the course of 4 weeks.

Khowaja and Salim (2019) evaluated the learning environment of a game to teach bird vocabulary in five children aged 6 to 10 years of age with ASD while listening to a computer-provided verbal instruction. All participants had ASD with required level of support, had difficulty learning different categories of vocabulary, and had a basic knowledge of computers. The participants had to identify the correct word by selecting one of three images. They improved on bird learning after using the prototype and retained the names of birds after the first and second weeks after the intervention was over.

McKissick et al. (2018) evaluated the effect of CAI for the acquisition of science vocabulary in middle school students with ASD. The participants were three middle school students aged 13 and 14 years. Two students used functional speech to communicate all desires and needs, and one student relied on verbal communication. The CAI intervention consisted of slides which included both explicit instructions and videos edited to highlight the explanation of the function of the cell membrane. Following the video, a slide appeared showing the amoeba with an arrow pointing to the cell membrane, and after a model slide, the question for the participant appeared with four options to answer. During baseline conditions, all three participants had low levels of correct responses, but all demonstrated improved performance over time. There appeared to be a functional relation between the CAI intervention and an increase in the number of correct response items answered correctly during the sessions.

Lastly, Mulholland et al. (2008) showed the effectiveness of using an animated software program called Team Up with Timo to teach expressive and receptive language by providing audiovisual animations for three participants with ASD, ages 5–9. The animated tutor was programmed according to each child's name and words to learn. The tutor highlighted a picture and told the student its name, and then the tutor randomly asked the student to click on the picture that reflecting the word the tutor used. Some students were asked to identify the pictures by clicking on the word spoken by the tutor, and others were asked to name the pictures as the tutor highlighted them. In the study, three of the five students demonstrated improved language skills in the post-test results. However, it is not clear which of those five participants were the three with ASD.

Overall, three of the eight studies described above used CAI, while five used tablets as a tool for vocabulary intervention. Interestingly, the three studies that used CAI showed positive results. With these results, it is not possible to draw a conclusion regarding the effectiveness of CAI in children with ASD, as the procedure, sample, and participants characteristics are too heterogeneous. However, in the studies that used a tablet as a tool, in four of the five studies the results are mixed, suggesting that while using a tablet may benefit some students in generalizing language concepts, for others it may be a less useful tool.

Technology vs. nontechnology-based intervention

Three group (Whalen et al., 2010; Allen et al., 2015; Pellecchia et al., 2020) and two single-case studies (Chebli et al., 2019; Pellegrino et al., 2020) compared technology-based and nontechnology-based instruction, thus providing information about the added value of technology.

Whalen et al. (2010) and Pellecchia et al. (2020) used a CAI intervention with software called TeachTown, designed to increase students' vocabulary and listening skills. The program included different ABA lessons, in which the program gave an instruction and participants had to select the correct response that had different levels of difficulty.

In Whalen et al. (2010), the TeachTown connection off-computer activities were lessons conducted in natural environments for students to work on skills not addressed on the computer and to enhance the generalization of skills learned on the computer to natural settings. Forty-seven participants joined from preschool and kindergarten/first grade classes, all identified as students with severe autism. Children with ASD aged 3–6, who had received TeachTown: Basic for 3 months, showed greater gains in all domain lessons, with 15 out of the 22 treatment group students demonstrating significant improvement. In the second study (Pellecchia et al., 2020), for the control group, teachers delivered lessons that targeted the same areas as the program. One hundred fifty-four participants joined from kindergarten through second grade autism support classrooms; however, specific symptoms of autism were not specified. Eighty-four children with ASD aged 5–9 years in the treatment group, who had received TeachTown for one academic year, did not show greater gains in receptive or expressive language compared to children in the control group (those without technology).

In a design within-subject, Allen et al. (2015) compared whether children with ASD learned new word-referent relationships better

using an iPad or a traditional picture book. Sixteen male children with ASD, aged 4 to 16 years, participated in this study. Stimuli consisted of color photographs presented through either picture books or an Apple iPad 2. In the book condition, the experimenter pointed to each training picture and verbally directed the child's attention. In the iPad condition, the iPad was placed in front of the child, allowing them to control their transition between pictures. The results did not indicate an advantage for learning with the iPad; the medium of presentation, whether iPad or book, did not affect the extension of labels by children.

A single-case study (Chebli et al., 2019) compared technology versus non-technology using a tablet as a digital device. The author recruited seven children with ASD from 5 to 9 years of age. Two participants had severe symptoms of ASD and did not have means of communication. Other three participants had mild to moderate ASD symptoms and used one word to communicate, while participant number six had mild to moderate ASD symptoms and meaningful sentences of three-to-five-word sentences, and, lastly, participant number seven had severe ASD symptoms and sometimes used a word statement with unclear pronunciation. In this study, the authors evaluated the generalization of concepts. In the tablet condition, the authors presented three images, one as a target concept, and two distractors. An automated digital voice named the concept and the child chose the associated image. In the non-tablet condition, the instructor presented three images on paper. As reinforcement, the tablet played a preferred small video, the reinforcement for some participants was different, some watched videos, and some participants received their preferred food. The generalization in both conditions was conducted by the instructor. The instructor named the target, and the child had to select the item. Two participants who had severe symptoms of ASD showed a faster generalization after instructor-led teaching. The remaining five participants had mixed results: two participants with mild ASD symptoms met the generalization criterion following instructor-delivered teaching on two of the three concepts and one concept using the tablet. Similarly, another participant with mild symptoms of ASD revealed a more rapid generalization after instructor-directed teaching of the first two concepts. A participant with severe ASD symptoms generalized the first two concepts with the instructor after fewer sessions. Lastly, a child with mild to moderate symptoms of ASD showed a more rapid generalization after instructor-directed teaching with the first concept and tablet condition with the second concept. In sum, nine of the 14 concepts were generalized more rapidly following instructor-condition and the remaining five concepts more rapidly using tablet condition, and almost all children engaged in less non- responding with the instructor than with the tablet.

Another study compared technology vs. non-technology (Pellegrino et al., 2020) using a flashcard and a tablet condition. In both conditions, the instructor manually rotated the order of stimuli. The procedure was the same for both conditions. The participants in this study were three boys, aged 4–5 years, who had a diagnosis of ASD. All of them had previous experience using a tablet for leisure purposes at home and school. A participant demonstrated skills at Level 3 according to the verbal behavior milestones assessment and placement program (Sundberg, 2008) and the other two participants were within Level 2. The Level 3 participant met the criterion after using a flashcard condition in one session faster compared to the tablet condition. The participant with Level 2 of verbal behavior milestones required four more sessions to reach the criterion in the tablet condition. The last participant required nine more sessions to reach the criterion in the tablet condition than in the flashcard condition. Interestingly, participants showed a preference to work with a tablet, although they required additional sessions to learn vocabulary compared to the instructor's condition.

Overall, five studies conducted comparisons between technology and nontechnology approaches. Among them, three used a tablet device as a tool, while two used computer-assisted instruction (CAI). Regarding the effectiveness of the studies evaluating a specific computer program compared to a control group, one yielded negative results while the other yielded positive results. Among the three studies that used tablets as tools, two followed a single-case study design and reported mixed results, while one followed a within-subject design and reported no impact on word learning using either an iPad or a book.

Quality assessment

The methodological quality assessment for the group studies was examined using the Sterne et al. (2019). Various group studies (Whalen et al., 2010; Novack et al., 2019; Pellecchia et al., 2020) showed some concerns of risk of bias, since the process of missing outcome data was not entirely clear. In another study, it was not clear whether participants were aware of the assigned intervention design (Allen et al., 2015). However, the randomization process, counterbalance, and multiple eligible analyzes of the data criteria were fully met. For single case studies, What Works Clearinghouse criteria were used. Most studies met standards without reservations (Kagohara et al., 2012; Ganz et al., 2013, 2015; Chebli et al., 2017, 2019; Khowaja and Salim, 2019; Pellegrino et al., 2020). The study by Mulholland et al. (2008) met the standards with reservations, as it did not provide detailed information about the design and did not appear to achieve interrater reliability.

Discussion

This systematic review examines the evidence in the literature on the effectiveness of digital interventions in vocabulary for children with ASD, by exploring technology-based interventions and, when possible, comparing them with non- technology interventions. A total of 13 studies were obtained. Eight studies only evaluated the efficacy of technology without comparing with a non-technological control group, and five compared technology with non-technology.

Efficacy of technology-based interventions

The first research question addressed the efficacy of technology-based interventions in improving vocabulary learning in children with ASD. Eight studies were reviewed, with five using tablets (Kagohara et al., 2012; Ganz et al., 2014, 2015; Chebli et al., 2017; Novack et al., 2019) and three others using computers (Mulholland et al., 2008; McKissick et al., 2018; Khowaja and Salim, 2019).

Most tablet-based studies reported positive impacts on vocabulary. For example, Kagohara et al. (2012) found that their two participants

improved their picture-naming. The severity of ASD in the participants was not specified, but they presented other comorbidities (severe intellectual disability, obsessive-compulsive disorder, and attention deficit hyperactivity disorder, respectively). Similarly, in the study by Chebli et al. (2017), the effectiveness of using a tablet was demonstrated as a method to teach vocabulary in an intervention addressed to five children aged 4–11 years, all with mild-to-moderate symptoms of ASD, except the older participant who had severe symptoms of ASD. In this case, the outcomes varied: three participants (those with mild ASD symptoms) showed generalization of concepts, but the two participants who required more prompts to sit down and continue working never displayed generalization and even showed high levels of nonresponses. This, according to the authors, may indicate a lack of interest in tablet-based instruction and consequently fewer opportunities to learn the new words. Ganz et al. (2014) found positive effects of using a tablet to teach vocabulary. In their small sample size of three participants (aged 8–14 years), all with ASD and a secondary diagnosis of speech impairment, the two youngest showed an increase in correct responses in the use of nouns and verbs using fewer prompts over time. Interestingly, all three participants demonstrated generalization when provided by a parent or teacher rather than the researcher, which could mean that the participants felt more engaged with the people they often work with. Another positive outcome was found by Novack et al. (2019). Their study included 28 participants with diagnosis of Autistic Disorder, Pervasive developmental disorder not otherwise specified, and ASD. All participants were divided into the IT group and the DTC group. Participants in the IT group demonstrated significantly greater learning, as evidenced by the difference between the pre- and post-treatment scores. However, both groups experienced benefits from the application. Although the study was conducted via tablet, the author used the term CBI to designate the intervention, in the sense that it was understood as a mobile extension of a CBI application. The availability of CBI applications on mobile devices could help overcome limited access.

Ganz et al. (2015) found mixed results. Their study included only one participant, a 4-year-old boy with ASD who communicated using single words and, when given a task, sometimes closed his eyes and turned to the side. Although the participant was able to select words using PECS and often used a tablet for a different purpose, the intervention resulted in a slight improvement for two of the three vocabulary words taught, although only slightly better than chance.

Therefore, in general, tablets can be considered useful tools to teach vocabulary to children with ASD, but there are some concerns about the results obtained so far. First, in some studies (i.e., Kagohara et al., 2012) it is not possible to know if participants generalized the knowledge since no follow-up or generalization tasks were implemented. Second, in other studies, the severity of ASD is not specified and, as the study by Chebli et al. (2017) showed, those with more disruptive behaviors may benefit less from this technology and those participants with lower symptoms of ASD severity might master more words using technology according to their specific traits (Novack et al., 2019). Therefore, the presence of these behaviors could explain the absence of positive results (i.e., in the case of the only participant in the study by Ganz et al.'s study). For this reason, individualized evaluation before using tablet-based instruction appears paramount to ensure that children will benefit from it.

Another important information that must be considered when using the tablet for vocabulary intervention is the previous experience that participants may have with this device before the intervention. In two of the studies (Kagohara et al., 2012; Chebli et al., 2017), participants had previous experience with tablets, often used to provide access to reinforcement activities in their classrooms.

Finally, the context of tablet use, and more specifically the person responsible for its use, is crucial. In the study by Ganz et al. (2014), it appears that the generalization of the vocabulary learned can be facilitated when the intervention is provided by a parent or a teacher rather than the researcher.

Taking into account all of these requirements, a tablet can be a useful instrument to improve vocabulary in children with ASD under certain conditions, contributing to learner independence, and minimizing trainer involvement, which, in turn, can facilitate the implementation of interventions with multiple students simultaneously.

Regarding the use of computers for vocabulary interventions, the three studies devoted to disentangling their efficacy have found positive results. The first study is that conducted by McKissick et al. (2018), which showed a functional relationship between the CAI intervention and an increase in the number of correct responses in the learning of science vocabulary in a sample of three middle school participants with ASD and intellectual disability. Khowaja and Salim (2019) obtained another positive result in a sample of five children with ASD (within an age group of 6–10 years) who had difficulty learning vocabulary and had basic knowledge of computers. In this case, the participants improved their learning of bird names after using the prototype and retained the names of birds after the intervention (at the end of weeks 1 and 2 following the withdrawal of the intervention). Therefore, the results showed that the prototype was effective in helping children with ASD to learn vocabulary. Lastly, Mulholland et al. (2008) included a small sample of five students, three of them diagnosed with ASD. Using the software program "Team up with Timo," they were able to teach basic vocabulary related to areas of play, food and hygiene in three of the five students. The two students who did not benefit from the animated software program were a six-year-old boy diagnosed with severe cognitive impairment who could not even use PECs, and a nine-year-old nonverbal boy who was not motivated to use the computer. However, the paper does not specify whether these students had a diagnosis of ASD.

In conclusion, the results obtained from the application of computers to teach vocabulary to children with ASD seem promising. However, the same concerns mentioned in relation to the use of tablets could be applied to computers. In the studies, the level of severity of ASD is not specifically mentioned, making it difficult to determine which children with ASD could benefit from the use of this device. However, it is apparent that the application of computers to teach vocabulary to children with ASD occurs mainly in the case of school-aged children, while tablets are applied to younger children. In addition to age, other requirements mentioned in the application of this technology include the presence of basic knowledge of computers in children to take more advantage of them (Khowaja and Salim, 2019) and the child showing motivation to work with the computer (Mulholland et al., 2008). In all cases, it is challenging to separate the benefits derived from the device itself from the particular methodology applied in each case. For example in McKissick et al. (2018) study the CAI intervention was a package with different instructional components (explicit instruction, visual aids, etc.) and therefore it was unclear which elements of the intervention caused the good results. In the case of the study by Mulholland et al. (2008), the software used

allowed the teacher to personalize the animation for each student based on the needs of each student. In any case, at least the computer provided the platform on which all these useful practices could be applied and was motivating and engaging for most of the students.

It should be taken into account that the results of the studies included in this review showed a range of heterogeneity in procedure, sample, and methodologies, as observed in the systematic review by Sandgreen et al. (2021). Diverse methods and applications were used to teach vocabulary; therefore, it is challenging to draw definitive conclusions about effectiveness. Factors contributing to this variation include small sample sizes, disparities in methodologies and the use of technology-assisted intervention, and variations in the severity of autism symptoms, making generalization of results difficult. Despite these challenges, the answer to our first question is that the technology used to teach vocabulary might be effective for some participants, but is it more effective than nontechnology approaches?

Technology vs. nontechnology-based interventions

Exploring the second research question, comparing technology-based interventions to nontechnological approaches for vocabulary development in children with ASD, five studies were reviewed: Three studies applied interventions on vocabulary using tablets, two were single-case studies (Chebli et al., 2019; Pellegrino et al., 2020) and three were group studies (Whalen et al., 2010; Allen et al., 2015; Pellecchia et al., 2020). They failed to demonstrate better outcomes for technology-assisted interventions, except Whalen et al. (2010), who showed positive gains in most of the participants.

In the single-case study by Chebli et al. (2019), the authors aimed to compare the effectiveness of tablet and instructor-delivered teaching on the receptive identification of one-word concepts. The results showed that two out of seven participants achieved a faster generalization after instructor-led instruction. The results of the remaining five participants varied across concepts, but, in general, the participants showed more rapid generalization (and lower levels of non-responding) with the instructor for most concepts taught. This result could mean that the non-technology intervention showed more effectiveness than the technology intervention, but the authors, conscientious of the great variability of their sample, preferred to conclude that some learners can benefit more from instructors while others can benefit more from tablets.

In the other single-case study by Pellegrino et al. (2020), the authors compared the learning of receptive labeling using stimuli delivered via tablet and flashcards during discrete trial instruction in three preschoolers with ASD, comparing the number of sessions required to meet a mastery criterion for label identification. They found that all participants met the criterion faster using a flashcard than under tablet condition. However, some participants preferred to use tablets instead of flashcards, although this preference was not related to overall performance during label acquisition.

Allen et al. (2015), with a sample size of 16 participants, which levels of autism were not specified, aimed to compare whether children with ASD are better able to learn new word referent relations using an iPad or a traditional picture book by using color photographs presented using the two mediums. This mapping test to learn new word referent relations showed that the medium of presentation did not have an impact on the extension of labels and therefore did not find an advantage for learning with the iPad.

To explain the advantage of instructor-led instruction over tablet-based instruction, as shown in these studies, we should consider that tablets are generally used at home and school for different purposes. Therefore, it is likely that the children were accustomed to using tablets for play rather than learning purposes. Furthermore, children could feel more comfortable with one-on-one interaction with a teacher than with a tablet (Ganz et al., 2014). But in Allen et al. (2015) children used the tablet in educational settings and reinforcement and found no differences as a result of the medium (book or iPad) used in word learning. Thus, more research is needed in which students use tablets for longer periods of time to compensate their previous experience of using them for other purposes and for different prior experience in the use of different tools for learning. For example, in the group study by Pellegrino et al. (2020), all participants knew how to use flashcards before as part of their individualized intervention, but that was not the case with tablets.

Regarding the use of computers to teach vocabulary, two group studies in this systematic review, Whalen et al. (2010) and Pellecchia et al. (2020), evaluated the effectiveness of computer-assisted instruction (CAI) by comparing it with a waitlist control group. Interestingly, in Whalen et al. (2010), 15 out of 22 children who received computer lessons for 3 months performed better across all measures than the children in the control group on standardized outcome measures. However, in Pellecchia et al. (2020), although children participated in numerous sessions throughout the year and computer lessons incorporated the principles of ABA, the CAI intervention did not show a significantly better impact on receptive or expressive language.

These studies had differences: Pellecchia et al. (2020) likely better represents most underresourced school districts compared to Whalen et al. (2010), who had better trained teachers. There were differences in participant characteristics, duration of study (1 year vs. 3 months), standardized tests used to evaluate vocabulary learning before and after tests, and offline interventions provided. In Whalen et al. (2010), interpersonal lessons using direct instruction were provided, while in Pellecchia et al. (2020), activities to implement in the natural environment and work on skills not targeted in the computer were employed, ensuring that the interpersonal area was not neglected to improve language.

In neither study were the symptoms of ASD specified; all groups were described as students with severe autism. According to Whalen et al. (2010), the students who did not master any lessons were students with severe behavioral and/or attention problems. In Pellecchia et al. (2020), the sample was not specified according to the severity of symptoms in children with ASD, making it unclear which individuals could derive greater or lesser benefits from the CAI method. In addition, concerns arise regarding the quality assessment, as the process of missing outcome data was not clear.

Conclusion

Our systematic review examined the efficacy of technology-based interventions but found a limited number of studies. The use of a variety of technological devices was limited and consisted only of tablets and computers to teach vocabulary to children with ASD.

Tablets, in particular, demonstrated positive results in several studies, showing increased correct responses and generalization of vocabulary skills, similar to Kagohara et al. (2013). They had suggested that incorporating the iPad and related technological devices into programs for the ASD population might be potentially useful.

However, concerns have been raised about the lack of information on generalization of knowledge in some studies and the potential impact of disruptive behaviors on the effectiveness of tablet-based instruction.

Similarly, computer-based interventions also yielded positive results in improving vocabulary in children with ASD. The studies highlighted the importance of factors such as the child's basic knowledge of computers and the motivation to work with the device. However, the heterogeneity of procedures, samples, and methodologies in studies makes it difficult to draw definitive conclusions about the overall effectiveness of technology-assisted interventions.

When comparing technology-based interventions to nontechnology approaches, the review found that nontechnology interventions, such as instructor-delivered teaching or the use of flashcards, demonstrated more consistent and rapid generalization of vocabulary skills. However, compared to the use of picture books, the use of tablets did not show differences in word learning. Thus, the need for further research is emphasized, particularly in terms of longer-term tablet use and consideration of previous experiences with learning tools, to obtain a more comprehensive understanding of the role of technology in vocabulary development for children with ASD.

In summary, while technology, including tablets and computers, appears to be promising in improving vocabulary skills in some children with ASD, individualized assessments, consideration of previous experiences, and attention to the context of use are crucial. The comparison with non-technology approaches underscores the need for more nuanced investigations to identify the specific conditions under which technology-based interventions can be most beneficial for this population. Future research should provide clearer information on the potential of technology to contribute to the development of vocabulary in children with ASD.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

AU: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft, Writing – review & editing. VF-T: Data curation, Investigation, Writing – review & editing. IR-O: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Validation, Writing – original draft, Writing – review & editing. DS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing.

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Influence of socio-family variables on parental assessment of the pragmatic development of children under 4 years of age

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Introduction: Interest in pragmatic development and its assessment has increased in recent years, not only because of the predictive value of pragmatic impairments as warning signs in the detection of multiple developmental disorders, but also because of the consideration that pragmatics has received in the field of mental disorders. Current contexts of child development assessment require pragmatic assessment instruments that accurately define profiles and take into account the immediate context in which they develop. Parents' knowledge of their children's abilities is supported by exhaustive observation over time of regularities in their behavior. But it is true that the way a caregiver interprets behavior is mediated by multiple variables. The aim of the present study, therefore, is to shed light on the possible influence of parental belief systems on the assessment of children's pragmatic development by analyzing the relationship between sociofamilial variables and the assessment of pragmatic competence.

Method: A total of 215 educational centers across Spain participated in the study. The final sample was of 262 parents of boys and girls between 6 and 48 months of age. The parental questionnaire for the evaluation of pragmatic development, The Pragmatics Profile, in an adapted Spanish version, was applied along with a number of items for the evaluation of parental beliefs.

Results: Analyses confirm the existence of an effect of child development conceptions and other socio-familial variables on the assessment of pragmatic development between 6 and 48 months of age. Furthermore, the results indicate that better scores on pragmatic development are associated with parents with higher socioeconomic and educational levels, greater number of children and more interactionist conceptions and realistic.

Conclusion: The effect of parental conceptions on the evaluation of pragmatics points to the need to obtain convergent measures in an area as complex as that of communicative development in early childhood, especially taking into account that an evaluation which is neutral and free from context is not possible or indeed desirable. Pragmatic development must be evaluated within this contextual framework and should take into account each of the variables present therein. Hence the complementarity between parental reports and performance-based test.

KEYWORDS

early pragmatic development, parental expectations about developmental timetables, determinants of development, context assessment, speech therapy intervention

1 Introduction

As Hoff et al. (2014) notes, pragmatics has to do with the earliest phase of communicative intentionality, which, together with form and effect, constitutes one of the three components of the speech act (Reese, 1978). Pragmatics as a focus of study can be addressed from a variety of different areas of knowledge, including speech therapy, neurology, psychology, linguistics and sociology. In clinical linguistics, three major components are identified here; enunciative pragmatics, interactive pragmatics, and textual pragmatics (Gallardo, 2007). Enunciative pragmatics involves the communicative intention of the speaker, while interactive pragmatics focuses on the role of the receiver; between these two lies textual pragmatics, which deals with the analysis of the utterance itself. With the aim of achieving an in-depth understanding of the sequence of development during the early years, Halliday (1975), from the perspective of the socio-semantic study of language development, proposed three phases to which a universal character can be attributed, and which are enmeshed in a structure based on the so-called Hallidayean pragmatic functions. Initially, pragmatic development is based on the instrumental, regulatory, interactional, personal heuristic and imaginative functions, these developing mainly between birth and 18 months, then to give way to pragmatic, mathematical and informative functions. From the age of 24 months a third phase begins, which consists of the mastery of the adult system itself, this characterized by a reconceptualization of the notion of function, understood in the first phase as "use of language," but now a component of the grammar of the mother tongue system that allows the development of ideational, interpersonal and textual functions.

It is within the first 5 years of life that pragmatic developmental milestones emerge at a faster rate (Oller et al., 2012). Before 12 months of age, children acquire the basic mechanisms of nonverbal communication. They must react to the human voice and identify familiar voices, pay attention to the adult's face, laugh out loud, or show responses to adult conversation through resources such as slang, pointing, or the use of communicative gestures during turn-taking (Berko and Bernstein, 2024). Understanding the role of context for the attribution of meaning requires the development of intentional behavior (from primary to secondary intersubjectivity), clearly identifiable at 9 months of age. At this stage, they actively participate in episodes involving joint attention (looking, attention-getting, etc.). Between 12 and 24 months of age, they already use language to make requests, express wishes or refusals, name objects, or share situations. From 24 months of age, they can ask contingent questions (Owens, 2011), inquire about the name and the reason for things, and begin to relate personal events. The symbolic function will make our knowledge about the meaning of things in the physical, psychological, and social world more accessible, allowing us to understand and give meaning to present and future situations, as well as plan actions based on this experiential knowledge. At the same time, they begin to tell fictitious stories (Sutton-Smith, 1986), paving the way for the more typical pragmatic developmental milestones of 36 months, which will consolidate the use of language. It is at this age when children accompany play with language, creating more complex narratives, and organizing their speech to make descriptions or recount stories heard (Pérez and Salmerón, 2006). Understanding the social rules that regulate interpersonal communication will allow them to better adapt to the context in their social exchanges (Messener, 1994). By 48 months, children can already adopt a variety of registers, especially in play situations (Owens, 2011), and these registers will provide training for refining narrative skills and adapting to the context needed in later stages. All milestones should follow the expected chronology to ensure harmonious pragmatic development.

Interest in pragmatic development and its assessment has increased in recent years, not only because of the evident predictive value of pragmatic alterations as the main warning signs in the detection of multiple developmental disorders (autism spectrum disorders, attachment bond disorders, attention disorders, etc.) but also because of the special consideration that pragmatics has received in the field of mental disorders. Proof of this is the recognition and categorization, for the first time, of pragmatic deficits in the diagnostic guidelines of the American Psychiatric Association (2013), (pragmatic) Social Communication Disorder (SCD) (González et al., 2015). Thus, alterations of a pragmatic nature that did not fit the clinical profiles established up to that point in time are now identified and recognized. For the first years of life, when the most significant pragmatic acquisition occurs (Santana et al., 2015), knowledge of the periods of pragmatic development is essential, not only for clinicians, but also for the family, the main context for stimulating communicative and social development.

For all these reasons, the current contexts of child development assessment require instruments of pragmatic evaluation that define profiles precisely and take into account the immediate context in which they are developed. Despite this, the number of methodological studies directly related to the evaluation of this in infants is limited (Portilla and Mogollón, 2015). The study by Prieto et al. (2021) includes an exhaustive analysis of the instruments available in Spanish. It highlights the difficulty of creating communicative situations with ecological validity in the clinical context, thus underlining the usefulness of parental reports as a complement to assessment, despite their limitations and possible biases (Jackson-Maldonado et al., 2013). Also, Šmit Brleković and Kuvač Kraljević (2023) confirm the usefulness of parental reports in the assessment of early language development, since their multidimensional nature, especially considering the limitations of other methodologies, make them a valuable source of information in the early stages of communicative and linguistic development. This is especially relevant in the assessment of pragmatic development before the age of 4, when evaluations of direct performance are difficult, and indeed at times impossible. This barrier is of particular relevance in the clinical setting, where such difficulties compound those arising from possible disorders or alterations in neurodevelopment.

The creation of parental questionnaires has made it possible to overcome these difficulties with a high degree of reliability, not only in the field of communication and language, but in development generally (Gonzalez and De Pedro, 2023). Despite their application and usefulness, some of their limitations can be pointed out. These include social desirability bias, that is, bias due to the experimenter, bias attributable to demand characteristics, and the difficulty that

some questionnaires have in obtaining accurate information about complex behaviors (Anis et al., 2020).

These and other biases can influence the way that parents perceive and evaluate their children's development. Undoubtedly, the knowledge that parents have about their own children's skills is undoubtedly supported by 56 prolonged and daily observation of their behavioral regularities (Guiberson et al., 2011), but they are also influenced by the knowledge coming from their socio-cultural group, forming true implicit theories about development and education. What goals should be achieved, when, through what tasks and actions, and that role children and social agents have in this process, are part of the representations we build as part of a society and are determinants of our actions and ways of interacting. The ideas that parents have about their children and about themselves as parents influence their actions (Triana, 1991; Sigel et al., 2014). This everyday knowledge, which is not in itself accurate, but rather functional, allows parents to be considered as reliable informants about their children's cognitive, motor, social, and also communicative skills, and this is of particular importance for the assessment of pragmatics at an early age (Šmit Brleković and Kuvač Kraljević, 2023). Its reliability has been shown in studies by Suskind et al. (2018), Andrés-Roqueta et al. (2021), and Botana (2021), for example. In these, significant correlations were found between the results of parental questionnaires and those from clinical evaluation by means of direct tests. Specifically, in the study by Botana (2021), a very significant convergence is observed in the assessment of pragmatic development up to the age of three, with divergences then being seen in the year-four group for both measurement instruments. This discrepancy coincides with the variation found in the solidity and strength of parental ideas on the determinants of development at the beginning of formal schooling, around 36 months, in the study by Ribao et al. (2021). On the other hand, at the age of three, there are notable modifications in structural pragmatic aspects due to the role of verbal language in the assessment of pragmatics. The possibility that parents might be biased in the information they provide when answering a questionnaire should itself be a parallel object of study in the evaluation of pragmatic child development. How an adult interprets children's behaviors has to do fundamentally with three aspects: the characteristics of the children, the characteristics of the parents, and the characteristics of the context, all of which contribute to generating expectations and attributions about children's behavior and its causes (Mills and Rubin, 1990).

The parental belief system is a complex construct. It involves shared beliefs, guided by cultural values about the goals of child development and the socializing practices that lead to the achievement of that development. Such evolutionary-educational ideas (Palacios and Rodrigo, 1998; Hidalgo and Hidalgo, 2003; Greenfield and Keller, 2004) are reflected in parents' conceptions of the determinants of development, about the attribution of the causes of behavior and development (to heredity, the environment, or the interaction between the two), and is related to parents' conceptions of what parenting itself entails. In the most innatist conceptions, development is solely determined by genetic factors. The most environmentalist perspectives attribute maximum competence in development to the environment. Meanwhile, interactionists position themselves somewhere in the middle, recognizng both the influences of the context and those of a genetic basis, and adopting a combination of beliefs in the causal attribution of child development. In addition, knowledge about the developmental calendar, the skills that the caregiver believes are developed at the stage in which the child is currently at, will influence the interpretation of their actions. The presence or absence of a behavior can be valued differently depending on parental expectations as to its probable age of acquisition. These expectations explain at what moment parents expose their children to tasks and propose goals for the achievement of which they consider parental support more or less necessary. Without doubt, the origins of expectations about the developmental milestones is cultural and takes form differently in each cultural group or subgroup, but it is also true that expected behaviors condition the beginning of parent-child interaction and its ongoing nature (Siegel et al., 1992; Palacios and Rodrigo, 1998; Hidalgo and Hidalgo, 2003).

In the case of notions about the determinants of development (the nature-nurture controversy) it seems clear that these mediate the behavior of caregivers insofar as they position them as more or less active agents of child development. What does not depend on these notions does not have to give rise to setting specific goals to achieve them. In the same way that if everything depends on these notions, the expectations generated about the effect of their educational activity will very often lead to frustration. Likewise, expecting developmental progress too soon can lead to forcing children into activities for which they are not ready, with a negative effect on the development of their self-efficacy or sense of personal competence. Dysfunctional expectations are related to action plans and consequences that are not positive for child development, and that condition the way in which children and caregivers interact. Excessive optimism about when skills can be achieved, as well as dysfunctional pessimism, can have consequences for the subjective assessment of pragmatic development. Expectations about the developmental milestones and the determinants of development are aspects that mediate the way in which parents and children interact within the area of proximal development (Bruner, 1983; Palacios, 1987).

In the case of pragmatic development, when parents or caregivers report on their children's pragmatic development, they generally refer to their communicative effectiveness. This usually includes an experience-based assessment of four pragmatic indicators that regulate the basic communicative power of children's interaction (Dewart and Summers, 1995): (a) communicative functions; (b) response to communication; (c) interaction and conversation; and (d) verbal variation according to context. These indicators are included in the TPP(e) (Botana and Peralbo, 2022).

These four parameters are decisive for estimating the acquisition of pragmatic skills in the early stages of development, beyond other more structural or formal requirements, such as morphosyntactic ones (Fernández, 2019).

The literature supports the effect of social, family and cultural variables on various aspects of child development (Kluczniok et al., 2013). It provides evidence of the relationship between coming from lower socioeconomic status (SES) environments and the increased risk of language delay (especially its lexical

and morphosyntactic components), as noted by Cohen et al. (2020). Similarly, parents' investment in their children varies with socioeconomic status, and socioeconomic status itself appears to be related to vocabulary development and to a greater presence of child-directed speech in early childhood (Rowe, 2008).

For this reason, and since parental reports are one of the most common assessment instruments in the evaluation of language development, it seems appropriate to determine the extent to which their reliability also extends to the assessment of pragmatic development. To this end, the following objectives have been established:

- To analyse the influence of the educational level of the family on the results of the TPP(e).
- To analyse the influence the socioeconomic status of the family on the results of the TPP(e).
- To see whether the number of siblings leads to any differences in the results of the TPP(e).
- To analyse differences in the results of the TPP(e) due to parents' conceptions of the determinants of development.
- To see if there are any differences between parents' conceptions of the determinants of development and their level of knowledge about the evolutionary calendar.
- To analyse the relationship between this knowledge of the evolutionary calendar and the results of the TPP(e).

2 Method

An ex post facto study of a fundamentally quantitative, descriptive and correlational nature was conducted. As is characteristic of this type of design, there is no intentional manipulation of and independent variable, participants have the characteristics required by the research, and consequently there is no possibility of controlling the variables and their effects, which have already occurred previously. In this type of design, internal validity is lower than external validity, because although extraneous variables cannot be controlled, they deal with more natural and representative situations (Shaughnessy et al., 2007).

2.1 Participants

First, a selection of pre-elementary schools across all the Spanish autonomous regions was made. For this purpose, a total of schools were identified, all of them either public and private centers of the first to the fourth years of primary education. From there, a distribution was made based on the percentage of the Spanish population in each autonomous region, resulting in the distribution as detailed in Table 1.

Of the 420 schools which were sent the information by means of email and were invited to participate, 215 accepted and informed the families of their children about this. Finally, having received the information through the school in question, 271 parents of boys and girls between 6 and 48 months age participated in the study. Participants ($N = 262$) had a mean age of 28.45 months ($SD = 10.449$). The data on asymmetry (−0.336) indicate a slightly skewed age distribution above the mean. Kurtosis data (−0.701) indicate a platykurtic curve with lighter tails than expected under normal distribution. The sample presents a mean of 1.01 siblings ($SD = 0.793$), with asymmetry (0.219), which shows more values above the mean than below, and a kurtosis (−0.819) that, as in the case of age, indicates a platykurtic distribution with lighter tails than expected in a normal distribution.

As can be seen in Figure 1, there is a greater representation of the medium socioeconomic level and the medium and high educational levels, compared to the others. Analysis of the relationship between these variables shows a significant association between them $\chi^2_{(4,245)} = 730{,}879$, $p < 0.001$.

Regarding the exclusion criteria, cases in which the parents reported alterations in development were excluded through a form in which they were asked for information about whether their child presented any of the following difficulties: moderate or severe hearing loss, severe visual impairment, syndromes of a genetic origin, neurodevelopmental disorders, prematurity, central nervous system disorders, long periods of hospitalization and/or institutionalization. Based on these criteria, from the initial collection of participants, a total of 9 were discarded, without any analysis of their characteristics to reveal indications that might justify their consideration as a subsample. The final sample was 262 fathers and mothers.

2.2 Variables and measuring instruments

2.2.1 Pragmatic competence

The TPP(e) questionnaire was used, as adapted by Botana and Peralbo (2022), and based on an original interview by Dewart and Summers (1995). The analyses of the adapted Spanish version show a Cronbach's alpha of 0.976 and a McDougal's Omega of 0.98, values that can be considered very adequate. The TPP(e) evaluates early pragmatic development through 35 items with three response options grouped into three axes of pragmatic development:

> Axis A: communicative functions, including how a child can express intentions, such as requesting, greeting and giving information, through communicative behaviors.
> Axis B: communicative response, indicating the way in which a boy or girl reacts and understands the communication of other people.
> Axis C: interaction and conversation, classifying the way in which children participate in conversation, as a part of social interactions relating to initiation, turn-taking, repair, etc.

It provides a direct score and a centile score for each axis as well as a total score.

2.2.2 Conceptions about the determinants of development

Palacios and Rodrigo (1998) refer to these, noting the problem of the relationship between heredity and the environment in determining human development. Thus, for example, innatist parents would be those who attribute the causes of their five children's development to their genetic characteristics. For

TABLE 1 Distribution of the selection of schools.

Autonomous region	Population	Percentage of population	Schools invited	Schools participating
Andalucía	8,500,187	17.87%	75	44
Cataluña	7,792,611	16.38%	68	41
Comunidad de Madrid	6,750,336	14.24%	60	9
Comunidad Valenciana	5,097,967	10.67%	45	18
Galicia	2,690,464	5.68%	25	24
Castilla y León	2,372,640	5.02%	21	7
País Vasco	2,208,174	4.67%	20	17
Canarias	2,177,701	4.58%	19	6
Castilla-La Mancha	2,053,328	4.32%	18	6
Región de Murcia	1,531,878	3.20%	13	8
Aragón	1,326,315	2.79%	12	3
Islas Baleares	1,176,659	2.47%	10	6
Extremadura	1,054,776	2.23%	9	7
Principado de Asturias	1,004,686	2.14%	9	9
Navarra	664,117	1.39%	6	4
Cantabria	585,402	1.23%	5	5
La Rioja	319,892	0.67%	3	0
Melilla	85,170	0.18%	1	0
Ceuta	83,117	0.18%	1	1
España	47,475,420	100%	420	215

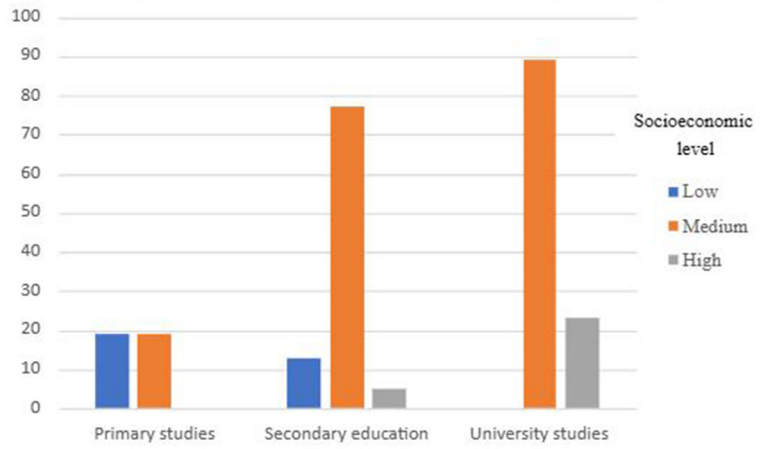

FIGURE 1
Distribution of the sample according to socioeconomic level and educational level.

interactionists, the main determinant of children's development is the relationship between environmental and genetic factors Environmentalists, meanwhile, consider the influence of the environment as the main cause of development. To evaluate these, three questions from the original study mentioned above were used: (1) Why do you think some children are more intelligent than others? (2) If a 4 or 5-year-old child is very shy, do you think that their parents can do something to make them less shy? and (3) Sometimes you would like your child to be able to do something that seems important to you. In those cases, you... Responses were coded as 1 (innatist responses), 2 (interactionist responses), and 3 (environmentalist responses).

2.2.3 Expectations regarding the developmental milestones

These refer to the age at which parents believe that their children will achieve certain normative developmental achievements in childhood (Hidalgo and Hidalgo, 2003). In this study they have been classified as:

> Pessimists: parents assume that developmental goals are achieved at an older age than the age at which this should really happen.
> Realistic: parents show knowledge appropriate for the normative age of acquisition.
> Optimists: parents believe that developmental achievements are achieved earlier, that is, prior to what is actually normative.

Inspired by the study by Palacios (1987), six questions were developed that elicit the knowledge or beliefs of the caregiver regarding the moment at which it is expected that children will reach a milestone; for this, certain milestones of child development were selected and three answer options were associated with them. (1) Next, I am going to ask you a series of questions on what you think about children's development. Please indicate the option that is closest to what you think. At what age do you think children sit up without support? (2) At what age do you think children begin to take their first steps? (3) At what age do you think they can control their own pee and poop? (4) At what age do you think they start to say their first words? (5) At what age do you think they start pointing out what they want or what catches their attention? (6) At what age do you think they start saying their first two-word sentences (e.g., *mamá-tetéorpapá-teté).* Answers which were incorrect because they cited times that were too early were coded as 1; correct answers were coded as 2; and incorrect answers because they were too late were scored as 3.

2.2.4 Socioeconomic level

Information on the educational level of the parents was collected directly through the questionnaire sent to the parents. To this end, parents were asked to state their socioeconomic level from three possible options: "low level" (1), "medium level" (2) and "high level" (3). The family's economic level is related to the type of material resources and experiences that can be achieved in the social context in which families develop.

2.2.5 Educational level

This variable was used to collect information on the educational level of the parent who completed the questionnaire, with the answer options "incomplete or primary studies" (1), "secondary education: vocational training or equivalent" (2) and "higher or university studies" (3). Educational attainment is one of the sources of information that contribute to the formation of parental beliefs.

2.2.6 Number of siblings

The number of siblings is a relevant variable due to its relationship with the developmental milestones, since it is one of the sources of information on what is expected or not in child behavior. Thus, information on the total number of siblings was collected through a direct question in which the parents provided the total number of siblings of the child being evaluated.

2.3 Procedure

Once the sample was selected, information including the objectives and procedures was sent to the schools for parental participation, indicating that the one with the higher educational level should answer the questionnaire. In addition, informed consent was acquired, and other recommendations of the ethics committee were complied. From the schools the information was sent to the families, and by means of a link to Google Forms they were able to access the questionnaire, which contained the 35 questions of the TPP(e), six questions on the developmental milestones, and three questions on the determinants of development. On this form, one item could be seen on each screen, so that it was necessary to answer a question before moving on to the next. The items corresponded to the TPP(e) questionnaire and to those used to classify parental conceptions about the developmental milestones and the determinants of development.

A 3-week deadline for receiving responses was set. From this moment, the data received was recorded and processed.

2.4 Data analysis

Statistical analyses were performed using SPSS (v.29). Missing values were considered to be those cases in which the response to any of the variables under study was omitted.

In order to have a measure that would allow us to group parents according to their conceptions of the determinants of development, the median was calculated for the set of responses. Given that the three questions on determinants of development had answer options ordered from 1 to 3 (innatist = 1, interactionist = 2 and environmentalist = 3), and since each parent could score differently on each item, it was considered that the median, as a measure of the central tendency, would be the statistic that best reflected the parent's perspective. In the case of expectations about the evolutionary calendar, the following were taken into account: the number of correct answers, the number of errors by default (excessively optimistic), the number of errors in excess (too pessimistic) and the total number of errors. In this way, it was possible to assess the level of knowledge that each informant possessed about normative development.

The data were tested for normal distribution using the Kolmogorov–Smirnov test and for homogeneity of variances using the Levene test.

Differences between groups were tested using one-way ANOVA, followed by the Games-Howell *post-hoc* test, which is appropriate when there are groups with different numbers of subjects, as in this case, and equality of variances is not assumed. Finally, a correlational analysis was performed using Spearman's rho.

3 Results

3.1 Descriptive analysis

First, parents were classified according to their conceptions of developmental determinants and developmental milestones. In the first case, of the 262 participants, 87.5% were interactionists, followed by 6.8% environmentalists, and 5.7% innatists. In the case of the evolutionary calendar, the most frequent trend was classified as "realist" (83.2%), followed by "dysfunctional pessimism" (13%) and, finally, with a clearly lower representation, "dysfunctional optimism" (3.8%).

We then tested whether the data obtained from the TPP(e) conformed to a normal distribution. The results of the Kolmogorov–Smirnov test are highly significant in all the axes of the TPP(e) and in the overall result of the questionnaire, so the null hypothesis that the data respond to a normal distribution is rejected. The A-axis scores show a distribution of $Z_{(262)} = 0.213$, $p < 0.01$, with an asymmetry of −0.602 and a kurtosis of −1.068. The B-axis scores show a distribution of $Z_{(262)} = 0.143$, $p < 0.01$ with an asymmetry of −0.426 and a kurtosis of −0.872. On the C-axis, the distribution obtained is $Z_{(262)} = 0.105$, $p < 0.01$ with an asymmetry of −0.565 and a kurtosis of −0.566, and in the total score it is $Z_{(262)} = 0.159$, $p < 0.01$ with an asymmetry of −0.548 and a kurtosis of −0.919. Overall, a negative skewness together with a negative kurtosis suggests that the distribution is skewed to the left and has shorter and less heavy tails than a normal distribution. This indicates that most of the data are concentrated near the mean, and there are relatively few outliers compared to a normal distribution.

3.2 Analysis of variance and *post-hoc* tests

3.2.1 Influence of the family's educational level on the results of the TPP(e)

The results of the ANOVA showed significant differences in the score on the B-axis, and the response to the communication of the TPP(e) between parents with primary education ($M = 19.66$; $SD = 5.095$; $F_{(2,244)} = 7.377$; $p < 0.015$; $\eta^2 = 0.0.57$), secondary studies ($M = 21.41$; $SD = 5.050$; $F_{(2,244)} = 7.377$; $p < 0.015$; $\eta^2 = 0.0.57$) and higher studies ($M = 23.10$; $SD = 5.010$; $F_{(2,244)} = 7.377$; $p < 0.015$; $\eta^2 = 0.0.57$).

Post hoc contrasts only show significant differences on the B-axis between groups 1 and 3 ($Diff = -3.440$; $p = 0.002$), 2 and 3 ($Diff = -1.688$; $p = 0.045$). In both cases, group 3 (high educational level) has the highest scores.

3.2.2 Influence of the family's socioeconomic status on the results of the TPP(e)

The results of the ANOVA again showed significant results in the score obtained on the B-axis of the TPP(e) according to the socioeconomic level reported by the family: parents with low socioeconomic status [$M = 19.28$; $SD = 4.595$; $F_{(2,244)} = 4.919$; $p = 0.008$; $\eta^2 = 0.0.92$], medium [$M = 22.29$; $SD = 5.186$; $F_{(2,244)} = 4.919$; $p = 0.008$; $\eta^2 = 0.0.92$] and high [$M = 22.39$; $SD = 4.947$; $F_{(2,244)} = 4.919$; $p = 0.008$; $\eta^2 = 0.0.92$].

In *post hoc* analyses, as in the case of level of education, differences in socioeconomic level are also concentrated on the B-axis, between groups 1–2 ($Diff = -3.011$; $p = 0.039$), and 1–3 ($Diff = -3.112$; $p = 0.004$). In all cases, the differences are in favor of group 3 (high socioeconomic level).

3.2.3 Differences in TPP(e) results due to the number of siblings

Next, an ANOVA was performed using the number of siblings as an independent variable (categorically coded as 0, 1, 2, and 3), with the three dimensions of the TPP(e) and the total score in the parental questionnaire as dependent variables. In this analysis no significant differences were found between the means of the four established groups.

However, a posteriori contrasts carried out with the Games Howell test show differences on the A-axis, between 0 and 3 siblings ($Diff = -6.389$; $p < 0.001$), between 1 and 3 siblings ($Diff = -4.675$; $p = 0.005$) and between 2 and 3 siblings ($Diff = -4.970$; $p = 0.012$), in all cases favorable to those families with a greater number of siblings. On the B-axis, the differences only appear between 0 and 3 siblings ($Diff = -1.736$; $p = 0.014$). On the C-axis, there are no significant differences. Finally, the results also show differences in the total score of the TPP(e) between 0 and 3 siblings ($Diff = -9.639$; $p = 0.002$).

3.2.4 Differences in TPP(e) results due to conceptions about the determinants of development

An ANOVA was conducted in order to see whether there were significant differences between the responses to the TPP(e) and the conceptions of the determinants of development (coded as 1, 2, and 3, as indicated). In the analyses conducted, the groups of parents showed differences in the total score for the TPP(e) depending on their conceptions of the determinants of development. The three groups of parents, innatists ($M = 54.93$; $SD = 20.03$), interactionists ($M = 74.25$; $SD = 21.97$) and environmentalists ($M = 64.72$; $SD = 24.70$) achieved differing overall scores. Analyzing the data by axes, it can be seen that differences exist between axes B and C. In the case of axis B, differences are observed between environmentalists [$M = 20.33$; $SD = 4.70$; $F_{(2,261)} = 7.534$; $p < 0.001$; $\eta^2 = 0.59$], interactionists [$M = 22.37$; $SD = 5.10$; $F_{(2,261)} = 7.534$; $p < 0.001$; $\eta^2 = 0.59$] and innatists [$M = 17.53$; $SD = 3.48$; $F_{(2,261)} = 7.534$; $p < 0.001$; $\eta^2 = 0.59$]. In the case of the C-axis, differences were found between envirtonmentalists [$M = 13.56$; $SD = 6.87$; $F_{(2,261)} = 6.757$; $p < 0.001$; $\eta^2 = 0.53$], interactionists [$M = 16.44$; $SD = 5.46$; $F_{(2,261)} = 6.757$; $p < 0.001$; $\eta^2 = 0.53$] and innatists [$M = 11.73$; $SD = 5.56$; $F_{(2,261)} = 6.757$; $p < 0.001$; $\eta^2 = 0.53$]. In all cases, parents with more interactionist conceptions obtain a higher average score.

Next, in the *post hoc* analyses, carried out with the Games Howell test, suitable in cases where the groups do not have equal variances, it can be seen that parents with more interactionist conceptions had higher mean scores on all axes of the PPT(e), A-axis ($Diff = 9.772$; $p = 0.018$), B-axis ($Diff = 4.835$; $p = <0.001$), C-axis ($Diff = 4.705$; $p = 0.015$), as well as in the total score

here (*Diff* = 19.312; $p = 0.006$) than the group of parents with more innatist conceptions, followed by the group of parents with environmentalist conceptions.

3.2.5 Differences between parents' conceptions of the determinants of development and the level of their knowledge about the evolutionary calendar

An ANOVA was carried out using the type of conception of the determinants of development (environmentalists, interractionists, innatists) as a factor, and as dependent variables the number of correct answers in the evolutionary calendar questionnaire, the number of errors by default (dysfunctional optimism), excess (dysfunctional pessimism), and the total number of errors. The results show significant differences between the three types of determinants in number of correct answers [$F_{(2,259)} = 39.59$; $p < 0.001$, $\eta^2 = 0.234$], in the number of errors by default [$F_{(2,259)} = 28.16$; $p < 0.001$; $\eta^2 = 0.179$], the number of errors due to excess [$F_{(2,259)} = 35.435$; $p < 0.001$; $\eta^2 = 0.215$], and the total number of errors [$F_{(2,259)} = 38.48$; $p < 0.001$; $\eta^2 = 0.229$].

In the *post hoc* comparisons, carried out with the Games-Howell test, it is clear that parents with more interactionist conceptions about the determinants of development are the ones who provide a greater number of correct answers in the questions on the evolutionary calendar, significantly above environmentalists (*Diff* = −3.84; $p < 0.05$) and innatists (*Diff* = 5.00; $p < 0.05$), with no differences between these. In other words, they have more realistic conceptions about the evolutionary moment at which the achievement of a milestone should be expected. On the other hand, those with the most errors by default (due to optimism) were those who had more environmentalist conceptions (*Diff* = 1.880 with interactionists, and *Diff* = 2.178 with innatists, $p < 0.05$ in both cases), with no differences in this type of error between interactionists and innatists. In the case of errors due to excess (pessimism), it is the innatist parents who differ significantly from both the interactionists (*Diff* = 8.395; $p < 0.05$) and the environmentalists (*Diff* = 8.267; $p < 0.05$), with no differences between environmentalists and interactionists for this type of error. Finally, considering the sum total of errors (whether due to over-optimism or over-pessimism) differences were found between the three types of parents. Among environmentalists and interactionists (*Diff* = 2.008), environmentalists and innatists (*Diff* = −6.089), interactionists and innatists (*Diff* = −8.097). In all cases, it is the interactionist group that makes the fewest errors (all differences were significant at 0.05), followed by the environmentalist group, and with the innatist group having the highest score here. That is, parents who are pessimistic in terms of the evolutionary calendar are essentially innatists. The dysfunctional optimists are essentially environmentalists.

3.2.6 The relationship between knowledge about developmental milestones and the results of the TPP(e)

A Spearman correlation analysis was carried out to explore the relationship between the conceptions of the determinants of development and the scores obtained in pragmatic development. Table 2 presents the resulting correlation matrix, which shows the correlations between the different conceptions and the axes of pragmatic development.

Significant correlations were observed between realistic conceptions and several axes of pragmatic development. Specifically, positive correlations were found with axis B, which addresses response to communication ($\rho = 0.233$, $p < 0.001$), as well as with axis C, which focuses on interaction and conversation ($\rho = 0.179$, $p = 0.004$). These findings suggest an association between realistic conceptions and greater development of communicative and interaction skills.

On the other hand, pessimistic conceptions showed significant negative correlations with all axes of pragmatic development. Moderate negative correlations were observed with axes A ($\rho = -0.169$, $p = 0.006$), B ($\rho = -0.202$, $p < 0.001$), and C ($\rho = -0.173$, $p = 0.005$). These results indicate an association between pessimistic conceptions and lower development in areas such as communicative functions, response to communication, and interaction and conversation.

Correlations between optimistic conceptions and axes of pragmatic development did not reach statistical significance.

Taken together, these findings suggest that conceptions of developmental determinants may be related to pragmatic development in early childhood, highlighting the importance of individuals' beliefs and perceptions in the process of developing.

4 Discussion

The analyses confirms the existence of an effect of the socio-family variables analyzed on pragmatic development between 6 and 48 months. These results show that it is parents with more interactionist conceptions on the determinants of development, with predominantly realistic conceptions about the developmental milestones, higher educational and socioeconomic level, and with more than one child, who obtain the highest scores on the pragmatic evaluation questionnaire TPP(e).

In relation to the objectives set out, the analyses show a significant correlation between the educational and socioeconomic level of parents and the scores obtained in pragmatic development, with the children of parents with a higher educational and socioeconomic level obtaining clearly better scores here. These results are in line with those reported in the study by Ajayi et al. (2017) from a sample of 1.580 children, which confirms the effect of socio-family variables such as educational level, socioeconomic level and nutrition on assessments of children's cognitive development. Also in the study by List et al. (2021), parents of higher socioeconomic status believed that their investment in their children influenced their children's development. Such investment in resources and experiences is, in fact, one of the decisive factors in the production of children's skills during the early stages of development. It has also been shown that this kind of investment differs according to socioeconomic status, as noted by Hoff (2003) and Rowe (2008).

Current studies in this area discuss the implications for understanding the possible effects of family structure on language development (Havron et al., 2022), pointing to possible effects of family structure on various aspects of language development. These

TABLE 2 Correlation matrix between the conceptions of the determinants of development and the scores obtained in pragmatic development (Spearman).

	Realistic conceptions ($n = 218$)	Pesimisstic conceptions ($n = 34$)	Optimistic conceptions ($n = 10$)
Axis A; Communicative functions	0.157	−0.169*	−0.038
Axis B; Response to communication	0.233**	−0.202**	−0.087
Axis C; Interaction and conversation	0.179*	−0.173*	−0.074
Total score of the TPP(e)	0.180*	−0.171*	−0.067

*$p < 0.05$.
**$p < 0.01$.

findings do not allow us to establish a clear profile of the family structure that favors language development, with controversial issues regarding the positive effect of the number of older siblings, for example, in the study by Tsinivits and Unsworth (2021), vs. the negative effect of the number of older siblings in that by Havron et al. (2022). In the present study, we analyzed the relationship between the number of siblings, without specifying the order of these, and scores in pragmatic development. The experience of parenting with more than one child is undoubtedly a relevant source of information toward understand the extent of developmental determinants and toward a better understanding of typical developmental patterns (Guiberson et al., 2011). But sibling interaction is also a driving force for pragmatic development.

The importance of parents' experience and knowledge on development are also related to socioeconomic and educational status, as reported by Hutchinson and Wojcik (2022). In their research they find that many adults with various cultural and professional backgrounds are unsure about how children develop, and the authors note differences in the way parents and non-parents think about development. Even so, it is important to bear in mind that, in our sample, the variable analyzed was the number of siblings, without including the order of birth, which hence does not assess differences in terms of being older or younger children, which would really allow us to discriminate the impact of experience and early exposure to communicative formats with siblings more thoroughly.

On the other hand, our results allow us to affirm that the children of those parents whose conceptions on the determinants of development are more interactionist and have a greater knowledge of the evolutionary calendar do obtain better scores in pragmatic development. At the same time, a higher educational and socioeconomic level, and the presence of siblings, also have a positive effect on the scores obtained in the pragmatic competences of the minors here.

These findings are consistent with those found in other studies on the favorable effect of parental conceptions on the assessment of their children's linguistic or non-linguistic achievements. For example, mothers who believe that the environment can positively influence child developmental outcomes are known to initiate quality language use with their children, which in turn correlates with more advanced lexical and syntactic skills (Gamble et al., 2009; Sigel et al., 2014; Wang et al., 2022).

We know that the ideas parents have about their children and themselves as parents influence their actions (Triana, 1991; Sigel et al., 2014), and therefore it is not surprising that those parents with more interactionist ideas, who perceive a relationship between their actions and their children's achievements, are the ones who obtain the highest scores in the assessments of their children's pragmatic skills.

In addition, the results of the present study show a relationship between expectations as to the maturation calendar and the assessment of pragmatic development, parents with more realistic conceptions obtaining higher scores on the pragmatic development questionnaire. These results are in line with other studies in various related areas of child development and academic achievement. We know that the structural characteristics of the family and the educational beliefs of the parents are related to the quality of the language acquisition process, and that the quality of the process is directly related to the child's outcomes (Kluczniok et al., 2013). But this is certainty not enough. Current lines of research are rigorously addressing the effect of family and contextual variables in the study of specific skills, examples here being studies of executive functions in ASD (Quero and Cañete, 2022) and in the assessment of academic performance (Rodríguez-Santero and Gil-Flores, 2018; Gonzalez and De Pedro, 2023), level of vocabulary (Cohen et al., 2020) and motor development (Jiménez et al., 2020). Again, these findings should not be surprising, since knowing the evolutionary moment at which a milestone should appear will undoubtedly favor the process by which parents, especially the most interactionist ones, propose appropriate spaces and contexts so that this milestone can occur, thus acting as facilitating agents of development.

Parents' expectations as to the developmental milestones, their causal attributions, and their position on the nature-nurture continuum, as well as their educational and socioeconomic status, will mediate not only the assessment of achievements, but also the way in which they adjust the stimulation of pragmatic milestones in the early years. A caregiver whose beliefs place them as an agent of their child's development will directly and indirectly contribute differentiated strategies to the interactions they share in daily life (Hidalgo and Hidalgo, 2003).

In the field of early care, where pragmatic development is of crucial diagnostic importance (Trivette et al., 2010; McWilliam, 2016), such evidence has been used as an anchor for family-centered practices, thus establishing routines as the main format for study and intervention. The family continues to be seen as the main context in which the most significant development opportunities of the early years take place, as it had been seen in earlier ecological theories (Bronfenbrenner, 1986). Knowing to what extent the opportunities for communicative development—the

formats defined by Bruner (1982)—are mediated by conceptions of development in parents and their social contexts, and to what extent they shape the zone of proximal development (Vigotsky, 1934; Vygotsky, 1984) in which children make their communicative advances, is important from the point of view of speech therapy. Not only because of the interest in knowing about parental perceptions and their conditioning factors to understand how these influence child development, but also toward having resources that allow them to be modified, since these are not static but change according to parents' own experiences as parents (Hidalgo and Hidalgo, 2003). Speech therapy evaluation requires new tools, and intervention here also echoes these shortcomings. In 2016, as a result of the work by Escorcia et al. (2016), it was pointed out that there was a need to reflect on the transformation of speech therapy services and how this change should be assumed by practice here. Subsequent research on evidence-based practices (Strain, 2018) suggests reflecting on professional practices in general in early childhood, and speech therapy practices in particular. Today, there is no doubt that context-focused speech therapy intervention is defined as a construct and needs not only a reconceptualization, but also broad research that delimits assessment and intervention methodologies within a framework based on research evidence.

Some limitations in the present study should be noted here. First, the sample size. It would be interesting to expand this in order to achieve a better representation of the various autonomous communities of Spain, since these regions have specific socio-cultural characteristics. The expansion of the sample would also allow a greater representation of parents with innatist and environmentalist conceptions.

Also, it would be of interest to have assessments through direct execution methods in parallel, so as to be able to clarify whether the scores obtained in the parental assessment of pragmatic development coincide with those obtained in direct execution tests, as is the case in other studies carried out with the TPP(e) (Botana, 2021).

Another issue that emerges from the present research, and which suggests future lines of work, is the study of the communicative formats of the family and their relationship with pragmatic development. The socio-family variables that indicate better achievement in pragmatic development are traditionally associated with better alternatives for a good work-life balance, and greater access to resources and experiences. This may allow for more time to be dedicated to children, but how this time materializes and to what extent it favors communicative formats that themselves favor pragmatic development is an interesting field of study, one that would allow new strategies in the framework of family-centered speech therapy intervention. A recent study by Martinot et al. (2021) presents a similar proposal regarding exposure to screens in childhood. These authors have shown that screen exposure times are not as much predictors of worse outcomes in children's communicative development as is traditionally believed, but that it is the social moment at which screen exposure occurs that poses more negative effects on communicative development. For example, the children with the worst communicative development skills are those whose families make use of screens during dinner, depriving children of the communicative and social routine that family meals imply, demonstrating the impact of a social routine, in this case dinner, on communicative development.

5 Conclusions

The effect of parental conceptions and other socio-family variables on the assessment of pragmatics points to the need to obtain convergent measures in an area as complex as that of communicative development in early childhood, especially considering that a neutral, context-free assessment is not possible, or desirable (Gibbs and Colston, 2020). Pragmatic development must be assessed within this contextual framework, and should take into account each of the variables present therein. Hence the complementarity between parental reports and direct execution tests.

Parental reports have been shown to be a valuable tool in the assessment of children's language development (Šmit Brleković and Kuvač Kraljević, 2023), so much so that their use is common in clinical and scientific settings. The fact that there is a great deal of congruence between educational and socioeconomic level, parental experience, beliefs about the determinants of development, and expectations about the evolutionary calendar and pragmatic development as assessed through the TPP(e), only reinforces the idea that parental reports are a robust indicator of children's development in the family environment.

However, it is not enough to claim that through parental reports it is possible to assess the development of children. It is also useful to explore the explanation of differences between clinical and parental assessments, as these reports may contain assessment biases. But it must also be understood that the assessment of the actions through which a child demonstrates their communicative skills needs be carried out in parallel with the child and their context (Mikulic et al., 2007), thus achieving complementary versions of the same assessment.

In any case, verifying the congruence and interest of the variables studied here for the evaluation of early pragmatic development should not obscure the importance of developing programs aimed at modifying these. In particular, parental belief systems, as well as the information and training that exist and arise within families, are dynamic and modifiable. Family intervention programs, and the incorporation of the social context into the clinical or educational treatment of communication and language problems, are increasingly necessary in today's complex society (Bronfenbrenner, 1986; Bronfenbrenner and Morris, 2006).

In short, such studies, as well as out own here, corroborate the notion that child development is not an isolated activity, but occurs in the context of interactions with caregivers, whose expectations and thinking have a decisive influence on the way they approach their children's development and education.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

IB: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Validation, Visualization, Writing—original draft, Writing—review & editing. MP: Formal analysis, Supervision, Validation, Writing—review & editing.

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Expressive syntax matters for second-order false belief: a study with hearing-impaired children

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While children with typical language development may capitalize on general language skills to grasp the content of others' minds, those with challenges in mind-reading could rather rely more specifically on complementation structures. However, most studies investigating mind-reading have focused on first-order false-belief reasoning, while much less is known about second-order false-belief, particularly for children that may present language difficulties, such as children with hearing impairment. This study aims to explore the link between language development and second-order false-belief in hearing-impaired children compared to their hearing counterparts. It seeks to ascertain whether mastering second-order false-belief requires the comprehension of complements or other language skills in hearing-impaired children, and if a distinct pattern emerges in their hearing peers. Children with hearing-impairment ($n = 22$) and a chronological age-matched control group ($n = 25$), ages 8–12, were administered a second-order false-belief task (carefully avoiding use of complements and highly visual). Alongside this, they completed assessments of expressive vocabulary, receptive and expressive syntax, recalling sentences, and a recursive sentential complements task. Correlational analysis revealed that in the control group only productive syntax was related to performance on the second-order false-belief task, while in the hearing-impaired group, expressive vocabulary, recalling sentences and sentential complements were related to second-order false-belief performance. These results show that vocabulary, recursive complements and expressive syntax are particularly important aspects for second-order false-belief success in children with hearing-impairment as compared to their hearing peers. These results shed light on how language and second-order false-belief understanding are related in their development.

KEYWORDS

second-order false-belief, language, hearing-impairment, recursive complements, syntax, theory of mind, children

1 Introduction

The study of the relationship between Theory of Mind (hereafter ToM) and language is fundamental to understanding the complexity of human interactions. ToM, or the ability to attribute mental states to others (Yu and Wellman, 2023), together with the mastery of language, allow us to communicate effectively, establish meaningful relationships and resolve conflicts. It is currently assumed that language and ToM are related (Astington and Baird,

2005). However, they are not monolithic concepts and do not develop in one fell swoop, and can moreover emerge differently across groups. Thus, it becomes relevant to ask: Which subcomponents of language are related to which ToM skills, and in what way do these relationships manifest themselves throughout development in different populations? In this study, we will delve into these issues by focusing on an advanced ToM ability that is rarely examined, 'second-order false belief' (SOFB), and its link to different language abilities in middle childhood (lexical and syntactic), in both hearing children and children with hearing impairment. The aim of this study is to expand our understanding of how these communicative and socio-cognitive skills relate to one another in hearing and hearing-impaired children.

Most studies that have reported links between language skills and ToM have focused on studying linguistic influences on first-order mentalistic skills (i.e., those that involve understanding, for example, other people's false beliefs) and have found that various language skills are important for its development, such as vocabulary (Schick et al., 2007), language referring to mental states (Ornaghi et al., 2015), grammatical skills (Farrar et al., 2009), conversational experience (Ornaghi et al., 2017), epistemic verbs (San Juan and Astington, 2017) or general language comprehension (Cheung et al., 2004). There is also evidence to suggest that children with language difficulties (Rieffe and Wiefferink, 2017) or hearing deficits (Woolfe et al., 2002; Schick et al., 2007; Slaughter and Peterson, 2011; Walker et al., 2017) have less difficulties in first-order false belief.

The literature on this topic has suggested different theoretical explanations for the influence of language on first-order ToM. One suggests that the mastery of the syntax of complementation (or comprehension of sentential complements) is an ideal tool to represent people's false beliefs. Specifically, it is argued that this type of complement with cognitive and communicative verbs (as in "Gabriel thinks/says that his brother ate the cake") can be true or false regardless of whether the subordinate sentence is true or false (i.e., Gabriel can say the brother ate the cake despite the brother having not eaten it), a fact that would make mastery of these sentences important for children's understanding that people can have false beliefs about reality (de Villiers, 2018). On the one hand, some studies have shown that comprehension of sentential complements is related to comprehension of first-order false beliefs, both in typically developing children (de Villiers and de Villiers, 2012) and in deaf and hard of hearing (hereafter DHH) children with slow linguistic development and no sign language (de Villiers and de Villiers, 2000). On the other hand, linguistic training with sentential complements can improve children's ability to understand first-order false beliefs, including in DHH children (Lohmann and Tomasello, 2003; Durrleman et al., 2019, 2021; Durrleman and Delage, 2020), suggesting that language does indeed help with this ToM ability.

There is an extensive literature on how children develop the capacity to understand first-order false beliefs. Such understanding is useful in a wide range of situations in which we need to anticipate or explain the behavior of others based on the consideration that their beliefs may not coincide with reality (e.g., the shop is closed, but Maria believes that the shop is open; Wimmer and Perner, 1983). However, a less explored aspect of ToM is the recursivity of belief attribution (Peloquin et al., 2023). When we attend to beliefs that refer not to the state of the world, but to *another's* belief about the state of the world (e.g., "*John believes* not that the shop is open/closed but *that Mary believes that* the shop is open/closed"), we perform a recursive mental state attribution commonly referred to as second-order false belief (SOFB) understanding (Perner and Wimmer, 1985; Perner, 1988). Developmentally, while first-order false-belief comprehension is achieved at around 4 years of age, the more complex operation of SOFB is usually achieved between 7 and 9 years of age in typically developing children (Miller, 2009, 2012). However, this SOFB skill has been studied to a lesser extent in the ToM literature (Miller, 2012), and even less is in DHH children. One example of such is the study by Walker et al. (2017) with 5-, 6- and 8-year-old DHH children, which included a measure of SOFB at 8 years. In their study, no differences were found between the hearing group and the DHH group in terms of SOFB resolution, which may be due to the age of the participants or the degree of hearing loss.

Along the lines outlined above, some authors hypothesize that in order to understand this type of recursive mentalistic reasoning (SOFB), mastery of recursive complement sentences is necessary, because it is precisely the subcomponent of language that allows us to construct sentences referring to the beliefs that one person has about another person's beliefs (e.g., "Peter's mother believes that Peter thinks…") (see de Villiers et al., 2014). In support of this view, Polyanskaya et al. (2018) found that mastery of recursive complements was a significant predictor of SOFB comprehension, even after controlling for variables such as age, grammatical comprehension, and working memory. On the other hand, the study by Hollebrandse et al. (2014) compared SOFB comprehension tasks (verbal and low verbal) and found that children aged 7–9 years performed worse on the low verbal version, arguing that language might help second-order belief reasoning by helping to keep track of the different beliefs of the people involved. However, this study does not allow us to draw conclusions about whether it was the syntactic, semantic, or pragmatic aspects of language that helped to perform better on the verbal SOFB tasks than on the low verbal version of these tasks.

Moreover, it is relevant to study the relationship between language and SOFB in children with language impairment because it has been suggested that ToM milestones may have a differential order of acquisition in DHH children (Peterson and Wellman, 2009; Yu et al., 2021). Such results suggest that ToM acquisition in these groups is not merely delayed, but develops differently. So the relationships between mentalistic skills and language may be different in children with language impairment compared to hearing children, as suggested by preliminary findings in children with autism (Polyanskaya et al., 2022). Furthermore, it has been observed that the difficulties of children with language impairment or auditory deficits in understanding the mental states of others may persist even into adulthood (Clegg et al., 2005; O'Reilly et al., 2014; Marschark et al., 2019), and they may also be present in children with early hearing provisions (Yu et al., 2021). Identifying the potential links between these abilities and language in DHH children may hint at possible remediation avenues (Durrleman et al., 2021) and thus contribute to minimizing challenges of this group before reaching adulthood.

1.1 Present study

Given that the link between the various components of language and SOFB has not been sufficiently elucidated, the aim of the present study is to shed light on the link between different components of language development and SOFB in DHH children compared to

hearing peers. First, we will analyze whether the link between ToM and language is similar in the two groups of participants and secondly whether SOFBs require global language skills or rather the specific recursive mastery of sentential complements.

Thus, two exploratory research questions emerge:

1 Which language components (vocabulary, general syntax or sentential complements) will show the strongest relationship with SOFB in hearing and DHH children, and are the patterns similar or different in these groups?
2 Is mastery of recursive sentential complements a necessary condition for hearing and DHH children to pass SOFB?

2 Methods

Participants were part of a larger study about the relations between language components and ToM in primary school children.

2.1 Participants

Forty-seven children participated in this study. They were divided in two groups: DHH children ($n = 22$; 9 females) and hearing children ($n = 25$; 14 females), ages 8–12. The DHH group included 22 non-signing children ($M_{age} = 9.92$ years; range 8.05–12.61 years; SD: 1.37), diagnosed with permanent bilateral hearing loss by a certified audiologist. The average age of first audiological devices was 43.8 months (SD: 28.7). The degree of hearing loss ranged from mild–moderate to profound. All of them needed audiological aids: 11 used 2 hearing aids, 7 had two cochlear implants (CI), 2 had 1 CI, and two had a CI and a hearing aid.

All of the children of the DHH group wore audiological devices and were assisted by Language-therapists. A total of 10 children had a profound loss, 2 a severe one, 9 a moderate loss, and one a mild/moderate loss. Due to the heterogeneity of the sample in terms of the degree of hearing loss, two groups were created to assess possible differences in terms of study variables: a subgroup of children with profound/severe hearing loss ($n = 12$) and a subgroup of children with moderate/mild hearing loss ($n = 10$). The analysis found no significant differences in study variables between the groups ($p > 0.05$).

The 25 hearing children had a mean age of 10.24 years (range 8.32–12.17 years; SD: 1.07). There were no significant age differences between the two groups ($F = -2.325$; $p = 0.134$), and no differences either in the non-verbal IQ ($F = 1.099$; $p = 0.403$).

2.2 Measures

The following tasks were individually administered in the following order.

2.2.1 Expressive vocabulary

The Part A of the vocabulary sub-test of the K-Bit test (Kaufman and Kaufman, 2000) was administered to assess children's expressive vocabulary. In this test, children are shown black and white drawings and they are asked to name the picture. The raw score of this part was used.

2.2.2 Non-verbal intelligence

The matrices subtest of the K-BIT test (Kaufman and Kaufman, 2000) was used to ensure that the non-verbal intelligence of the two groups was similar. The items of the test require to understand the existent relationships between different items by pointing or naming the correct response in a multiple-choice question. The standard score of this sub-test was calculated.

2.2.3 Comprehension of first- and second-order complements

We designed a task to evaluate children's comprehension of first- and second-order sentential complements with communication verbs. It was based on the task used by Hollebrandse et al. (2008). In this task, children were told 2 stories, with the support of 2 colored drawings for each.

In each story a first character said something to a second character in direct speech (while showing the first drawing). After that, the second character reported the same information to a third character, but this information contradicted what was seen in the drawing 2. After that, two test questions were asked: The first-order complement question asked about what the first character said to the second character (e.g., "What did the mother say?"). The second-order complement question asked about what the second character had said to a third character (e.g., "What has Gabriel said to Marta?").

Children were awarded one point if they replied correctly to the first question using a first-order sentential complement (e.g., "She said that it was sunny"), and they were awarded another point to the second-question if they responded correctly by using a second-order sentential complement (e.g., "He said that the mother had said that it was sunny"). Since there were two tasks and they scored 0–2 each, the range of total scores was 0–4.

2.2.4 Understanding first- and second-order false belief

An adaptation from the Sally-Anne task used by Braüner et al. (2020) was designed for this study. In this adaptation we created two tasks with low verbal content, and we avoided the use of second-order sentential complements. Each story was told with 6 colored drawings, presented in pairs. The tasks contained questions about the understanding of first and second-order false beliefs in addition to control questions. In each task children were awarded 1 point for responding correctly to the control and SOFB questions, and another point for justifying their answer to the latter (if they explained that one of the characters did not see or did not know that the other character had seen or known where the object really was). The description of one of the tasks can be found in Supplementary material.

2.2.5 Sentence repetition

The sentence repetition subtest of the Clinical Evaluation of Language Fundamentals (CELF-V; Wiig et al., 2013), a standardized test designed to assess language in children from 5 to 15 years, was used. The sub-test measures the child's ability to listen to sentences of increasing length and complexity and repeat them without changing the meaning, content or structure. It has 26 items with different starting points, and items are valued from 0 to 3 according to the mistakes made by children. The raw score of the test was used.

2.2.6 Receptive grammar

The Comprehension of Grammatical Structures (CEG) test (Mendoza Lara et al., 2005) was administered to evaluate receptive grammar. It was designed to evaluate children from 4 to 11 years of age. In this test children are shown four drawings and they have to choose which of them corresponds to a sentence read by the examiner. It does not require any type of verbal response, so it is an appropriate measure to evaluate language comprehension in children who may have expressive language difficulties. The CEG has 80 evaluation items, we only included a selection of 16 items that were mostly linked to the aims of our research, with the following grammatical structures: 2 items of predicative non-reversible SVO sentences; 2 items of attributive sentences; 2 items of pronominalized predicative sentences; 2 items of predicative sentences SVO with plural subject; 4 items of relative sentences from the type SO; 2 items of OVS sentences with a focused object; 2 items of relative sentences of the type SS.

2.2.7 Expressive syntax

In order to evaluate the expressive syntax of the participants, we administered the syntax subtest of the BLOC-SR (Puyuelo et al., 2007), a standardized test designed for evaluating the language of children from 5 to 12 years. This test uses practice items for children to understand which type of sentences they are expected to produce. The syntax subtest has 35 items plus 10 items of practice. However, for the interests of the present study, only 12 items of the syntax subtest were administered to the children (plus 3 practice items), corresponded to the following parts of the sub-test: (a) 4 items of simple sentences of the type S-V-adverbial of place; (b) 4 items of simple sentences of the type (S-V-DO-IO); (c) 4 items of adverbial clauses of cause and condition.

2.2.8 Other measures

In addition to the tests administered to the children, the following questionnaires were administered to the parents or speech therapists of the participants:

a Sociodemographic data questionnaire: A brief questionnaire was administered to the parents to ask for: gender, date of birth, date of schooling, language used by the parents to address their children, language used between the child's parents, existence of learning difficulties, and existence of medical problems or disorders.

b Hearing loss questionnaire: A brief questionnaire was administered to the speech therapists to gather information about the following variables: age of onset and cause of the hearing loss, age of detection, level of loss in each ear, types and age of onset of hearing devices, and relatives with hearing loss.

2.3 Procedure

First, permission to conduct the study was obtained by the ethical committee of the institution where the first author works. Parents of the participants were asked to sign a consent form.

DHH children were contacted through public services attended by children with hearing loss and/or linguistic difficulties. The speech therapists working in this service visit children at the child's school on a weekly basis. This service contacted the families and schools. Speech therapists were present to the sessions as listeners but did not participate in them. Hearing children were contacted through a public school.

Tasks were administered in 2 sessions, lasting about 25 to 40 min each, in a quiet room in the child's school.

Due to the relatively small size of the sample and the fact that three of the study variables, including the dependent variable, did not meet the assumptions of parametric analysis, the Mann–Whitney U group comparison test and Spearman's correlation analysis were applied.

3 Results

Descriptive statistics of language measures and SOFB comprehension are shown in Table 1.

Between-group comparisons showed no differences in the acquisition of recursive complements between the hearing and DHH groups ($Z = -0.393$; $p = 0.694$), nor in the receptive grammar ($Z = -1.356$; $p = 0.175$), or expressive syntax ($Z = -1.766$; $p = 0.077$); however, significant group differences were found in the level of vocabulary ($Z = -4.159$; $p < 0.001$), in sentence repetition ($Z = -3.565$; $p < 0.001$), and in the understanding of SOFB ($Z = -2.169$; $p = 0.030$).

Correlational analysis (see Table 2) revealed that in the control group only general expressive syntax was related to performance on the SOFB task while in the hearing-impaired group, vocabulary, sentential complements and expressive syntax were related to SOFB performance.

We then specifically studied the relationship between second-order sentential complements and SOFB understanding. Most children (95.6%) who passed the second-order complements task also passed the SOFB task (22 out of 23). Conversely, among those who failed the second-order complements task, 62.5% passed the SOFB task (15 out of 24). Fisher's Exact Test indicated a significant

TABLE 1 Means (and standard deviations) of the variables in the study, comparing DHH and hearing children.

	Hearing children	DHH children	Comparison (Mann–Whitney)
SOFB	3.48 (1,26)	2.86 (1.49)	$Z = -2.169$
			$p = 0.030$
			$r = 0.32$
Vocabulary	38,84 (3.36)	32.09 (5.63)	$Z = -4.159$
			$p < 0.001$
			$r = 0.61$
Sentence repetition	8.9 (2.82)	5.05 (3.42)	$Z = -3.565$
			$p < 0.001$
			$r = 0.53$
Sentential Complements	3.24 (0.93)	3.18 (0.79)	$Z = -0.393$
			$p = 0.694$
Receptive grammar	12.64 (2.29)	11.82 (2.11)	$Z = -1.356$
			$p = 0.175$
Expressive syntax	9.84 (1.79)	8.50 (2.61)	$Z = -1.766$
			$p = 0.077$

The effect size estimate r was calculated using the formula $r = |Z|/\sqrt{n}$ (see Rosenthal, 1991; cited in Field, 2018).

TABLE 2 Spearman correlations between SOFB and other variables in the DHH and hearing groups.

		Vocabulary	Sentential complements	Sentence repetition	Receptive grammar	Expressive syntax
SOFB	Hearing children	$r_s = 0.167$	$r_s = 0.314$	$r_s = 0.278$	$r_s = 0.077$	$r_s = 0.501$*
		$p = 0.424$	$p = 0.126$	$p = 0.179$	$p = 0.713$	$p = 0.011$
	DHH children	$r_s = 0.432$*	$r_s = 0.448$*	$r_s = 0.435$	$r_s = 0.203$	$r_s = 0.523$*
		$p = 0.045$	$p = 0.048$	$p = 0.055$	$p = 0.364$	$p = 0.013$

*Correlation is significant at the 0.05 level (2-tailed).

TABLE 3 Crosstabs showing the relationship between children's performance in SOFB tasks and their performance in second-order complements task.

		Pass SOFB tasks	Fail SOFB tasks	Total
Hearing children	Pass second-order complements task	13	1	14
	Fail second-order complements task	8	3	11
Total		21	4	25
DHH children	Pass second-order complements task	9	0	9
	Fail second-order complements task	7	6	13
Total		16	6	22

In this table, children were considered as passing SOFB tasks if they responded correctly to the question about SOFB in each task; also, children were considered as passing the second-order complements if they responded correctly to the second-order complements question in both tasks.

relationship ($p = 0.010$). Further analysis for each group separately (see Table 3) showed significance for DHH children ($p = 0.046$) but not for hearing children ($p = 0.288$). Notably, 53.8% of DHH children passed the SOFB task without mastering second-order complements task, compared to 72.7% for hearing children.

4 Discussion

Similarly to prior studies, comparative results between hearing and DHH groups showed differences in SOFB understanding in favor of the hearing children (Jones et al., 2015; but see Walker et al., 2017). In relation to the linguistic variables, differences were observed too in terms of expressive vocabulary and sentence repetition. However, no such differences were observed in expressive syntax or receptive grammar, nor in understanding sentential complements.

With regard to our first research question, the relationship between SOFB and language was observable in both groups for expressive syntax, with a correlation of moderate-high intensity. For hearing children, this more advanced component of ToM (SOFB) was not related to some of the language components to which simpler, first-order belief performance had been linked in prior studies, such as vocabulary (Schick et al., 2007) or grammar (Farrar et al., 2009). These results are partially in line with those obtained by other scholars focusing on SOFB, namely Filip et al. (2023), who reported that in 5–6-year-olds, neither syntactic comprehension nor vocabulary production explained SOFB understanding, whereas syntactic recursion and pragmatics did. In another study, Bigelow et al. (2021) found that vocabulary was associated with advanced ToM in both young and old children. However, their results are not entirely comparable with ours, as their study included different types of ToM tasks (including first- and second-order FB tasks). Moreover, their vocabulary task consisted of defining vocabulary, which requires syntactic skills. Taken together and bridging the differences between the tasks, the results of the abovementioned studies and ours point to a greater importance of expressive syntactic skills (through syntactic recursion, pragmatics or vocabulary definition) in explaining SOFB understanding. Of course, it can be suggested that syntactic expression (of simple and complex sentences) requires a higher level of morphosyntactic mastery than the necessary for syntactic comprehension. The results show, therefore, a relationship between the mastery of complex linguistic skills and SOFB. Unfortunately, our study does not allow us to explore the relationship with the pragmatic and discursive skills that are in full development in the ages of the children in our sample, which should be the subject of future studies.

While the SOFB-language link emerged in both groups for expressive syntax, the group of hearing children nevertheless had a differential pattern to that observed in the group of DHH children, in which sentential complements, sentence repetition, vocabulary and syntactic expression showed a clear relationship with SOFB. In the DHH group, therefore, a more global relationship between language and SOFB was observed, with several linguistic components involved. The intensity of this relationship was also stronger than the one reported for hearing children by Osterhaus and Bosacki's (2022) meta-analysis between the linguistic measures and advanced SOFB. Prior studies also have found that ToM skills were more strongly related to language in DHH children as compared to hearing children (see Sidera et al., 2017, 2020).

In short, although we observed that language was associated with SOFB both in hearing and DHH children, it should be emphasized that not all components were associated to the same extent in both groups. It is possible that these differences in the relationship between language and SOFB are due to variations in their developmental progress. This may be due to a different progress in global language development, which affects the domain of the SOFB, or the differences may even stem from the specific mastery of some of the components of the language, such as that of the recursive complement sentences.

In relation to our second research question, we did not observe that mastery of recursive complement sentences was necessary for SOFB understanding, neither in DHH or hearing children. While we found that almost all children who mastered second-order sentential complements were successful in understanding SOFB, many children who did not pass the second-order sentential complements task still

passed the SOFB task. However, these variables were significantly associated in DHH children and not in hearing children, which means that mastering second-order complements was more important for passing 2OFB for DHH children than for hearing children. In sum, understanding sentential complements may not be a necessary condition for understanding the SOFB task, but it seems to help, as previously found for first-order FB understanding (de Villiers and Pyers, 2002). Nevertheless, the sentential complements task that we used, despite the fact that it had visual aids, required from syntactic expression and thus may be more demanding than the syntactic comprehension questions involved in SOFB comprehension tasks. In this sense, the results of the study by Guan et al. (2018), with complementation and first-order FB tasks, suggest that the two tasks involve interacting but separate neural networks. Precisely these authors pointed out that the complementation task is potentially more demanding than the FB task. In this regard, future studies could study the link between SOFB understanding and recursive sentential complements understanding using also receptive and not only expressive tasks of sentential complements.

The results of this study, although exploratory, showed that beyond first-order FB, the relationship between language and advanced aspects of ToM, such as SOFB, continues to be observed. In this sense, improving language abilities can help the development of mentalistic skills. In particular, we observed the relevance of the mastery of complex aspects of linguistic ability, such as the syntactic component in its expressive aspect. In this regard, at an educational level, fostering the development of syntactic skills in conversations about people's beliefs, including sentential complements, might be beneficial for fostering SOFB, as interventions with sentential complements may be useful for developing FB understanding in DHH children (Durrleman et al., 2021). Finally, our study shows that the relationship between SOFB and language was different in hearing and DHH children, as authors such as Farrar et al. (2017) have already suggested, both in relation to the syntax of complementation and other aspects of linguistic competence. Future studies should study this differential development in more detail.

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 Comitè d'Ètica i Bioseguretat de la Recerca, University of Girona, Spain. This study was conducted in accordance with the local legislation and institutional requirements (reference for this study CEBRU0014-2018). Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

ES: Conceptualization, Formal analysis, Funding acquisition, Investigation, Writing – original draft, Writing – review & editing, Methodology, Project administration, Resources, Supervision. AA: Investigation, Resources, Writing – review & editing, Methodology. SD: Conceptualization, Methodology, Writing – review & editing, Supervision. AI: Investigation, Resources, Writing – review & editing. FS: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing, Data curation, Project administration, Supervision.

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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.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2024.1401576/full#supplementary-material

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The acquisition of object relative clauses in Spanish

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The aim of this paper is to compare children's performance in a declarative object and subject relative comprehension task. Relativized Minimality proposes that object relative clauses are more difficult to process than subject relative clauses because they feature the intervention of the subject between the head and its trace. A comprehension test to 80 Spanish monolingual children aged from 4;6 to 7;10 was applied. Sentences with subject/object relative clauses when NPs had the same or different morphosyntactic features were tested. A significant statistical difference was found for the performance between object relatives and subject relatives, since the number of correct answers is higher in subject relatives ($p < 0.001$). In addition, a significant statistical difference was found in object relatives between clauses that had the same or different morphosyntactic features, since the former were more difficult to understand ($p < 0.001$). The fact that Object Relatives differed in number morphology facilitated the interpretation of the sentence.

KEYWORDS

acquisition, L1, object relatives, typical, Spanish

1 Introduction

It has been found that children have difficulties in understanding object relative clauses up to five years of age (English: Sheldon, 1974; Goodluck and Tavakolian, 1982; Perez-Leroux, 1993, 1995, Diessel and Tomasello, 2000; French: Labelle, 1990, 1996; Guasti and Shlonsky, 1995; Spanish: Ezeizabarrena, 2012; Italian: Guasti and Cardinaletti, 2003; Adani, 2011, Contemori and Belletti, 2014; Hebrew: Arnon, 2005, 2010; Friedmann et al., 2009; Portuguese: Costa et al., 2011; Catalan: Gavarró et al., 2012; German: Adani et al., 2013). In particular, it has been found that children's ability to understand relative clauses depends heavily on the test used, in addition to an important contrast across languages: in languages with head initial relative clauses, subject relative clauses are easier to understand than object relative clauses (Adani, 2011). Contrary to this finding, in languages with head final relative clauses we might find a different pattern, although authors usually find mixed results (Chinese: Chang, 1984; Lee, 1992; Hsu et al., 2009; Chen and Shirai, 2014; Hu, 2014).

In the particular case of the study of the acquisition of object relatives (ORs) in Spanish, some longitudinal corpora have found the production of both subject relatives (SRs) and ORs by age 2;6; however, general rates of subject relatives are higher than those of object relatives (Hernández-Pina, 1984; Barreña, 2000). In an elicited production study, Ferreiro et al. (1976) found that children avoided object relativization, and preferred to produce relatives with passives, "resumptive" NPs, or clitic pronouns in a relative clause internal position. Perez-Leroux (1993) and Ezeizabarrena (2012) have found a preference for subject relatives versus object relatives in production; however, to our knowledge, no language comprehension studies have been carried out on the acquisition of object relatives in typical L1 monolingual

Spanish-speaking children. Children usually avoid the production of headed ORs (Contemori and Belletti, 2014), tending instead to produce alternative constructions, which might be easier for them to acquire, like causative passives and resumptive pronouns (Contemori and Belletti, 2014). However, Ezeizabarrena (2012) did not identify any morphosyntactic pattern as an alternative to the production of object relatives, like the use of passives or resumptive pronouns, so she concludes that it is difficult to propose the existence of a OR-by-SR substitution strategy in Spanish for 5;0- and 7;0-year-old children; maybe this is because resumptive pronouns in Spanish require a long structural distance between the nominal head and the gap (De Mello, 1992) or between the relative pronoun *que* and the gap (Brucart, 1999).

In addition to all these findings, some authors have related the acquisition of relative clauses with the development of passives (Guasti et al., 2012; Contemori and Belletti, 2014; Contemori and Marinis, 2014), resumptive pronouns (Contemori and Belletti, 2014), wh-questions (Stromswold, 1995; Friedmann et al., 2009; Guasti et al., 2012) and free relatives (Friedmann et al., 2009). Also, some authors have studied ORs with clinical populations, such as those with Developmental Language Disorder (DLD) (Friedmann and Novogrodsky, 2004; Adani et al., 2014) and agrammaticality (Grillo, 2009). Some comparisons on the data about children with DLD and data from the field of Second Language Acquisition (L2) will be developed later on in this paper.

Many factors can affect the preference for subject relatives over object relatives: this difficulty depends on (a) the structural similarity between the moved element and the intervening subject (Friedmann et al., 2009); (b) animacy: relative clauses are significantly easier to interpret when the object of the relative clause is inanimate or when the verb of the subordinate clause is intransitive (Goodluck and Tavakolian, 1982; Guasti et al., 2012); (c) methodology: the methodology used is crucial for the performance in comprehending and producing object relatives (Friedmann et al., 2009; Adani, 2011), since children can produce and comprehend relative clauses at age four when a suitable task is performed (Hamburger and Crain, 1982); (d) type of NPs: object relative clauses are easier when the head is lexically specified and the embedded constituent is a 1st or 2nd person pronoun or a proper name (Arnon, 2010); (e) gender: Belletti et al. (2012) found that when NPs have a gender mismatch, it sharply improved the comprehension of object relatives in Hebrew, but not in Italian; these authors compared object relative clauses where the moved object and the intervening embedded subject have the same or different gender. They argue that gender is part of the featural composition of the clausal inflectional head in Hebrew, whereas tensed verbs are not inflected for gender in Italian. In adults, it has also been found that object relative clauses are more difficult to understand than subject relative clauses in previous studies (Frauenfelder et al., 1980). This asymmetry has been explained by the Noun Phrase Accessibility (Keenan and Comrie, 1977), the Active Filler Hypothesis (Frazier and Fodor, 1978), the Dependency Locality Theory (Gibson, 1998) or by Intervention (Grillo, 2008; Friedmann et al., 2009).

2 Theoretical background

2.1 Previous studies

This section describes studies on the acquisition of subject and object relatives in several languages and the main theories that account for the data found so far. Perez-Leroux (1993) developed two studies of elicited production, in a task where children had to produce different kinds of relative clauses (SS, SO, OS, SS). In the first study, she found that children produced many truncated relatives after the main clause with no syntactic connection and a few embedded relatives. In another elicited production study, in which children had to produce direct object extractions, oblique phrase extractions, possessive phrase extractions and locative phrase extractions, children preferred to produce subject relatives (see Montrul, 2004, for a review).

Furthermore Ezeizabarrena's (2012) study with 15 children consisted of a selection task to elicit relative clauses. She tested the children longitudinally when they were 5;0 and 7;0 years old; she found that 5 year-old children produce correct subject relatives in Spanish almost at the same rates as adults, whereas the rates of correct object relatives are close to chance at age 5;0. Children who are 7;0 years old produce less correct object relatives than adults. Ezeizabarrena found that all 5;0 and 7;0 years old children produced one or more target deviant relative clauses, which suggests that errors are generalized even at age 7;0. Headless relative clauses are very frequent (38%) in 5;0-year-old children, whereas in 7-year-old children they only represent 4%, and in adults, only 2.6% of relative clauses. With respect to the production of clitics, she found that half of the relative clauses in all the samples contain a clitic, though rates of clitics decrease with age. Clitics are mostly attested in 5;0-year-old children, whereas lexical objects are the most frequent option for 7;0-year-old children and adults. Only 5-year-old children produce clitics in subject relatives, whereas clitics also appear in the speech of 7-year-old children and adults. Deviant sentences usually consist of a role reversal, a person reference error, an incorrect use of the preposition or incorrect inflection on the verb.

Studying production of object/subject relatives in Italian, Guasti et al. (2012) found that object relatives are more difficult to acquire than subject relatives. Children improve their production of correct object relative clauses as they get older but the asymmetry persists in 9-year-old children. They focused on how animacy explains the difficulty to produce object relatives, and found that sentences with inanimate objects and animate subjects were easier to produce than sentences where both were animate. Sentences where both objects and subjects were animate were disambiguated by number feature, so that only one agreed with the verb. They found that production of sentences disambiguated by number feature was more difficult in object relatives than in subject relatives. They also found that the production of correct sentences disambiguated by number feature were more frequent in 9;0-year-old children than in 5;0-year-old children. Common errors that children committed were reduced in head relative clauses, declarative responses or reverse head responses in 5-year-old children, whereas 9-year-old-children produced more passives and reverse head responses.

Studying production of object relatives in Italian, Utzeri (2007) used a Preference Task and a Picture Description Task, based on elicitation procedures by Novogrodsky and Friedmann (2006). Findings show that it was difficult for children to produce object relatives, and that they used other strategies such as changing the verb of the relative clause, or using a passive sentence. Guasti and Cardinaletti (2003) also found the use of passive and the *si*-causative as a strategy to avoid object relatives. Belletti and Contemori (2010) focused on the fact that many relative clauses are ambiguous since these can be interpreted as a subject relative with the postverbal noun

phrase being the direct object of the verb of the relative clause, or can be interpreted as an object relative with the postverbal noun phrase being the postverbal subject of the relative clause. They took into account unambiguous sentences (i.e., where object and subject were disambiguated by number feature). They also found that object relatives were produced less than subject relatives for all age groups.

Arosio et al. (2009) studied the effect of number agreement and word order for disambiguating subject and object relatives in the acquisition of Italian, and they compared the processing cost of these two ways of disambiguating relative clauses. In Italian, when the head of the Relative Clause and the embedded NP do not have the same number features, the sentence is not ambiguous, because only the subject agrees in number with the embedded verb. Also, in Italian object relatives are disambiguated by placing the embedded subject in the preverbal position. Their findings suggest that subject relative clauses are easier to comprehend than object relative clauses for all groups of children. They found no development in the comprehension of subject relative clauses, since these were very easy to understand from an early stage. They found that object relative clauses disambiguated by position are easier to comprehend than object relative clauses disambiguated by number agreement.

In another study, Belletti et al. (2012) took into account the nature of the subject in Italian. They noticed that in previous studies, the subject was always a lexical noun phrase. In this new study, the subject was always a pronoun, either overt or null. With this new design, these authors found that children had no difficulties producing the elicited object relative clause. Therefore, the production of object relatives is significantly improved when a pronominal is used as subject in the relative clause.

With respect to comprehension, Adani (2011) contrasted subject and object relatives in Italian; this time, controlling for ambiguity, since a postverbal noun phrase can be interpreted as a direct object or as a postverbal subject, which could be the cause of difficulty for object relatives. This ambiguity disappears when the relative head and the noun phrase internal to the relative clause have a different number marker and, therefore mismatch in number. In this case, Adani (2011) found that subject relatives are the best understood at all ages, object relatives are understood at chance, and that object relatives with the subject of the relative clause in postverbal position are poorly understood by children of all ages.

Arosio et al. (2009) tested the comprehension of unambiguous ORs in (a) a number match condition between the relative and the subject of the relative clause in pre-verbal position, and in (b) a number mismatch condition with the subject in postverbal position. In this contrast, the authors also found that subject relatives were easier to understand than object relatives for children. In addition, Adani et al. (2010) studied the comprehension of object relative clauses with Italian children. For this study, they controlled Number and Gender feature values on subject and object relative clauses. They found that accuracy in number conditions was higher than in gender conditions. They propose that external and syntactically active features (such as Number) reduce intervention whereas internal and lexicalized features (such as Gender) reduce intervention to a lesser extent.

In Catalan, Gavarró et al. (2012) performed an elicitation task, based on Novogrodsky and Friedmann (2006). They used transitive verbs in the embedded sentences, some of them reversible, and some irreversible. They observed that children produce subject relatives like adults, but they produced fewer object relatives. They detected that children produced object relatives with a full DP copy of the relativized constituent. Children also produced resumptive pronouns, but only with object relatives. These authors claim that processing resources might be limited in children. Similarly in a study on the production of subject relatives in French, Labelle (1990, 1996) reports the production of resumptive pronouns as a strategy to facilitate the acquisition of subject relatives. In addition, studying the production of subject/object relatives in European Portuguese, Costa et al. (2011) found that children produced object relatives less often than subject relatives. They propose that the difficulty of children to produce object relatives is due to the interpretation of the displaced argument across the intervening subject in this type of clauses.

Finally, studying the acquisition of Hebrew, Friedmann et al. (2009) concluded that headed object relatives with a resumptive pronoun are difficult to understand for children. They did not find any significant difference between object relatives with and without a resumptive pronoun. Performance on the free object relatives was significantly better than on the headed object relatives whereas comprehension of free subject relatives was only marginally significantly better than headed subject relatives. Children performed above chance on free subject relatives and free object relatives, and this performance was better than on headed object relatives. They explain the easier performance of free object relatives pointing out that the relative operator in free relatives does not contain any lexical NP restriction, and therefore should disqualify the subject as an intervener. They also studied the comprehension of object relatives with an arbitrary impersonal subject, where the possible intervener does not have any lexical NP restriction. Thus, the intervener and the crossing element are again of different types. The object relatives with the arbitrary subject were comprehended significantly better than the headed object relatives.

2.2 Theoretical proposals

Several theoretical proposals have tried to explain the asymmetry between Subject Relatives (SRs) and Object Relatives (ORs), most of them based on adult language processing. The Dependency Locality Theory (DLT) attributes the difficulty in the acquisition of relative clauses by children to the storage cost of grammatical dependencies (Gibson, 1998, Gibson, 2000). Storage resources are required to keep track of syntactic dependencies. DLT predicts that ORs are more difficult than SRs in head initial languages due to a larger number of unresolved dependencies in the processing of object relative clauses in a given part of the sentence, but ORs are easier than SRs in head final languages. The Linear distance Hypothesis (LDH) proposes that processing difficulty increases in proportion to linear distance between gaps and fillers: object – subject (OS) will be more difficult than subject – subject (SS) in head initial languages, but easier than SS in head final languages (Tarallo and Myhill, 1983). The Structural Depth Hypothesis (SDH) proposes that processing difficulty is determined by the number of syntactic nodes intervening between the gaps and fillers: object relatives will be more difficult than subject relatives in head initial and head final languages (O'Grady, 1996, 1999). The Active Filler Hypothesis proposes that the parser tries to close an A' dependency as soon as possible: when an A' binder is processed, the parser tries to postulate the variable in the closest argument position, i.e., the subject position (Frazier et al., 1983, Crain and Fodor 1985,

Frazier and Clifton 1989). This strategy explains the fact that subject relatives are easier to understand than object relatives, because ORs require a reanalysis. The Mismatch Detection Point Hypothesis (MDPH) proposes that the garden path strength in the processing of relative clauses depends on the different points of the analysis of Relative Clauses at which the temporary ungrammaticality triggers reanalysis (Arosio et al., 2009). The Noun Phrase Accessibility (Keenan and Comrie, 1977) proposes that languages differ with respect to the relativization of NP positions; Keenan and Comrie say that there is a hierarchy for the relative accessibility to relativization of NP, where subject relatives are higher in the accessibility than object relatives. Finally, Relativized Minimality (RM) proposes that object relative clauses and object which-questions are more difficult to understand than subject relative clauses because they feature the intervention of the subject between the head and its trace (Rizzi, 1990, 2004). RM follows the principle of constraining syntactic computations (Chomsky, 2001). All these theories make the same prediction in head initial languages, although for head final languages their predictions are differentiated by the difficulty of object relative clauses with respect to subject relative clauses. In this paper, RM will be the theory applied and developed. RM predicts that number mismatch will be relevant only in ORs, but not in SRs whereas the rest of the theories would predict a facilitation of number mismatch for both ORs and SRs.

RM (Rizzi, 1990) is a locality constraint on dependencies within sentences, where a local structural relation cannot hold between X and Y when Z intervenes as a potential candidate for the same local relation:

(1)	a.	X … Z … Y (Rizzi, 2004: 225)
	b.	Z intervenes between X and Y iff Z c-commands Y and Z does not c-command X.

The configurations for the Relativized Minimality are given in (2), where A and B stand for abstract morphosyntactic features triggering movement.

(2)		X	Z	Y	
	a.	+A ……	+A ……	<+A>	(identity)
	b.	+A, +B……	+A ……	<+A, +B>	(inclusion)
	c.	+A ……	+B ……	<+A>	(disjunction)
		Friedmann et al. (2009)			

Friedmann et al. (2009) suggest that this constraint applies to adults, but children apply a strict version of RM, which requires a distinct featural specification of the target with respect to the intervener and a disjoint specification, since inclusion is too difficult for children to interpret. These authors suggest that young children might have difficulties understanding object relative clauses because at early ages, they have less processing resources. Disjunction is easier to process than inclusion, since it requires being held in working memory (Friedmann et al., 2009; Guasti et al., 2012); in contrast, adults do not commit errors with an inclusion relation although it does slow down parsing.

3 Method

3.1 Participants

The purpose of this paper is to present the results of an experiment in which monolingual Spanish-speaking children between 4 and 7 years of age are tested on their ability to understand object and subject relatives. 80 Spanish monolingual children aged from 4;3 to 7;9 completed a comprehension test. The children were collapsed into four age groups with the following age ranges: age group 4 (4,3-4,11), age group 5 (5,1-5,10), age group 6 (6,2-6,11) and age group 7 (7,2-7,9). Children were recruited from public schools near Madrid, and all of them were typically developing children. All participants were monolingual Spanish speaking children, and Spanish was the only language spoken at home. All children lived in the area of Madrid. Researchers explained the main purpose of this research to all parents of the children participating in this study, and they were requested to sign a form approving their child's participation in this research. Since studies in the acquisition of relative clauses in Spanish have been limited to production studies, this study furthers the state of the field by providing data of the comprehension of object relative clauses in Spanish. This research was approved by the ethical Commission of the University with the reference COEDU_FECORA.

3.2 Procedure

This study compared six different relative clauses differing in two dimensions: (a) the case of the head of the relative clause, and (b) number agreement. In half of the sentences, the head of the relative clause in the embedded clause is an object (3a, 3c), and in the other half, the head of the relative clause in the embedded clause is a subject (3b, 3d). The number of the subject and the object of the relative clause can be the same (3a, 3b) or it can be different (3c, 3d). Also tested were sentences where the head of the relative clause in the embedded clause is an object, and the subject of the relative clause is in postverbal position, with the same number (3e) or with number mismatch (3f). The last two sentences are ambiguous in Italian in the same number condition, but not in in Spanish because of Direct Object Marking (DOM) (i.e., "a"). OR refers to the cases where head of the relative clause in the embedded clause is an object, SR refers to the cases where head of the relative clause in the embedded clause is a subject, SM refers to the cases where the number of the subject and the object of the relative clause are the same, DM refers to the cases where the number of the subject and the object of the relative clause are different.

3.	a)	el gato que la rana está mojando (object relative, same morphology).
		the cat that the frog is watering.
	b)	el gato que está mojando a la rana (subject relative, same morphology).
		the cat that is watering the frog.
	c)	el gato que las ranas están mojando (object relative, different morphology).
		the cat that the frogs are watering.

	d)	el gato que está mojando a las ranas (subject relative, different morphology).
		the cat that is watering the frogs.
	e)	el gato que está mojando la rana (object relative, same morphology) postverbal.
		the cat that the frog is watering.
	f)	el gato que están mojando las ranas (object relative, different morphology) postverbal.
		the cat that the frogs are watering.

The test is a set of 18 picture/sentence pairs (see Appendix A). The pictures were taken from a test by De Vincenzi (1996) originally designed to test subject/object wh-questions in Italian (see Appendix A). The sentences were translated into Spanish. All Noun Phrases were animate and all verbs were transitive. This test was administered to children in individual sessions in a separate room in their school. In half of the sentences both object and subject had the same morphosyntactic features (both were singular), and in half of the sentences object and subject had different morphosyntactic features (one of them was in plural and the other was in singular). All children were exposed to the same 18 items, and the sentences were presented in a randomized order. A sample of the pictures in this test is shown below:

Children are requested to point to the animal that the sentence refers to. The same picture is used for all the conditions. In the case of the sentence "Point to *'the cat that the frogs are watering'*," the correct answer is to point to the cat on the left in Figure 1.

This is a mixed designed study between subjects and within subject variables. The independent variables were the age of children, the head of the relative clause in the embedded clause (OR *vs* SR), the number of the subject and the object of the relative clause (SM *vs* DM) and the dependent variable was the number of correct answers by children. The statistical analysis of Chi Square was used to compare the performance of children depending on the type of sentence (subject relatives vs. object relatives), type of Morphological Features (Same Morphology vs. Different Morphology), and to compare Age (4 year-olds vs. 5 year-olds vs. 6 year-olds vs. 7 year-olds).

4 Results

Table 1 shows the frequencies of correct interpretations of sentences with subject relative clauses and object relative clauses when both object and subject had different and the same morphosyntactic features. I collapsed the data in order to show more clearly the effect of type of sentence independently.

Relativized Minimality (RM) predicts that children will have more difficulties understanding ORs, compared to SRs. The observed frequencies of correct answers in subject relatives are higher than in object subject relatives for all ages, confirming this first prediction of RM. A significant difference was shown between these structures for all ages ($\chi^2 = 133.779$; $p < 0.001$), and performance improves with age ($\chi^2 = 20.015$; $p < 0.001$). Table 2 shows the frequencies of correct and incorrect interpretations of sentences with the same and different morphosyntactic features, with subject relative clauses and object relative clauses collapsed. I collapsed the data in order to show more clearly the effect of morphology independently.

A significant difference was found between sentences with the same and different morphosyntactic features for all ages ($\chi^2 = 424.67$; $p < 0.001$), and performance improves with age ($\chi^2 = 21.446$; $p < 0.001$). Relativized Minimality (RM) predicts that children will have more difficulties understanding object relatives when morphological features are the same with respect to number, but this contrast should not be found in SRs, since there is no interference in this case. As you can see in Table 3, the frequencies observed for all ages of correct answers in ORs are higher when morphological features are different than when morphological features are the same, confirming this second prediction of RM; however, there is no significant difference

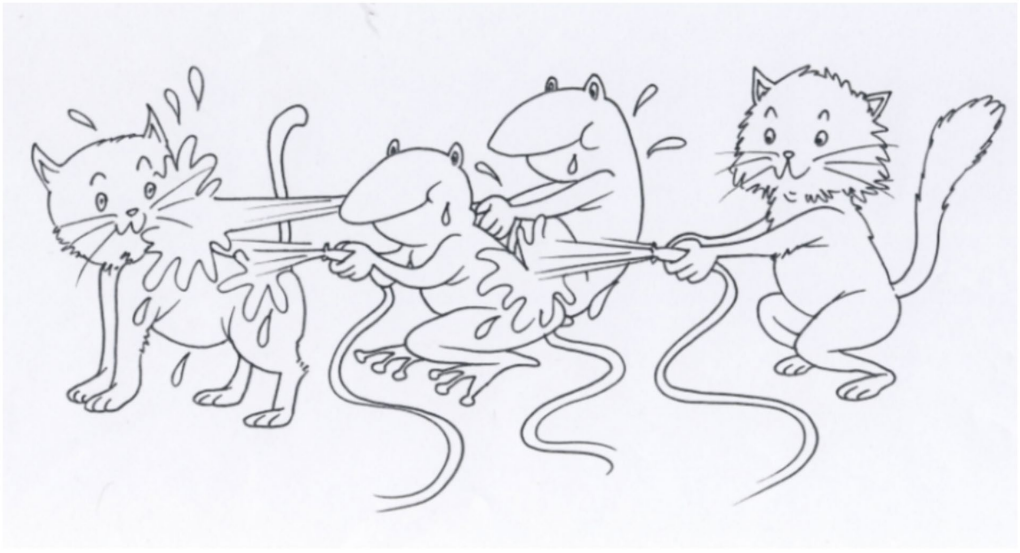

FIGURE 1
Example of pictures used, based in De Vincenzi (1996).

TABLE 1 Frequencies of correct interpretations of subject and object relative clauses.

Age	Subject relatives	Object relatives
4;0	143	106
5;0	149	120
6;0	154	127
7;0	160	146

TABLE 2 Frequencies of correct interpretations of sentences with the same and different morphosyntactic features.

Age	Different morphology	Same morphology
4;0	130	119
5;0	137	132
6;0	145	136
7;0	155	151

TABLE 3 Frequencies of correct interpretations of sentences with subject relative clauses and object relative clauses with the same and different morphosyntactic features.

Age	SRDM	ORDM	SRSM	ORSM	ORDMPS	ORSMPS
4;0	73	57	70	49	14	12
5;0	75	62	74	58	15	13
6;0	78	67	76	60	15	14
7;0	80	75	80	71	18	16

in SRs. A significant difference was found between sentences with the same and different morphological features for all ages ($\chi^2 = 424.67$; $p < 0.001$), and performance improved with age ($\chi^2 = 21.446$; $p < 0.001$). Table 3 shows the frequencies of correct interpretation of sentences with the same and different morphosyntactic features, with subject relative clauses and object relative clauses shown separately:

Relativized Minimality (RM) predicts that children will have more difficulties understanding object relatives than subject relatives, and in understanding clauses with the same morphological features than those with different morphological features. Analysis of accuracy scores in the comprehension of all types of relatives across age groups revealed that the highest number of correct answers observed is for subject relatives with different morphological features (SRDM) and the worst performance were obtained for object relatives with postverbal subject with different morphological features (ORDMPS) and with the same morphological features (ORSMPS), confirming this third prediction of RM. A significant difference between object relatives and subject relatives with different morphosyntactic features ($\chi^2 = 64.766$; $p < 0.001$), and between object relatives and subject relatives with the same morphosyntactic features ($\chi^2 = 68.568$; $p < 0.001$) was found.

In addition, there is a significative difference between object relatives with the same morphosyntactic features and subject relatives with different morphosyntactic features ($\chi^2 = 42.493$; $p < 0.001$), and between object relatives with different morphosyntactic features and subject relatives with the same morphosyntactic features ($\chi^2 = 104.507$; $p < 0.001$) when all ages are collapsed. With respect to postverbal subjects, a significant difference was found between object relatives with the same and with different morphosyntactic features, the latter being the easiest ($\chi^2 = 51.097$; $p < 0.001$). However, no statistically significant difference was found between the performance on the comprehension of object relatives on preverbal subjects and postverbal subjects, both with different morphological features (ORDMPS) and with the same morphological features (ORSMPS).

After analyzing the results, we can conclude that object relatives are more difficult to understand than subject relatives for all ages in Spanish. However, performance improves with age, as a statistically significant difference was shown for different age groups. The difficulty in understanding object relatives depends on whether the subject and the object of the relative clause have the same or different morphology with respect to the number feature. I propose that the difficulty in acquiring object relative clauses is explained by Relativized Minimality: children may have difficulties with dependency when the two terms of the relation are separated by an intervener, as in object relative clauses (Friedmann et al., 2009).

5 Discussion

This study focuses on comprehension of object relatives by monolingually-raised Spanish-speaking children. Their performance in object and subject relatives with a comprehension task was compared. Postverbal subjects were also taken into consideration, which might be important when we compare the data with the acquisition of object relatives in Italian, because in Spanish there is a preposition which is a Direct Object Marker (DOM); and this is relevant for the interpretation of data. As we have seen in previous studies, an adapted task for children shows that children can interpret subject and object relatives, although object relatives are more difficult for children to understand; the main error that children commit is to

interpret object relatives as subject relatives. This error can be explained by the locality effects of the intervention of an embedded constituent. With respect to object relatives, children committed less errors in a mismatch condition than in conditions where both constituents had the same number value. These findings are consistent with the literature on the acquisition of object relatives in Spanish production. We found similar data in Perez-Leroux (1993), as I mentioned earlier, since children preferred to produce subject relatives; and in Ezeizabarrena (2012), who found that correct object relatives are close to chance level at age 5;0. Similar results have been found in other languages like Italian (Arosio et al., 2009; Friedmann et al., 2009; Guasti et al., 2012), Catalan (Gavarró et al., 2012), French (Labelle, 1990, 1996) or European Portuguese (Costa et al., 2011). With respect to postverbal subjects, a significant difference was found between object relatives with the same and with different morphosyntactic features. In addition, no statistically significant difference was found between the performance on the comprehension of object relatives with preverbal and postverbal subjects; however, the number of correct answers in postverbal subjects found in Spanish is higher than in Italian, which could be due to the Direct Object Marking found in Spanish, since Italian children have no cues to differentiate direct objects from subjects in postverbal position.

If errors are due to locality effects of the intervention of an embedded constituent, then we should find similar errors in similar structures, like interrogative sentences, since these also have locality restrictions. Wh-questions are universal to all languages (e.g., Comrie, 1981). The wh-word can move overtly to a sentence-initial position or can remain *in situ* like in a declarative sentence. Object and subject questions have a different structure, and it shows in the grammatical acceptance for the that-trace effect, parasitic gaps, wh-islands, relative clauses, and do-support (Chomsky 1986a,b). Because of the different structure of subject and object questions, subject relative questions are supposed to be easier to learn than object relative questions (Gazdar, 1981). In this vein, it has been attested that wh-questions are mastered relatively early cross-linguistically, although crosslinguistically, children can produce subject questions more easily than object questions (Clahsen et al., 1995, for German; Guasti, 1996, Guasti et al., 2012, for Italian; Håkansson and Hansson, 2000; Santelmann, 1998, for Swedish Wilhelm and Hanna, 1992; Van der Lely and Battell, 2003 for English). In addition, this asymmetry has also been attested in comprehension (Avrutin, 2000 for English; Friedmann et al., 2009 for Hebrew; Philip et al., 2001 for Dutch; De Vincenzi et al., 1999 for Italian).

Italian children attain adult-like performance much later than English and Hebrew speaking children (de Villiers et al. 1979). De Vincenzi et al. (1999) found that in the acquisition of Italian-speaking children, comprehension of subject questions was unproblematic from the age of 4; however, comprehension of object questions was rather inaccurate in the early stages. Guasti et al. (2012) say that the subject/object asymmetry depends on the surface form that wh-questions have in each language. They propose that this difficulty in Italian questions is because disambiguation comes from verb agreement, as the subject may stay in a postverbal position. These authors report that when children made errors, they produced a subject question for an object question, a wh-element alone, an argument drop, a passivization, a topicalization, or they changed a wh-question into a yes/no question. These authors compared a group of Italian children and a group of adults. They report that the rate of correct subject questions was higher than that of correct object questions in children but only for who-questions; they also found that adults were more accurate than children in producing who-questions, although no difference was found for subject which-questions; another interesting finding is that in subject-questions children performed who-questions better than which-questions; in object-questions this difference is not found because children are equally bad at who and which-questions. These authors propose the object/subject asymmetry in wh-questions is based on the interference of the object copy in the AGREE relation between AgrS and the subject in the Spec of the verb phrase.

In addition, if errors are due to locality effects of the intervention of an embedded constituent, then we should find similar errors in similar processes like Second Language Acquisition or in Developmental Language Disorders (DLD). In the acquisition of object relatives as a Second Language, the results depend on the proficiency in the L2: when participants have a high proficiency, results are similar to what is found in adult processing and child L1 acquisition. Also, in L2 the results depend on the properties of L1: when L1 and L2 are both head initial, results are similar to adult language processing; however, if L1, L2 or both are head final languages, mixed results are usually found. Izumi (2003) studied English L2 learners, with many different languages as L1. In addition, participants had different levels of proficiency; because of the heterogeneity of the participants involved, Izumi did not find significant differences for the difficulty between subject and object relative clauses. Aydin (2007) studied the learning of Turkish as a second language (Turkish is a head final language with respect to relative clauses) by L1 English, Japanese, and Korean participants (English is a head initial language, whereas Japanese and Korean are head final languages with respect to relative clauses). Aydin found that subject relative clauses were easier to understand than object relative clauses by intermediate learners, but found no differences when participants were basic learners. In this vein, Chen (2006) studied the learning of English as a second language by Chinese native speakers and found that object relative clauses were more complex when participants were advanced learners of English, but did not find any differences when participants had lower proficiency levels. Özçelik (2006) studied English (head initial language), Japanese (head final language) and Korean (head final language) native speakers, who were learning Turkish as a second language; Özçelik found that subject relative clauses were more difficult to understand for English, Japanese and Korean L1 speakers with an intermediate level of Turkish as a second language. As we can see, the contrast between subject and object relatives has mixed results when we observe the data found in Second Language Acquisition.

As studies above show, in the acquisition of object relatives as a Second Language (L2), the results depend on the proficiency in the L2: when participants have a high proficiency, results are similar to what is found in adult processing and child L1 acquisition. Also, in L2 the results depend on the properties of L1: when L1 and L2 are both head initial, results are similar to adult language processing; however, if L1, L2 or both are head final languages, mixed results are usually found.

Since it has been argued that first language acquisition and language disorders can follow a similar path with a slower pace, in this paper, studies on the acquisition of object relatives in children with Developmental Language Disorder (DLD) in head initial languages also deserve a mention, in order to see whether this development parallels the development found in typically developing children. Friedmann and Novogrodsky (2004) studied the comprehension and

production of Hebrew-speaking DLD children, and they compared the data with typically developing children. They found that children with DLD have difficulties to process object relative clauses, but children with DLD did not have any particular difficulty with subject relatives, compared to typically developing children. These authors proposed that children with DLD have difficulties to assign the thematic role to a moved constituent. Studying children with DLD who speak English, Schuele and Nicolls (2000) found that they omitted obligatory relative markers in subject relative clauses and produced a wrong relative marker in object relative clauses.

Adani et al. (2014) found that children with DLD learning English are more accurate in Subject relative sentences than in Object relative sentences. When the NPs had different number features, children with DLD were more accurate than in match conditions in both sentence types and for all groups. They developed a qualitative study of the errors found in the answers of typically developing children and children with DLD, and found that typically developing children are very accurate for Subject relative sentences. However, typically developing children have the tendency to produce relative clause Errors (RCE), which consist in interpreting Object relative sentences as Subject relative sentences. Grillo (2008) proposes that this error is due to the requirement to interpret the relationship between the head of the relative clause and its copy, which has to cross the embedded subject. Even though this effect of intervention is found until the age of 4;0, we cannot find a ceiling effect in older children.

On the other hand, children with DLD commit many main clause errors (MCE) in SS sentences (Adani et al., 2014). When children with DLD misinterpreted the sentences, they rely on the linear word order. Adani et al. (2014) propose that this is because children with DLD have difficulties to compute movement derived dependencies. They argue that the data support the Computational Grammatical Complexity hypothesis (CGC). This hypothesis proposes that the impairment in DLD is restricted to non-local dependencies at the clause level (Van der Lely, 1998, 2005). Therefore, it predicts difficulties in subordinate clauses, wh-questions and passive sentences. Local syntactic dependencies, like specifier-head agreement, should be preserved. Children should produce more accurate relative clauses when number features between the main sentence and the relative clause are mismatched. In this respect, Adani et al. (2014) propose the notion of "movement optionality" to explain the fact that children with DLD interpret SR and OR sentences above chance. However, these authors propose that specifier-head agreement is preserved in children with DLD. In production, some of the strategies that children with DLD usually apply are simple declarative sentences and coordinated sentences. Stavrakaki (2001, 2002) explains this strategy as a last resort processing strategy: children interpret subject-verb relations as locally as possible, without taking clause boundaries into account. Compared to typically developing children, children with DLD produce three types of errors: main clause errors (MCE), relative clause errors (RCE) and double clause errors (DCE); therefore, children with DLD use different facilitative strategies, compared to typically developing children, who use predominantly relative clause errors. All these data can be helpful for therapy, since using different number features among DPs can facilitate sentence comprehension.

To conclude, data on the comprehension of subject and object relatives in Spanish, are analyzed and compared to other languages like Italian, Catalan and French. In addition, data from the production of object relatives in Spanish, Italian, Catalan and French are discussed, where children show a slower pace compared to Spanish speaking children, due to Direct Object Marking. I compared the performance on postverbal subjects, which is relevant compared to other languages, since Spanish has a Direct Object Marker (DOM). I also compared these structures with the contrast of subject and object wh-questions in Italian, English and Hebrew since interrogative sentences also have locality restrictions. The results show a locality effect, where children have many difficulties with sentences containing object relatives, especially when the subject and the moved object constituent have similar morphological features. The results bear out Relativized Minimality Hypothesis, since this Hypothesis describes the data found better than alternative theories, mainly with respect to the fact that locality effects are not found with sentences containing subject relatives. Furthermore, these contrasts have been paralleled with data from Second Language Acquisition and from Developmental Language Disorder when the L1 is a head initial language. More research is needed in related fields like literacy, since it has been found that the amount of exposure to written language can be relevant to improve the acquisition of object relatives (Dąbrowska et al., 2022); language attrition, where Merino (1983) found that children have more difficulties on object relatives that subject relatives in bilingual English/Spanish bilingual children; or narratives, where Dasinger and Toupin (1994) found a significant relation between the development of relatives clauses and narratives in a crosslinguistic study.

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 Rosa María Martín Aranda, Dean of Research, Universidad Nacional de Educación a Distancia. 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. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

VT: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

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

Publisher's note

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Appendix

(1) OS DM el caballo que está cazando a los leones.
"The horse that is chasing the lions".
(2) OO DM el camello que los elefantes están siguiendo.
"The camel that the elephants are following".
(3) OS DM el mono que está lavando a los osos.
"The monkey that is washing the bears".
(4) OO DM El perro que las niñas están mirando.
"The dog that the girls are looking at".
(5) OS DM la tortuga que está siguiendo a los peces.
"The turtle that is chasing the fish".
(6) OO DM el cisne que los pollos están picoteando.
"The swan that the chicks are pecking".
(7) OS DM la pantera que está empujando a los elefantes.
"The panther that is pushing the elephants".
(8) OO DM el gato que las ranas están mojando.
"The cat that the frogs are watering".
(9) OO DM PS la tortuga que están siguiendo los peces.
"The turtle that the fish are chasing".
(10) OS SM la gallina que está picando al pollito.
"The chicken that is pecking the chick".
(11) OO SM el pato que el conejo está cazando.
"The duck that the rabbit is chasing".
(12) OS SM el niño que mira a la princesa.
"The boy that looks at the princess".
(13) OO SM el policía que la mujer está mirando.
"The policeman that the lady is looking at".
(14) OS SM la gallina que sigue a la tortuga.
"The chicken that is following the turtle".
(15) OO SM la vaca que la oveja está empujando.
"The cow that the sheep is pushing".
(16) OS SM la niña que está mirando al policía.
"The girl that is looking at the policeman".
(17) OO SM la vaca que el caballo está cazando.
"The cow that the horse is chasing".
(18) OO SM PS la tortuga que está siguiendo el pez.
"The turtle that the fish is chasing".

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Conceptual subordination in the oral retelling of Spanish-speaking children

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Although retelling as a technique to assess narration has been widely used, the input modality seems to impact in different ways on the elicited text, generating a debate about the biases that may appear. To contribute to this discussion, the objective of this study is to describe the development of conceptual subordination and its forms of coding in the oral stories of Spanish-speaking children as well as its relationship with the source text. The stories of 28 five-year-old Chilean school children collected through a retelling task were studied. The analysis consisted of firstly assessing the production of conceptual subordination through the identification of asymmetric links between states of affairs. Then, the encoding forms that instantiated these links were classified. Finally, indices were constructed and applied to compare the children's texts with the source text. During the comparative analysis with the input, three qualitative categories emerged: similar production, reformulation and new link. The results showed that the participants' stories present significantly less production of conceptual subordination link than the source text. However, the children were able to create new links that were not presented in the story and reformulated others, as evidence of an interpretive process that goes beyond the mere reproduction of the input in these types of tasks. Regarding the encoding forms, the results were very similar between the source text and the children's text without significant differences. Both in source texts and children's texts, the prototypical forms of Spanish dominated, allowing us to conclude a possible input bias.

KEYWORDS

conceptual subordination, typical language development, retelling, syntactic complexity, subordination strategies in Spanish, typical and alternative encoding forms

1 Introduction

This study addresses the syntactic complexity through the study of the subordination oral uses of Spanish-speaking children. Similar studies have been carried out in various languages (Cohen and Walters, 2012; Zanchi et al., 2016, among others) but although they have assumed different theoretical perspectives, including generative and functionalist approaches, they could not develop a coherent framework to understand the complex conceptual and grammatical processes that syntactic development entails. Generative linguistics assess

syntactic complexity in terms of the extension of its major syntactic units (T-Units) (Hunt, 1965, 1970; Picca and Delicia, 2015). The functionalist perspective, on the other hand, emphasizes how much are interrelated the use of subordination and the kind of text (Ravid and Tolchinsky, 2002; Nir and Berman, 2010; Meneses et al., 2012; Crespo et al., 2013; Berman, 2018). Both perspectives have contributed in the description of some peculiar features of subordination in children's language but, because they focus mainly only on the formal structures they dismiss other characteristics of the children's linguistic knowledge that underlie. In fact, both approaches consider as isolated two complementary aspects.

This proposal aims to take a step further by linking syntactic forms with the conceptual representations that underlie these forms, particularly in the construction of a narrative. To achieve this, we have adopted Cristofaro's approach (Cristofaro, 2003), which defines subordination as a conceptual link between events or States of Affairs (SoAs). Subordination corresponds to a higher-order, asymmetric link between representational units, where one of them—dependent SoA—lacks an autonomous profile and is considered from the perspective of the other—the principal SoA (Cristofaro, 2003, 2014). This conceptual link has linguistic correspondence, as its encoding is based on verbs and the link between SoAs on clause relations. In completive relations, the asymmetric semantic link is established from the predicate of the main SoA and can be declarative, modal, phasal, desiderative, manipulative, etc. In relative relations, asymmetry occurs because the dependent SoA provides some type of specification about a participant in the main SoA. In adverbial relationships, two SoAs are linked in such a way that the dependent SoA corresponds to the circumstance under which the main SoA takes place, such as final, temporal, causal, etc. (Hopper and Thompson, 1984; Croft, 1990; Givón, 1990). By adopting this approach, we can determine the number of elements (semantic, pragmatic, and syntactic) that intervene in the processes of subordination and can more precisely visualize the linguistic-cognitive performance of the child.

Within this typological framework, Cristofaro (2003) assumes that subordination is a universal phenomenon given that all languages present subordination. Nonetheless, their speakers instantiate it by using different resources or strategies (Van Gijn et al., 2011), since they do not have the same formal elements to subordinate. Furthermore, it is recognized that within the same language there are similar contents that can be expressed in different ways (Foley and Van Valin, 1984; Givón, 1990, 2001; Van Valin and LaPolla, 1997; Cristofaro, 2003). Considering these premises, this article proposes that variation in resources or subordination strategies, usually observed between different types of languages, can also occur within the same language. Thus, in Spanish there is a predominant or prototypical strategy to account for an asymmetric relationship between events, which is characterized by syntactic embedding and morphosyntactic dependence (1.a; 2.a; 3.a; 4.a). However, along with it, other strategies that semantically imply an asymmetric link may appear, which we have called alternatives (Crespo et al., 2024), such as coordination (1.b), juxtaposition (2.b), nominalization (3.b), and the use of non-finite verbal forms (4.b).

(1) a. Cuando Pedro entró, María salía por la ventana
(When Peter entered, Mary was leaving through the window)
b. Pedro entró y María salía por la ventana.
(Peter entered and Mary left through the window).

(2) a. No iré al cine porque no tengo dinero
(I will not go to the cinema because I do not have money)
b. No tengo dinero, no iré al cine.
(I do not have money, I will not go to the movies).

(3) a. Espero que regreses a casa
(I hope you come home)
b. Espero tu regreso a casa
(I wait for your return home).

(4) a. Era un niño que se llamaba Juan
(It was a boy who was named Juan)
b. Era un niño llamado Juan
(It was a boy named Juan).

Crespo et al. (in press) observed in a longitudinal study of children that the number of alternative forms was significantly higher in the youngest group (5 years old) and subsequently decreased as they grew older, and their level of education increased. This finding suggests that at an early age, children are capable of conceptually representing instances of subordination. However, these instances have not been considered by other analyses that assume theoretical perspectives that rely only on formal elements. In this study, we examine subordination usages in preschoolers not only as a formal device although mainly a conceptual device influenced by the kind of elicitation method.

Children's narrative has been assessed through various techniques, of which the most notable is retelling. This task consists of asking the subject to retell a story to which they have been exposed through oral, visual or audiovisual input. This type of semi-structured task (Eisenbeiss, 2010; Reese et al., 2012) allows speakers to generate ecological discourses with comparable lexical and semantic structures; it is also easily replicable independently of the evaluator (Alonso-Sánchez et al., 2023). Regardless, there is a discussion about the advantages or disadvantages of using a certain input (Schneider, 1996; Schneider and Dubé, 1997; Gazella and Stockman, 2003; Schneider and Dubé, 2005; Diehm et al., 2020). Thus, both Schneider and Dubé (2005) and Diehm et al. (2020) point out that when retelling an audiovisual story, children produce significantly longer stories, with greater syntactic complexity and lexical variety, than with static stimuli and/or without language.

Therefore, in a study with a retelling technique based on an audiovisual stimulus, it is worth asking the following questions. What will be the influence that this specific input has on the construction of representations through subordination and on the choice of prototypical or alternative forms in 5-year- old children? Furthermore, and considering that the retelling technique is not a test of memorization but instead of linguistic production from a stimulus, it is necessary to pose a second question to understand the extent of influence of the input. Will the children produce a text whose representational and structural complexity will be similar to the source text or, on the contrary, will they create texts that are more representative of their own abilities to encode subordination? The issue is not minor, since the description of the linguistic production of a certain population must, without a doubt, consider the possible bias that discourse elicitation techniques could cause. To answer this question, the general objective of this research is to compare the conceptual subordination of children's stories with the source text in a retelling task. To this end, four specific objectives are proposed: (i) identify the number of links between SoAs, produced by 5-year-old Spanish-speaking children in a retelling task; (ii) identify the encoding

TABLE 1 Formal and conceptual measures of subordination.

Subordination index	T-Unit	Conceptual subordination index
[The mother bought bread (because the children were crying for food)]. (The father saw them crying.)	(The mother bought bread because the children were crying for food). (The father saw them crying.)	(The mother bought bread because the children were crying for food*). (The father saw them crying) In spanish is: *asking food
Number of subordinate clauses (1)* 100, divided by total clauses (2)	Number of words (14) divided by number of T Units (2)	Subordination links (3: bought-crying, crying-asking, saw-crying) dividing by total number of clauses (2) for 100
50%	T-Unit = 7 palabras	150%

forms (prototypical and alternative) used to instantiate such links; (iii) compare the productivity of conceptual subordination and its prototypical and alternative encoding forms in stories produced by the participants with the source text, and (iv) describe the relationship between the encoding forms in the source text and the encoding forms in the children's text, by means of three categories (similar production, reformulation and new linkage). Based on the questions and objectives posed, two research hypotheses were proposed: (i) The texts created by children will present a significantly lower subordination link productivity index than the source text. (ii) The texts created by children will have a significantly higher encoding through alternative forms than the source text.

2 Methods

A mixed study is proposed, with a non-experimental, cross-sectional, comparative design of descriptive scope. The subordination links (SL) elicited in a child's narrative as well as their encoding forms (prototypical and alternative) were measured and compared with the links present in the source text (ST). Along with this, unforeseen linguistic manifestations in the children's stories were also analyzed and quantified.

2.1 Corpus and participants

We worked with a part of the NIR2014 corpus (Crespo, 2019), composed of narratives (elicited through audiovisual stories) by 28 native Spanish-speaking Chilean school children, who were in preschool education and were between 5;0 and 5;11 years of age at that time (mean = 5.6; SD = 0.11). Of the total participants, 13 were boys and 15 were girls, all within Typical Development (TD). For sampling, the following inclusion/exclusion criteria were applied: presenting a normal cognitive and linguistic performance, having a schooling history according to the regular standards of the Chilean educational system, attending a normotypical schooling according to the criteria of the educator and the psycho-pedagogical department of the educational establishments and not having a history of language disorders or being part of an integration or school support program. The participation of all subjects was carried out after obtaining a consent signed by their parents or guardians and the assent of the boys and girls, under regulation of the Bioethics Committee of the Pontificia Universidad Católica de Valparaíso, Chile. The children's corpus was composed of a total of 28 texts, totaling 2,177 words.

2.2 Data collection instrument

The children's narratives were elicited in a retelling task of the audiovisual story "The Flopi Butterfly."[1] The source text (ST) was created within the framework of two previous investigations (Fondecyt 1130420, 11606539) and following the concept of story grammars (Stein and Glenn, 1979; Marchesi and Paniagua, 1983; Pavez et al., 2008). The structure presented: (i) the establishment of the scene; (ii) two episodes, each composed of an initial event, internal response, plan, intention, and direct consequence; and (iii) resolution and conclusion. The images, which were in both the audiovisual version and the paper format, were designed with the purpose of promoting the elicitation of a narrative and non-descriptive discourse, based on the considerations of visual grammar (Kress and van Leeuwen, 1996; Kress and van Leeuwen, 2001). Table 1 presents the linguistic features of the story, including the following measurements: mean clausular extension (MCLEx), index of subordination linkage (ISL), index of prototypical forms (IFProt) and index of alternative forms (IFAlt) which are explained in detail in 2.3.

To apply the retelling task, the participation of two speech therapists trained for this purpose was needed. The first one initially showed the story drawn in paper format and, later, in audiovisual mode. Subsequently, the participant was asked to narrate the story to the second evaluator, who had not participated in the previous activity, to simulate a more natural rhetorical situation. During this phase, the child was encouraged to manipulate the story in paper format to control the memory variable. The entire interaction was recorded on video.

The children's stories were transcribed phonetically according to the Chilean Phonetic Representation System (AFI-CL) (Sadowsky and Salamanca, 2011). Subsequently, the texts were segmented to identify the presence of the narrative elements proposed by Stein and Glenn (1979). Three expert analysts then segmented the clauses and identified the analysis categories: (i) subordination links, (ii) encoding forms, and (iii) their relationship with the source text: (iii.a) similar form to source, (iii.b) reformulation, and (iii.c) new link. Inter-rater agreement among the analysts was 92%. Discrepancies were re-analyzed, and if they remained unresolved, a fourth codifier was consulted to solve them. The inter-rater agreement was calculated based on the total number of tokens analyzed, and the percentage of agreement was calculated. It is worth noting that this procedure was carried out collaboratively, combining criteria to assess the degree of elaboration of a category in the oral production of each student and resolving any doubts that arose during the application of the instrument.

1 https://vimeo.com/91330174

2.3 Measures

The subordination links codifying a semantic-syntactic relationship between two SoAs were measured through the subordination linkage index (ISL). The clausular encoding corresponds to the morphosyntactic structure used to encode a conceptual link between SoAs and it is measured through the mean clausular extension (MCLEx), index of prototypical forms (IFProt), and index of alternative forms (IFAlt).

The structures that enabled us to distinguish between subordination and non-subordination in children's stories were determined based on the fundamental functional parameter: whether or not they differ from an independent declarative clause structure in the context of isolated use (Cristofaro, 2003). To calculate the productivity of this variable, the Index of Subordination Linkage (ISL) was applied, which is calculated by dividing the total number of subordination links by the total number of clauses, multiplied by one hundred. As we observe in Table 1, if we analyze and compare the parsing proposed of some different subordination index (such as the Formal Subordination Index or T-units) with those obtained through the Typological-Functional approach (Cristofaro, 2003) we could obtain very different measures. In fact, via the ISL we could assess if the child conceives the functional relationships that some lexical items entail even they omit the lexical item that typically subordination requires.

The results of this analysis were compared with the amount of subordination links of the source text (Table 2). Likewise, during the comparative analysis with the input, three qualitative categories emerged: similar form to source text (SFST), reformulation (REF) and new link (NL) that allowed to establish the relationship between the children's stories and the linguistic input. These categories will be explained in depth when the results are analyzed (section 3.1).

The number of clauses and words of the encoding forms were quantified. Subsequently, the number of instances of subordination links was observed and the proportion of prototypical forms (FProt) and alternative forms (FAlt) was identified. Thus, the MCLEx was calculated based on the total number of clauses divided by the total number of words, multiplied by one hundred. The variable FProt instantiates a representative encoding within the possibilities that Spanish offers, whereas the variable FAlt refers to a structure that does not present the morphosyntactic features of subordination but is semantically equivalent to an asymmetric link between events. To calculate this variable, three indices were constructed: (i) Mean clausular extension (MCLEx), (ii) Index of Prototypical Forms (IFProt), and (iii) Index of Alternative Forms (IFAlt). To calculate the productivity of these variables, the IFProt and IFAlt were each divided by the total number of subordination links, multiplied by one hundred.

2.4 Hypothesis

Based on the questions and objectives posed, two research hypotheses were proposed:

> *H1*: The texts created by children will present a significantly lower subordination link productivity index than the source text.
>
> *H2*: The texts created by children will have a significantly higher encoding through alternative forms than the source text.

3 Results

3.1 Relationship between children's retellings and the source text

To address the first research hypothesis, the ISL was applied to the texts created by the children (CT) and compared with the ISL of the source text (ST). Table 3 shows the descriptive data for the ISL of the CT. Once these results were obtained, the normality and homogeneity of variance tests were applied: Shapiro–Wilk & Levene, respectively. In both cases the p value indicated violation of the assumptions ($p = <0.0001$). With this background, to compare the ISL of the source text reported in Table 2 (=50.0) with the mean obtained by the children (=42.7), the Mann–Whitney U test was used under the hypothesis that the text created by children (CT) would have a lower ISL than that of the source text (ST). The data showed that it is possible to reject the null hypothesis: the difference between CT and ST was significant ($p = <0.01$) with a large effect size ($d = 0.0571$).

It is necessary to point out that not all the subordination links (SLs) created by the children exactly reproduced those presented by the source text. As indicated in Figure 1, the children elaborated 55.1% of the stimulus links in a similar way to the source text, however, they reformulated these links by 30.1% and created 14.8% new links.

The categories of similar form to the source text (SFST), reformulation (REF), and new link (NL) emerged in the analysis. We believe it is necessary to include examples of these forms to illustrate the findings. As seen in Table 4, in the similar form to the source text (SFST), the link and the form as presented in the source text are preserved. Thus, the example of this category shows the relative link (named) that occurs in the two texts. Regarding the reformulation (REF) category, it refers to the fact that, although the links are maintained, they appear in a different order or logic within the grammar structure of stories. Sometimes, they are even implied. Thus, in the reformulation example in Table 4 there are two links: A complement relation (wait) and a temporal adverbial relation (Don

TABLE 2 Formal and conceptual characteristics of the source text (ST).

Word count (WCT)	Total number of clauses (CLAU)	Mean clausular extension (MCLEx)	Total number of subordination links (SL)	Index of subordination linkage (ISL)	Total number of prototypical forms (FProt)	Index of prototypical forms (IFProt)	Total number of alternative forms (FAlt)	Index of alternative forms (IFAlt)
253	58	23	29	50.0	19	67	10	33

TABLE 3 Descriptive data for the ISL of the CT.

	Group	N	Mean	Median	SD	SE
ISL	CT	28	42.7	42.3	15.62	2.952

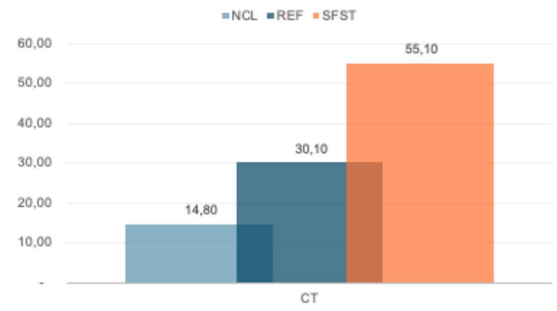

FIGURE 1
Proportion of qualitative categories in the CT.

TABLE 4 Relationship between the encoding forms in the source text and encoding forms in the children's text.

Category	Source text (ST)	Children's text (CT)
Similar form to source text (SFST)	*El campo era de un señor muy enojón llamado Don Bigotes The field belonged to a very angry man named Don Bigotes.*	*"y llegaron al campo de un señor llamado Bigotes" (DT17) "and they arrived at the field of a man named Bigotes"*
Reformulation (REF)	*"Esperemos a que se duerma Don Bigotes y vamos a rescatarla." "Let us wait for Don Bigotes to fall asleep and let us rescue her."*	*"y las amigas se preocuparon y fueron a salvarla. (Esperemos) Primero que don Bigotes se quede dormido" (DT67) "And her friends got worried and went to save her. (Let us wait) First Don Bigotes falls asleep" (DT67)*
New link (NL)	*"Flopi y sus amigas huyeron rápidamente " "Flopi and her friends quickly fled"*	*"y escaparon rapidito antes que don bigotes despertara" (DT 10) "and they escaped quickly before Don Bigotes woke up" (DT 67)*

TABLE 5 Descriptive data of the CT.

	Group	N	Mean	Median	SD	SE
MCLEx	CT	28	20.1	21.0	2.59	0.490
IFProt	CT	28	66.2	69.5	21.73	4.107
IFAlt	CT	28	30.3	29.5	18.50	3.496

Bigotes falls asleep—Friends rescue) are identified. The child omits the completive link and inverts the order of the temporal link. Finally, the new link (NL) corresponds to a link that is not present in the source text and that the child creates in his retelling. For example, the temporal link (escaped—Don Bigotes wakes up) illustrates this process.

3.2 Encoding forms

Regarding the linguistic encoding of conceptual links, Table 5 shows the descriptive data applied to the mean clausular extension (MCLEx), the index of prototypical forms (IFProt) and the index of alternative forms (IFAlt). When comparing these productivities with those of the source text (Table 2), results show that the average clausular extension MCLEx (=20.1) obtained by the subjects in their retellings is below that of the input text (MCLEx_ST = 23). The same trend is observed when comparing the average Index of Alternative Forms (IFAlt) of the produced texts (=30.3) with the IFAlt of the input (=34.5). On the other hand, the average of the Index of Prototypical Forms IFProt (=66.2) is slightly higher than that of the input (=65.5). Considering that the sample violates the assumptions of normality, these differences were analyzed with the Mann–Whitney U test. By observing the *p* values, it can be stated that the difference between the MCLEx of the input and that of the texts produced by the children is statistically significant and that the effect size is large. However, this significance does not occur when comparing the IFProt and IFAlt indices of the source text with the texts produced by the children. In this way, for this second result, the second null hypothesis of this research is accepted.

4 Discussion

The aim of this study was to explore the production of conceptual subordination and its encoding forms in Spanish during a retelling task. To achieve this, various descriptive and inferential statistical tests were applied. The results revealed several phenomena. It is possible to conclude that, although children at this age produce fewer subordination links compared to the source text, they utilize the typical resources of syntactic complexity to encode them, specifically those related to subordination.

In this retelling with audiovisual stimuli, the children produced texts that are significantly shorter than the source text and they also produced a significantly smaller number of subordination links. This was to be expected given the age of the children. However, there is a finding that is very interesting when analyzing the children's texts, because only 50% of the links produced by the children were similar to the source text, i.e., there was a space for linguistic creativity whether they reformulated links that were present or created links that were not present in the text. This finding allows three inferences to be made regarding the instrument and the population that was measured.

First, the instrument is only an elicitation, and, in that sense, it allows creativity and reformulations by the subjects, confirming the value of a semi-structured and ecological instrument as pointed out by Reese et al. (2012). Secondly, we highlight the value of employing an audiovisual stimulus, ratifying the findings by Schneider and Dubé (2005) and Diehm et al. (2020). Finally, regarding the child population, it is expected that in a population of normotypical 5-year-old children, there will be processes of interpreting information that lead to

paraphrasing and the creation of new elements. Now, regarding the encoding forms, the children's selections were very similar to what the ST presented. This finding leads us to seriously consider the need to control the stimulus to truly observe the linguistic competence of children.

5 Limitations and projections

The small sample (28 children) could be one of the limitations of this study. In fact, although we could perform some statistical analyses, the extension of the findings remains an issue to address. To replicate this study, we believe it is necessary to proceed with a larger sample. Additionally, it would be interesting to analyze subordination within this perspective in a longitudinal way. Moreover, studying and describing the mechanisms by which children construct subordination links from texts solely of independent sentences, without any formal subordination features, and asking them to create subordination links spontaneously (Alfaro-Faccio and Figueroa-Leighton, 2020) could provide further insights.

6 Conclusion

The objective of this study was to describe the development of conceptual subordination and its encoding forms in the oral narratives of Spanish-speaking children, as well as its relationship with the source text. The results showed that the participants' stories had significantly lower production of subordination links compared with the source text. Regarding the encoding forms, the results were very similar between the source text and the children's texts, with no significant differences. In both the source texts and the children's texts, the prototypical forms of Spanish dominated, suggesting a possible input bias. However, the children were able to create new links that were not present in the story and reformulated others, indicating an interpretive process that goes beyond mere reproduction of the input in these types of tasks.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: the base of the NIR2014/2019 children's linguistic corpus used in this study is in the process of being transcribed to be uploaded to the CHILDES platform. Requests to access these datasets should be directed to NC, nina.crespo@pucv.cl.

Ethics statement

The studies involving humans were approved by Comité de Bioética de la Pontificia Universidad Católica de Valparaíso, Chile. 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

CA: Writing – original draft, Writing – review & editing, Conceptualization, Formal analysis, Investigation, Methodology. NC: Conceptualization, Methodology, Writing – review & editing, Writing – original draft, Investigation, Resources. PA-F: Formal analysis, Methodology, Writing – review & editing. MS: Conceptualization, Formal analysis, Validation, 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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A Spanish Sentence Repetition Task and its relationship with spontaneous language in children aged 30 to 36 months

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Sentence Repetition Tasks (SRTs) have been convincingly established as a reliable tool for assessing child language development. However, there are important aspects of this task that deserve more attention. For example, few studies have explored their potential role for identifying language disorders in children under 4 years of age, as almost all evidence refers to children above this age. There is also scarce evidence regarding the relationship between the results of these tasks and measures of spontaneous language. To address this gap, we conducted a study with 24 Typically Developing (TD) monolingual Spanish speakers aged between 30 and 36 months. They performed a Spanish Sentence Repetition Task (SSRT), and their language was recorded and analyzed during spontaneous play with their parents. Variables such as Mean Length of Utterance (MLU), an index of lexical diversity (ILD) and the structure of the Noun Phrase were considered. The statistical analyses reflect a positive and significant correlation between the results obtained in the SSRT and both the MLU and Noun Phrase structure. A positive and significant relationship is also obtained between the MLU in repetition and the MLU of spontaneous language. However, no significant correlation is found between the ILD with either the SSRT or the other measures of spontaneous language. Based on these results, we interpret that the SSRT effectively mirrors the language development of children measured through spontaneous production and is suitable for assessing language skills of Spanish children under 4 years old.

KEYWORDS

sentence repetition task, Mean Length of Utterance, spontaneous language, lexical diversity, early language assessment

Introduction

Research has shown that sentence repetition is a good indicator of children's linguistic skills (Polišenská et al., 2015). Sentence Repetition Tasks (SRTs) have been widely used with children that present language difficulties and have been adapted to different languages (see Rujas et al., 2021 for a recent review). Despite its usefulness and the widespread use of the task both in research and clinical contexts, little is known about the relationship between children's performance in these tasks and their skills in spontaneous language during naturalistic interactions.

Usually, to measure children's linguistic abilities with sentence repetition tasks, researchers and clinicians present a list of sentences to the child, and the child is requested to repeat them. The accuracy of the repetitions, the Mean Length of the Utterances repeated, and the omission and commission errors are taken as indexes of children's linguistic level. Nevertheless, research devoted to analyze whether the same children present similar abilities in their spontaneous speech is very scarce. The aim of this work is to analyze to what extent the abilities that are displayed during sentence repetition are related to the linguistic skills needed for spontaneous speech during the interaction in naturalistic contexts. This evidence would add to concurrent validity of this kind of tasks.

This study analyzed the performance of Spanish-speaking children from 2;6 to 3;0 in a Spanish Sentence Repetition Task (SSRT) that has been previously tested (Bravo et al., 2020, 2023). In addition, we analyzed three characteristics of their linguistic development (MLU, linguistic diversity and the use of Noun Phrases) by taking a sample of spontaneous speech during the interaction with their parents. Finally, we analyzed the results that relate the measurements of both tasks.

The use of SRT

The SRT is an apparently very simple task, requiring children to repeat immediately the linguistic items presented to them by the examiner. However, the task is not simple, as when the child repeats a sentence, he or she does not do so merely mechanically and by rote. In order to respond to an SRT, after listening to a sentence, the listener creates a conceptual representation of the utterance and must activate a series of lexical and grammatical knowledge and processes involved in phonological production in order to subsequently reproduce it (Klem et al., 2014; Andreou et al., 2021).

These types of tasks have been designed and tested in a multitude of languages such as English (Stokes et al., 2006; Baddeley et al., 2009; Seeff-Gabriel et al., 2010; Riches, 2012–comparing English and Cantonese), French (Leclercq et al., 2014), Hungarian (Gábor and Lukács, 2012), Icelandic (Thordardottir, 2008), Mandarin Chinese (Wang et al., 2021), Italian (Devescovi and Caselli, 2007) and Catalan (Gavarró, 2017), among others.

In addition to being used as a language assessment tool with Typically Developing Children (TDC) (Devescovi and Caselli, 2007; Klem et al., 2014; Bravo et al., 2020, 2023), SRTs have also been used as a language measure in research with clinical populations, such as with people with Down syndrome (Koizumi and Kojima, 2022), Williams syndrome (Grant et al., 2002), Autism Spectrum Disorders (Botting and Conti-Ramsden, 2007; Harper-Hill et al., 2013) and with children with hearing aids or cochlear implants (Friedmann and Szterman, 2011; Ruigendijk and Friedmann, 2017). Furthermore, in recent years, SRTs have even been specifically designed for sign language users with hearing impairment, such as the one developed by Schönström and Hauser (2022). However, the most evidence for the value of this task as a tool for detecting language disorders is in relation to children with Developmental Language disorder (DLD) (Conti-Ramsden, 2003; Thordardottir and Brandeker, 2013; Peña et al., 2014; Polišenská et al., 2015; Auza et al., 2018; Simon-Cereijido and Mendez, 2018; Pratt et al., 2021). Indeed, the effectiveness of SRTs in identifying children with DLD lies precisely in their multifactorial nature (Polišenská et al., 2015). As mentioned above, the task involves the activation of working memory, but also complex linguistic processing of sentence reconstruction and reproduction (Haug et al., 2020).

SRTs as a tool for the assessment of linguistic skills

In relation to this multifactorial nature, Klem et al. (2014) conducted a longitudinal study with 216 TD monolingual Norwegian children aged 4–6 years. The children were assessed with a SRT, a test of vocabulary knowledge and a test of grammatical skills. The authors concluded that the "SRT is best seen as a complex linguistic task that reflects the integrity of language processing at many levels, speech perception, lexical (vocabulary) knowledge, grammatical skills and speech production to name but a few" (Klem et al., 2014, p. 7). As it has been previously stated, SRTs are a useful tool to identify and assess children that present linguistic difficulties. For example, Moll et al. (2015) assessed a group of children with and without dyslexia using the SRT and other measures of language and memory. The results indicated that the children with dyslexia scored worse on the repetition task than the group of children without dyslexia, but they found that these differences were specifically attributable to a subgroup of children who had a history of language development difficulties. The authors also noted that when controlling for memory-related skills, significant differences between the groups remained, which would indicate that the differences were not attributable to this variable as "the memory demands of sentence repetition should not be viewed as distinct from those involved in language production". Other recent works have highlighted the sensitivity of SRTs to measure lexical and grammatical aspects (Polišenská et al., 2015; Simon-Cereijido and Mendez, 2018; Fitton et al., 2019; Schönström and Hauser, 2022). Moreover, in studies where proficient language speakers were asked to repeat ungrammatical sentences, the results indicate that a very high percentage of participants grammatically correct the sentences when repeating them, suggesting that it is not so much memory but rather grammatical knowledge that guides repetition (Over and Gattis, 2010; Schönström and Hauser, 2022).

In Spanish, Bravo et al. (2020) conducted a study with a sample of 130 TD Spanish children aged 2 to 4 years who were assessed using a SSRT, revealing a clear developmental effect. Participants in the 3 to 4 year-old group scored better than those in the 2 to 3 year-old group, indicating that the SSRT is sensitive and reflects the changes that occur in language at this developmental stage. In addition, this SSRT achieved good concurrent validity results, obtaining a positive and significant correlation with a pseudoword repetition task. In a second study Bravo et al. (2023) designed a longitudinal study with children aged 2 to 4 years and analyzed to what extent the score obtained in this task at 33 months (T1) can predict language development 6 months later, at 39 months (T2). Results showed a positive and significant relationship between SSRT scores at T1 and scores

in the expressive language development scale from the Merrill-Palmer-Revised Scales of Development (Roid et al., 2004) applied 6 months later.

Another important issue to consider regarding SRT is that it's not only relevant to analyze the number of sentences repeated correctly or incorrectly, but also to conduct more qualitative analyses. For example, knowing the type of error that is made when the error occurs or the type of word the error affects (function or content words) can provide fundamental information regarding the linguistic and cognitive processes involved. Devescovi and Caselli (2007) showed that, particularly for the youngest group of their participants (aged 2 to 3 years), the omission of articles, prepositions and other modifiers was the most frequent error when repeating SRT items in Italian. From 3 years and 6 months onwards, the mean number of omission errors of function words decreased considerably. In the study conducted in Spanish by Bravo et al. (2020), similar results were found, as children omitted many more function words than content words in their repetitions, with this difference being significant especially in the younger group (2 years to 3 years and 6 months). These results have also been found in other languages, such as English (Seeff-Gabriel et al., 2010; Komeili and Marshall, 2013) and Hungarian (Novogrodsky et al., 2018). The higher rate of omissions in function words than in content words might indicate that SRTs are tasks more sensitive to the morphosyntactic than lexical development of children as young as 2 years old.

SRTs and spontaneous speech

Despite the numerous research studies conducted on SRTs, very few have focused on comparing their results with measures of spontaneous language. Most research has centered on comparing the performance of SRTs with other standardized tasks, ignoring the value of more natural assessments of children's language development, such as the analysis of spontaneous language samples. One of the few works in this line was conducted by Devescovi and Caselli (2007). They carried out a study comparing the results obtained in a sentence repetition task in Italian with some measures extracted from spontaneous language samples. They took a sample of 25 children aged 2–4 years and found that MLU in words, omission of articles and use of verbs in the SRT correlated significantly with the same measures obtained through the analysis of spontaneous language samples. In Spanish, the only study we have found in this line is a pilot study carried out by Moreno-Torres Sánchez et al. (2013) with a group of 10 children aged between 30 and 42 months, with bilateral profound deafness who received a cochlear implant between 12 and 24 months of age. They administered a SRT (PRO-24) comprising a total of 24 sentences (18 simple and 6 compound) and took spontaneous language samples to obtain, among other measures, MLU in spontaneous production. These authors found that most of the children tested scored very low in the sentence repetition test; only two children scored above 20% of correctly repeated sentences, and 5 did not produce any correct responses. However, they also found a significant correlation between the MLU of the spontaneous language sample and the MLU of the repeated sentences, which seems to indicate a relationship between the morphosyntactic skills measured by the SRT and the skills displayed during spontaneous interaction. A third study is that of Wang et al. (2021), who administered a sentence repetition task to Mandarin Chinese-speaking children. They assessed 59 TD children aged 3.6–6.5 years and compared the results with some indexes extracted from spontaneous language samples such as the MLU, a measure of lexical diversity, the number of predicates (verbs) and a composite structural measure, designed for that study, which evaluates children's correct use of classifiers, aspect markers, passives, and relative clauses. These authors found significant correlations between the results obtained in the SRT and all the spontaneous language measures used, concluding that the SRT adequately reflects the linguistic ability of the children assessed. This conclusion is similar to that obtained by the authors of previous research, which is highly relevant, as it endorses the use of this type of task to infer the actual linguistic development of children. Nonetheless, despite the study conducted by Wang et al. (2021) finding interesting relationships between performance at the SRT and other measures, they presented data from a group with a very wide age- range in which developmental changes were not tracked. Further research is needed to explore the relationships between children's spontaneous speech and their performance in SRTs.

Inferring the linguistic level through the analysis of spontaneous language measures

Regarding spontaneous speech, although the analysis of language samples can be time consuming, it proves to be a valuable method when combined with other external measures (Ambridge and Lieven, 2011). Furthermore, it is possible to obtain different measures from transcriptions of children's speech. The Mean Length of Utterance (MLU) is an index widely used across different contexts since Brown (1973) proposed the milestones associated with the number of words and morphemes that children produced during the first stages of early language acquisition (Parker and Brorson, 2005). MLU, measured as the mean number of words that are part of the utterances produced by the speaker, is a valuable indicator of children's grammatical level that is usually associated with age and is even an index of linguistic delay (Rice et al., 2010).

For Romance languages, with rich morphology, there are other relevant indexes of linguistic development. This is the case of determiners, which carry syntactic and morphological information (number and gender in Spanish and Italian) within Noun Phrases. Different studies in these languages carried out mainly in the nineties (Pizzuto and Caselli, 1992; Bottari et al., 1993; López-Ornat, 2003; Mariscal, 2009) have shown that the acquisition of determiners constitutes a key grammatical development that occurs between 2 and 4 years of age. They found a high frequency of determiner omissions in linguistic contexts of obligatory use during the initial phases of the process of Noun Phrase (NP) acquisition. More recent studies, as Guasti et al. (2008), confirm that children speaking Romance and non-Romance languages omit articles in their earlier productions. And regarding non-typical language development, Bottari et al. (2001) already shown that SLI

children omit determiners significantly more often than almost any other functional category or free morphemes. So, omission of articles and other determiners is a well-known phenomenon in child language. A decrease in this error type is a clear index of grammatical development, that can be good candidate for spontaneous production analysis in a Romance language as Spanish, particularly in very young age.

Children's linguistic variability is also associated with their expressive vocabulary development and therefore with their general linguistic level (Altenberg et al., 2018). The type/token ratio has been broadly used as a measure that is beyond the level of vocabulary (i.e., the number of words produced by the child) and it is employed on the assessment of children's expressive skills. Although it is easy to calculate this measure, it is very dependent on the size of the sample, since very small samples may result very high type/token ratios (Hindman et al., 2021). Another measure that has been proposed as an index of children's vocabulary diversity is the Vocabulary Diversity (VOCD or simply D), which uses an algorithm based on the whole sample to estimate the variety of words in samples with different size (MacWhinney, 2000). The comparisons between type/token ratios and the use of the VOCD showed that the latter was more sensitive detecting children with expressive language delay (Yang et al., 2022). However, further evidence is needed to answer the question of to what extent these indexes, taken from spontaneous language samples, are related to the measures obtained from sentence repetition tasks.

Thus, the aim of this study is to analyze the relationships between a Sentence Repetition Task developed in Spanish (SSRT) (Bravo et al., 2020) and linguistic measures of spontaneous speech, thus providing new evidence on the concurrent validity of the task. In order to analyze these relationships, this study takes measures of children's linguistic skills that have been proved as good indicators of their early grammatical knowledge. We seek to further analyze the characteristics of the SSRT as a tool to assess linguistic development in this language. Therefore, we contrast measures from the SSRT (such as, accuracy, Function Word Omission (FWO), and the MLU of repeated sentences in the task) that could be comparable to measures derived from spontaneous speech sample (such as, Determiner omission within NP, MLU in words and lexical diversity).

Following previous research reviewed above, we expect to find a significant correlation between the accuracy in the SSRT and the other two indexes obtained with the task: MLU of repeated sentences (MLU-r) and FWO. Regarding spontaneous speech, we also hypothesize that there will be significant relationships between children's use of NP, their MLU in words (MLU-w) and the lexical diversity (VOCD). Finally, we expect to find strong relationships between the accuracy of the SSRT and the measures derived from spontaneous speech samples. Specifically, we expect to find significant correlations between SSRT's accuracy, MLU-r and FWO, in relation to the proportion of Determiner omission within NP, the lexical diversity index and MLU-w taken from spontaneous speech samples.

We provide a sample of Spanish-speaking children who completed the SSRT and were video-recorded during interactions with their parents in a naturalistic setting. Furthermore, this study adds to the existing literature in the field by focusing on the age range from 2; 6 to 3 years.

Method

Participants

Twenty-four children (14 boys and 10 girls) aged between 30 and 36 months ($\bar{x}$ = 32.5; SD = 3.02) from different schools in Madrid and Toledo (Spain) participated in this study. All children came from a monolingual background, are Spanish speakers and have a medium socioeconomic family profile. No families expressed concerns about current difficulties in their children's development, nor did they report any previous history of hearing loss or problems in language development.

All families have expressed their willingness to participate in this research by signing the informed consent form, which was previously approved by the ethics committee of Universidad Autónoma de Madrid.

Procedure

The tasks were administered on different days and always in the same order: first the recording of spontaneous language in a natural interaction context and then the assessment with the SSRT.

The SSRT was administered individually by a trained evaluator at the nursery school, within a play-base scenario. This play scenario involves the child teaching a "non-speaking" puppet to speak by repeating sentences that the examiner says one at a time. The examiner presents each sentence clearly and with a marked rhythm, inviting the child to immediately repeat it back to the puppet. Every 5 or 6 sentences, to give the child a short break, a sticker is offered which can be stuck on a paper train. The first two sentences are for training, to make sure that the child understands what he/she is expected to do.

The spontaneous language samples consisted of 15 min of recordings of each child's interaction with his or her mother or father. The average duration of the sessions was 16.03 min (min. 14:11 and max. 20:10). The dyads were recorded at home or in a quiet room in the nursery school each child usually attends, depending on family preferences. The researcher provided the same set of toys to all children (a symbolic play set with cups, plates and spoons, several building blocks, a plastic ball, several dolls representing animals, and a book with pictures depicting actions in different contexts). Families were instructed to play with their child as they normally would. If the child or adult wished to use other toys in the room, they were also encouraged to do so.

Materials and task

Spanish Sentence Repetition Task

This task has been designed by Bravo et al. (2020) to assess the language development of children aged between 24 to 48 months. The SSRT includes a list of 33 sentences of varying length and

morphosyntactic complexity, ranging from 2 to 9 words. It is designed to elicit verbal production of specific morphosyntactic structures, that children typically produce at the ages tested. In developing the task, vocabulary was controlled by extracting words frequently used in the Spanish acquisition process from the database of the Spanish version of the MacArthur Communicative Development Inventory (López-Ornat et al., 2005). Moreover, we considered syllable structure, including words with a simple syllabic structure (consonant-vowel). The complete list of sentences is shown in Appendix A.

Coding

Spanish Sentence Repetition Task

The evaluation with the SSRT was audio-recorded for subsequent orthographic transcription. Next, the following aspects were coded, and the following scores were obtained:

- Accuracy in the child's repetition of sentences. Each correctly reproduced sentence is scored with 1 point; if it is not repeated correctly, 0 points are assigned. The maximum score in the "Accuracy" dimension is, therefore, 33, and the minimum is 0. Children's articulation errors in their utterances are not penalized.
- Mean Length of Utterance in repetition (MLU-r) refers to the number of words the child is able to repeat correctly, divided by the number of sentences he/she repeats during the completion of the task.
- Function word omissions refer to the frequency of FWO errors (determiners, pronouns, conjunctions, adverbs) made by the child when repeating each sentence. We use this value because it is the most frequent error found in sentence repetition and is considered a good index of morphosyntactic development (i.e., fewer omission errors occur as grammatical development progresses) (Devescovi and Caselli, 2007; Bravo et al., 2020).

Spontaneous language samples

A trained researcher transcribed the verbal production of the child and his or her interlocutor using the Child Language Data Exchange System (CHILDES) transcription system (MacWhinney, 2000). Subsequently, all Noun Phrases produced by each child were coded. In order to obtain a reliability index of this coding, another researcher coded the Noun Phrases produced in 25% of the language samples collected. An inter-rater reliability analysis was carried out, reaching a Kappa value of 0.847.

The coding of Noun Phrases was carried out following Mariscal (2009) according to the codes shown in Table 1. Grammatical omissions of determiners and the use of the structure Determiner+Noun indicate more advanced morphosyntactic knowledge, while errors of omission of the determiner indicate lower morphosyntactic knowledge.

In order to investigate the relationship between spontaneous language and performance on the sentence repetition task, the following measures were obtained from the spontaneous language samples:

TABLE 1 Noun phrase coding and examples.

Code	Description	Example	Translation
0N	Grammatical omission of the determiner	*CHI: quiero *agua*	*CHI: (I) need *water*
0N	Agrammatical omission of the determiner	Responding to "qué es esto?" *CHI: *pe* (instead of "un pez")	In response to "what is this?" *CHI: *fi* (instead of "a fish")
DN	Determiner + Noun (any determiner, whether it be an article, demonstrative, possessive …)	*CHI: y dónde está *el lobo*?	*CHI: and where is *the wolf*?
UN	Uncertain	*CHI: este es *te… tete* (instead of "chupete" or "el chupete")	*CHI: this is *te… tete* (instead of "dummy" or "the dummy")–in this case, the syllable "te" in front of the Noun could stand for the article "el (the)" or the first syllable of the Noun.

*CHI stands for "child".

- Vocabulary Diversity Index (VOCD) from the CLAN program of the CHILDES project.
- Mean Length of Utterance in words (MLU-w). We took the MLU-w index using the CLAN program of the CHILDES project.
- Proportion of correct (0N and DN) and incorrect (0*N) Noun Phrases, as morphosyntactic measures.

Results

All the data analyses were conducted with the SPSS program, version 25.0.

Relationship between measures obtained from SSRT

To analyze the relationship between the three SSRT measures, we calculated raw scores for accuracy (number of correctly repeated sentences), MLU-r (calculated across the total number of repeated sentences) and the number of function words that were omitted within the repeated sentences. Then, we conducted a series of bivariate Pearson correlations among these scores.

Table 2 displays the descriptive statistics obtained from the scores in the SSRT. It can be observed that out of the 33 SSRT items, children accurately repeated an average of 13.08 sentences. Regarding MLU-r, we found an average of 4.3 words, with 2.3 being the minimum and 6 being the maximum. Note that the total number of words in the longest sentence is 9. The omission of function words in the repeated sentences averages at 18, with the SSRT including a total of 86 function words across its 33 items.

TABLE 2 Means, standard deviations and ranges of the SSRT measures.

	N	Min	Max	Mean	SD
Accuracy	24	1	30	13.08	7.46
MLU-r	24	2.3	6.03	4.37	0.86
FWO	24	0	50	18	15.18

TABLE 3 Means, standard deviations and ranges of the spontaneous language measures.

	N	Min	Max	Mean	SD
MLU-w	24	1.45	2.52	2.05	0.32
VOCD	24	32.25	80.76	52.89	14.02
Total proportion of noun phrases	24	0.17	0.61	0.31	0.10
Proportion of correct noun phrases	24	0.56	1	0.89	0.11
Proportion of incorrect noun phrases	24	0	0.44	0.11	0.12

In relation to the previous scores, we found a positive and significant correlation between the variable Accuracy and MLU-r [$r_{(24)} = 0.923$, $p < 0.001$], a significant and negative correlation between Accuracy and FWO [$r_{(24)} = -0.712$, $p < 0.001$], and also a significant and negative correlation between FWO and MLU-r [$r_{(24)} = -0.686$, $p < 0.001$]. These correlations show, as expected, that children who perform better on the sentence repetition task are those who produce longer sentences and omit fewer function words. Furthermore, children who produce longer utterances tend to make fewer omission errors.

Relationship between measures from spontaneous language

For the purposes of this study, we recorded the total frequency of NP (*number of NP)*, summing up instances of correct NP (*DN*), grammatical omissions of determiner *(0N)* and agrammatical omissions of determiner (*0*N)*. Additionally, we computed the number of correct NP by considering *DN* instances along with grammatical omissions of determiner. Lastly, we determined the frequency of incorrect NP, those with agrammatical determiner omissions. For the analyses in this study, we did not take into account the so-called "uncertain Noun Phrases" (see Table 1), due to their ambiguous categorization, and they also constitute only 3.25% of the total sample of NP produced.

To analyze the relationship between the indexes derived from the spontaneous speech sample we initially computed the MLU-w and the diversity index VOCD as it was stated in the method section. We also calculated each child's proportion of NP over the total number of transcribed utterances, along with the ratio of correct and incorrect NP over the total number of NP produced by each child (see Table 3).

As can be seen in Table 3, regarding the MLU-w, we found an average production of 2.05 words, with a minimum of 1.4 and a maximum of 2.52. The Vocabulary Diversity Index (VOCD) shows an average of 52.8, ranging from a minimum of 32.2 to a maximum of 80.7. Note that we report here the values for D optimum average, since the command offers different values. This values usually range from 10 to 100, and higher values indicate higher diversity (McCarthy and Jarvis, 2010). We also found that, out of all the Noun Phrases used by children in their spontaneous language, 89% are produced accurately, while only 11% constituted determiner omission errors.

Regarding the statistical analyses, we found that MLU-w positively and significantly correlates with the proportion of correct NP structures [$r_{(24)} = 0.685$, $p < 0.001$] and negatively and significantly correlates with the proportion of determiner omission errors in NP [$r_{(24)} = -0.685$, $p < 0.001$]. We did not find a significant relationship between VOCD and child-produced MLU-w [$r_{(24)} = 0.378$, $p = 0.068$], nor between the VOCD index and the correct usage of NPs ([$r_{(24)} = 0.231$, $p = 0.276$].

Relationship between SSRT and spontaneous language measures

To analyze the relationship between the SSRT scores and the measures obtained from the spontaneous language samples we performed further bivariate Pearson correlations. Table B1 in the Appendix B show the results of these analyses. We found a positive and significant correlation between Accuracy on the SSRT and MLU-w in spontaneous language [$r_{(24)} = 0.435$, $p < 0.05$], indicating that children who perform better on the SSRT tend to produce longer utterances in their spontaneous language. Regarding the relationship between MLU-w and MLU-r, the results also show a positive and significant correlation between these 2 variables [$r_{(24)} = 0.460$; $p < 0.05$]. On the other hand, the VOCD index has a positive, but not significant, relationship with the SSRT Accuracy score [$r_{(24)} = 0.319$, $p = 0.129$].

Regarding the structure of Noun Phrases and their relation to SSRT, a positive and significant correlation is obtained between the proportion of incorrect NP (i.e. determiner omission errors) produced in spontaneous language and FWO in the SSRT [$r_{(24)} = 0.463$; $p = 0.023$] and a negative and significant correlation between the proportion of such determiner omission errors and the total score in the SSRT [$r_{(24)} = -0.490$, $p = 0.015$]. That is, children who make more determiner omission errors in their spontaneous language achieve lower scores in the SSRT. On the contrary, a positive and significant correlation is found between the correct use of NP (sum of DN and 0N) and the total score in the SSRT ($r = 0.490$; $p = 0.015$) and the MLU-r ($r = 0.444$; $p = 0.023$).

The correlation analyses conducted between the various measures of spontaneous language considered in our study and the SSRT indicate that the child's language MLU-w and measures related to NP usage are closely linked to the child's performance in the SSRT. To assess the extent to which each of these variables explains the performance in the SSRT, we conducted a multiple linear regression analysis considering that this kind of analysis is more suitable than other options as ANOVA for example,

to specifically explore accuracy measures (Jaeger, 2008). The dependent variable was the accuracy in the SSRT, and the predictors were linguistic measures obtained from the spontaneous language sample (MLU-w and the proportion of correct NP). We found that the model fits both variables (proportion of correct NP and MLU-w) as follows: $F_{(3,20)} = 3.6$, $p = 0.043$. We also found that these two variables account for a significant portion of the variance in SSRT accuracy ($R^2 = 0.26$).

Discussion

Despite the extensive research on SRTs, few studies have compared their outcomes with children's spontaneous language measures. Most research has focused on comparing SRT performance with standardized tasks (see Hesketh and Conti-Ramsden, 2013; Thordardottir and Brandeker, 2013; Aguado et al., 2018; Bravo et al., 2020), overlooking the value of assessing children's language development through natural language sample analyses. In this context, the aim of this study was to examine the relationship between different scores obtained in a sentence repetition task developed in Spanish (Bravo et al., 2020, 2023) for children from 2 to 4 years of age and other well-attested measures taken from spontaneous speech samples. Taken together, our results show that children's performance at the SSRT is related to their grammatical skills expressed during their spontaneous interactions with their caregivers.

We first found a strong relationship between the three measures of the SSRT; children with higher accuracy also exhibited lower levels of function words omission and higher scores in the MLU-r. Other studies, such as Leclercq et al. (2014) in French, have also analyzed the relationship between internal measures of the SRT (or sub-measures) and the total score obtained from the task, finding similar results. The authors concluded that the overall morphosyntactic measure in the SRT strongly correlates with function word measures, verbal morphology, and grammatical accuracy in repetition, affirming that the task effectively mirrors its intended purpose. In their study with Italian-speaking children, Devescovi and Caselli (2007) also found significant correlation between the different measures of the SRT, number of repeated verbs, FWO, and MLU-r. Although our study does not use identical measures, it complements previous research by demonstrating consistency in the measures obtained using the SSRT.

The analyses concerning the indexes derived from spontaneous language samples revealed robust associations between MLU-w and the accurate usage of Noun Phrase. Children with longer MLU-w exhibited fewer omission errors of Determiners in NP. Previous research has found that NP is commonly acquired early and is a frequent structure both in experimental and naturalistic contexts (Mariscal, 2009). The correlation between NP measures used in this study and MLU suggests that both measures are good indicators of children's grammatical knowledge at 2.6 (Rice et al., 2010).

Regarding the relationship between the measures derived from the SSRT and the spontaneous speech samples, our findings indicate that children's SSRT accuracy and MLU-r are strongly related to both the MLU-w and the correct use of NP when they produce the sentences in naturalistic situations. This result suggests that the measures obtained with the SSRT serve as reliable indicators of children's grammatical development and that the mechanisms involved to produce elicited sentences during repetition in clinical or experimental contexts reflect the skills necessary to produce sentences spontaneously. Previous research, such as Devescovi and Caselli (2007) in Italian, also identified a correlation between the SSRT and specific measures derived from spontaneous language: MLU, FWO, and verb usage. However, the participants' age range was broad (2 to 4 years), and, when age was controlled, the associations between SSRT accuracy and certain aspects of spontaneous speech were weaker and sometimes non-existent. Moreover, Wang et al. (2021) established a connection between SRT, MLU, VOCD, and a composite structural measure of spontaneous language in their study involving Mandarin-speaking children aged between 3.6 and 6.5 years. Compared to these studies, our research focuses on a narrower age range and results show the relationships between the ability to repeat sentences (typically used in clinical and experimental settings) and spontaneous speech during the earliest phases of syntactic development.

In our study, we did not find a relationship between the SSRT and the Vocabulary Diversity Index (VOCD), nor did we find a correlation between this index and the rest of the measures used for the analysis of spontaneous language samples (neither MLU-w nor the use of determinants in Noun Phrase). There could be several reasons for this. Despite the recent presentation of VOCD as a promising measure for assessing children's lexical diversity, it is not without issues. In a recent study, Yang et al. (2022) tested 4 measures used in clinical practice to calculate the lexical diversity index: the Type-Token Ratio (TTR) index, the Number of Different Words (NDW), the Moving Average Type Token Ratio (MATTR) and the Vocabulary Diversity (VOCD). They found that, if these indexes are used as a measure of lexical richness, the VOCD and NWD are the ones that best reflect the vocabulary of the participants, but did not show correlation with traditional measures of syntax, like MLU in words or morphemes.

Although numerous studies have found continuity between lexical and grammatical skills (Mariscal and Gallego, 2013), this relationship fundamentally refers to the early stages. A critical mass of vocabulary is necessary to support the construction of the first multiword utterances and morphological variations (Marchman and Bates, 1994). However, at later ages this relationship is far from direct, and is closely related to contexts and input (Brinchmann et al., 2019). On the other hand, the children in our sample are very young, between 30 and 36 months, and it is possible that at these ages the lexical diversity is not varied enough to reflect the grammatical level of each child. In fact, the words used in the repetition task are frequent, the lexical diversity indexes allow us to reflect the use of rare words, which, in other studies, is related, for example, to access to literacy (Hindman et al., 2021). Therefore, to solve the SRT it is not necessary to have a very high variety of word types, although it is necessary to have a minimum vocabulary that the children in this sample, being typically developing, clearly achieve.

It is interesting to note that this fact allows us to think that the SRT is a very specific assessment tool for grammatical development that can be administered to children whose lexical skills follow a typical course of development but who may

begin experiencing specific grammatical difficulties from an early age.

Further research with spontaneous language samples in diverse contexts could provide more insight into this matter, adding new and more fine-grained evidence that contributes to concurrent validity of SSRT.

Taken together, the results of the present study with the Spanish Sentence Repetition Task (SSRT) are in line with previous research that has shown the usefulness of sentence repetition tasks in assessing children aged between 2 and 4 years old (Devescovi and Caselli, 2007; Gábor and Lukács, 2012; Novogrodsky et al., 2018; Bravo et al., 2020, 2023). Its ability to discriminate between different developmental levels has been demonstrated, and concurrent and predictive validity results support its use (Bravo et al., 2020, 2023). Establishing that this new tool, simple and easy to apply, may provide results mirroring those obtained through the study of spontaneous language, could represent a valuable opportunity in the field of child language assessment. Usually, the analysis of spontaneous speech is complex and time consuming and therefore is not suitable for clinical contexts. The correlations shown in this study suggest that the scores obtained with the SSRT reflect children's linguistic knowledge.

While Bravo et al. (2020) study involved 130 children, the current research was carried out with a smaller sample, allowing us to focus on the earliest stages of grammatical development in younger children. Although the sample size is a limitation to consider in this study, analyzing spontaneous language samples is very time and resource-consuming. We believe that the results could provide more valuable information if we had a larger sample. Similarly, it would have been interesting to include children with different ages, and to study the relationship between language measures and the SSRT at different development stages. In fact, this is the first study of this type conducted with a monolingual Spanish-speaking population at such an early developmental phase. Therefore, it would be possible to continue analyzing measures of the SSRT that may reflect more sophisticated changes in morphological and syntactic development.

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 Ethics Committee of the Universidad Autónoma de Madrid. 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

NB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. SM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. MC: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. ML: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, 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

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Short versions of the Basque MacArthur-Bates Communicative Development Inventories (children aged 8–50 months)

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This study provides a brief review of the adaptation of the short MacArthur-Bates Communicative Development Inventories (CDI) instruments into Basque. The study aims to provide the scientific community with several standardized instruments designed to measure the vocabulary size of young children (aged 8–50 months) who are learning Basque, a language spoken in Spain and France. Data from over 2,400 children, obtained using the Basque adaptations of the short CDI parental questionnaires, the BCDI-1s(hort), BCDI-2s, and BCDI-3, revealed the capacity of these instruments to identify the effect of age on the language development of preschool-age children exposed to this language, as has been attested in other (minority and non-minority) languages. The study also examined the effect size of age, sex, and language input. The results showed that sex had a null or very small effect on both lexical development and the rest of the scales, whereas the effect of language input increased as children grew older and was even stronger than the effect of age from 30 months onwards. These findings provide solid ground for discussing the relevance of various factors that affect young children's language acquisition.

KEYWORDS

short CDI, Basque, child language, input, sex, 8–50 months

Introduction

Parents (and caregivers) are considered a relevant source of information on children's communicative and language skills and have positively contributed to early child language research. Similar to medical consultations, where parents report on their children's behavior, capacities, and feelings, they can also provide information on language development. Parents' impressions and knowledge of their child's capacities are based on hours of observation of spontaneous behavior in varied interactions, situations, and contexts. Noticeably, parental questionnaires allow researchers to compile valuable information ecologically, and consequently, this information is less likely to be affected by contextual factors in other observational spaces (e.g., a laboratory or clinic), which may affect the child's skills.

The MacArthur-Bates Communicative Development Inventories, commonly known as CDI instruments, are a set of parental questionnaires originally designed to measure lexical skills and gestural or grammatical skills in English for preschool-age children living in the USA. The first set of questionnaires were the Words and Gestures or CDI-1 instrument (8–15/18 months, depending on the versions) and the Words and Sentences or

CDI-2 (16–30 months). Based on these original questionnaires, which included a vocabulary checklist of over 350 items among other sections, shorter versions were developed, with fewer subsections and a checklist of approximately 100 words (Fenson et al., 2000, 2007): the CDI-1 short or CDI-1s (8–18 months), the CDI-2 short or CDI-2s (16–30 months), and the CDI-3 (30–48 months). Depending on the language, all or some of these five instruments have been adapted to over 100 oral and sign languages, which provides interesting ground for inter-/intra-individual and cross-linguistic comparison (Dale and Penfold, 2011; Ezeizabarrena and Kovacevic, 2023, a.o). More specifically, research into how variables such as age, sex, and/or prematurity, and/or language exposure affect lexical development has facilitated cross-linguistic comparisons using instruments suitable for clinical use. Notable among these are recent adaptations of short CDIs for several languages, including Arabic (Abdelwahab et al., 2021), Australian English (Jones et al., 2022), Basque (Garcia et al., 2011, 2014), Croatian (Šmit Brleković and Kuvač Kraljević, 2023; Kuvač Kraljević et al., 2024), Estonian (Tulviste and Schults, 2020; Urm and Tulviste, 2021), Finnish (Stolt, 2023), Galician (Perez-Pereira and Resches, 2007), Hungarian (Kas et al., 2022), Italian (Rinaldi et al., 2019), Korean (Pae et al., 2008), Mexican Spanish (Jackson-Maldonado et al., 2013), European Portuguese (Frota et al., 2016), Mandarin (Soli et al., 2012), Norwegian (Holm et al., 2023), and Swedish (Eriksson, 2017).

Basque is a European language spoken by approximately 800,000 adult speakers in the western part of the Pyrenean Mountains on the Spanish–French border. It is a minority language currently undergoing a revitalisation process. According to data from 2011 and 2021, Basque is the home language of 21% and 25% of families living in the Basque Autonomous Community (BAC). Moreover, the educational system, in which over 99% of 3-year-old children are involved (ISEI/IVEI, 2021), promotes the use of Basque in kindergartens and schools in this region, where Basque has a co-official status with Spanish. Recent census data gathered in the BAC indicate that the knowledge of Basque (active and passive knowledge combined) among 2- to 4-year-olds has reached 97% in the last few years (Eustat, 2021). In other words, the youngest age group currently has the highest rate of Basque speakers. In this context, in which the minority language, Basque, is in constant contact with Spanish and/or French and, to a lesser extent, with other languages, the variation in the relative amount of exposure becomes relevant to the assessment of young and older children's linguistic skills (Hurtado et al., 2014; Thordardottir, 2019).

The five CDI instruments mentioned above, two long forms and three short forms, have been adapted into Basque. However, the current article focuses on the vocabulary scales of the three short Basque CDI questionnaires, namely, BCDI-1s, BCDI-2s, and BCDI-3, with a two-fold aim. First, this study aims to demonstrate these instruments' reliability (internal consistency) and concurrent validity for measuring lexical development in early Basque among children aged 8–50 months. Second, it highlights the need to include the variable of relative exposure, in addition to age and sex, in the research and use of CDI instruments within bilingual populations, especially if minority languages are involved.

Three short Basque CDI instruments

Following the criteria established by Fenson et al. (2000, 2007), the short Basque CDIs have retained the original scales for receptive vocabulary (BCDI-1s), expressive vocabulary (BCDI-1s,−2s, and−3), mean length of utterance (MLU) (BCDI-2s and BCDI-3), and language use (BCDI-3). The vocabulary checklists were based on the long forms of BCDI-1 and BCDI-2 (Barreña et al., 2008; Garcia et al., 2011, 2014). Data were collected from across various Basque-speaking areas of Spain and France, with the majority of data gathered from the Basque Autonomous Community (BAC), which has the highest concentrations of Basque speakers.

The BCDI-1s and BCDI-2s were standardized using data from 468 children aged 8–15 months, including 221 girls and 247 boys and with additional 926 children aged 16–30 months, comprising 427 girls and 499 boys (Garcia et al., 2011). The BCDI-3 was normed with a sample of 1,024 children aged between 30 and 50 months, which included 526 girls and 498 boys (Garcia et al., 2014).

Subsequently, the participants were divided into three input groups according to their relative exposure to Basque (and Spanish/French): Basque-dominant children (over 60% Basque input), balanced (40–60% Basque input), and Spanish/French-dominant children (below 40% Basque input). In all three BCDI samples, i.e., BCDI-1, BCDI-2, and BCDI-3, the Basque-dominant group was the largest (N = 334/678/814, respectively), followed by the balanced groups (N=41/125/105) and, finally, the Spanish/French-dominant group (N = 81/74/93).

Figure 1 shows the results of receptive and expressive vocabulary obtained by Garcia et al. (2011) using the BCDI-1s and BCDI-2s instruments and by Garcia et al. (2014) using the BCDI-3. For uniformity, vocabulary size is plotted as mean percentages of the total vocabulary checklist included in each instrument (90 words for BCDI-1, 100 words for BCDI-2, and 120 words for BCDI-3) rather than the mean numbers of words selected from each list. The uninterrupted increase in the four curves for expressive vocabulary in Figure 1 illustrates these three instruments' sensitivity to age variations. The two upper curves plot the means of the sample in receptive (words understood) and expressive vocabulary (words produced). The two bottom curves represent the P10 values, which are the percentages of words known by 10% of the participants with the lowest scores in receptive and expressive vocabulary. Values below P10 are traditionally used as benchmarks in CDI studies to identify children who have or are at risk of language delay.

Table 1 displays the means of the number of words and standard deviations for receptive vocabulary (ages 8–15 months) and overall vocabulary (ages 8–50 months), segmented by age, sex, and language input across the three instruments. These statistics are based on the data from Garcia et al. (2011) for the BCDI-1s.

Table 2 displays the means of the number of words and standard deviations for expressive vocabulary (8–50 months), categorized by age, sex, and language input across the three instruments. These data are derived from the study by Garcia et al. (2011) for the BCDI-1s and the BCDI-2s and from Garcia et al. (2014) for the BCDI-3.

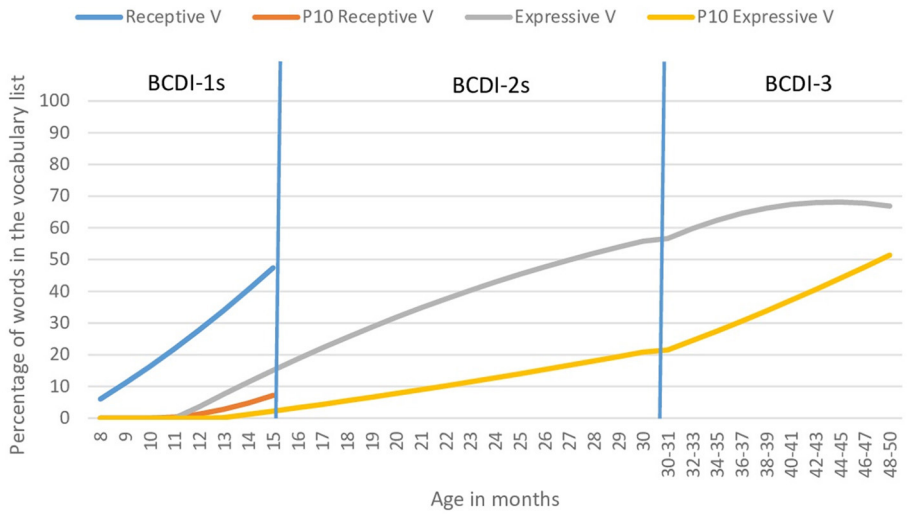

FIGURE 1
Adjusted mean rates and P10 scores of receptive and expressive vocabulary scales between 8 and 50 months in 3 short BCDI instruments.

The means of receptive vocabulary measured with the BCDI-1s increased steadily during the 8–15-month period (a total increase of 40 words, five words/month mean increase), as shown in Table 1. In contrast, the growth rate in expressive vocabulary displayed in Table 2 varied during the studied period: there was a 1–2 word increase by month during the period of 12–18 months in the BCDI-1, a five-word/month increase over the next 10 months, and a slowdown to a 1–2 word/month increase in the 28–50 month period, with a decrease in word production observed in the last age group of 49–50 months. Only a low percentage of children reached the maximum score of 120 (below 12% in the oldest age groups), eliminating any potential ceiling effect in BCDI-3. The ANOVA statistical analyses revealed a significant and strong effect of age on receptive vocabulary in the BCDI-1s instrument [$F_{(7,460)} = 36{,}10$, $p < 0.001$, $\eta_p^2 = 0.353$], as well as on expressive vocabulary in the BCDI-1s [$F_{(7,460)} = 14{,}10$, $p < 0.001$, $\eta_p^2 = 0.176$], BCDI-2s [$F_{(14,913)} = 48.69$, $p < 0.001$, $\eta_p^2 = 0.427$], and BCDI-3 instruments [$F_{(9,1004)} = 17{,}08$; $p < 0.001$; $\eta_p^2 = 0.133$]. The effect size of the children's age indicates the sensitivity of these three instruments for detecting developmental changes in both receptive and expressive vocabulary. Interestingly, age also significantly affected the rest of the BCDI-2s and BCD-3 scales, showing a strong impact on morphology, grammatical complexity, language use scales, and medium-sized effects in the MLU scales (Garcia et al., 2011, 2014).

Mean vocabulary scores differed for boys and girls across most age groups (Table 1). Differences ranged from 0 to 8 words in receptive vocabulary and from 0 to 10 in expressive vocabulary, favoring boys in some age groups and girls in others. Specifically, the total mean number of words understood was 1.5 words higher for boys in receptive vocabulary and 0.2 words higher for girls in expressive vocabulary in the BCDI-1s sample. However, the ANOVA statistical analysis revealed that these sex differences did not reach statistical significance in either receptive [$F_{(7,452)} = 0.12$, $p = 0.728$, $\eta_p^2 = 0.000$] or expressive vocabulary scales [$F_{(7,452)} = 0.53$, $p = 0.469$, $\eta_p^2 = 0.001$]. Among older children, girls outscored boys in 19 out of the 25 age groups in expressive vocabulary by a range of 0 to 21 words, although boys outscored the girls in six age groups by 0 to 10 words. Further ANOVA analyses conducted with BCDI-2s [$F_{(14,896)} = 7.20$, $p = 0.007$, $\eta_p^2 = 0.008$] and BCDI-3 samples [$F_{(9,1004)} = 4.43$, $p = 0.036$, $\eta_p^2 = 0.004$] revealed that the differences in total mean scores, which were higher for girls by 0.4 and 2.5 words, respectively, reached statistical significance. However, the effect of sex was very weak, explaining <0.1% of the variance. Interestingly, this effect size was similar to those found in the MLU scales in BCDI-2s and in morphology in BCDI-3, while sex differences did not reach statistical significance in the rest of the BCDI-2s and BCDI-3 scales.

The highest total mean scores in receptive (28 words) and expressive vocabulary across the three instruments (2/42/92 words, respectively) were observed in the Basque-dominant group (>60% input), followed by the balanced bilingual group (24 and 2/37/84 words) and the Spanish/French dominant group (19 and 1/35/62 words), as displayed in Table 1. This pattern may indicate that vocabulary scores decrease with the relative amount of exposure. However, this ranking is consistently observed only in age groups older than 13 months for both receptive and expressive vocabulary. The ANOVA analyses showed that the effect of the amount of exposure to Basque was not significant in either receptive or expressive vocabulary in the youngest age range (8–15 months). In contrast, language input significantly affected expressive vocabulary in the 16–30 month age range, where children with Basque input >60% scored higher than those in the <40% input group. This effect was weak, accounting for less than 3% of the variance [$F_{(2,834)} = 8.00$, $p < 0.001$, $\eta_p^2 = 0.019$]. In the 30- to 50-month age range, the effect of language input on expressive vocabulary was strong [$F_{(2,947)} = 124.80$, $p < 0.001$, $\eta_p^2 = 0.209$], as well as on other scales, with the Basque-dominant group achieving the highest scores (Garcia et al., 2011). In the 30- to 50-month age range, language input accounted for over 20% of the variance (high effect size) for expressive vocabulary and the rest of the BCDI-3 scales, except for MLU, where its effect was medium (Garcia et al., 2014).

TABLE 1 Means and standard deviations for receptive vocabulary (8–15 months).

	Receptive vocabulary (8–15 months)															
	Age	Receptive vocabulary		Sex				Input								
				Girls		Boys		>60		40–60		<40				
	Months	*N* of words		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
		Mean	SD													
BCDI-1s (90 lexical items)	8	6.72	9.14	6.72	10.23	6.72	8.28	6.06	7.95	5.00	7.44	8.16	11.31			
	9	11.18	11.02	10.06	10.13	12.90	12.36	12.09	11.71	3.50	2.52	11.83	10.44			
	10	14.97	13.70	13.07	12.03	16.73	15.09	14.91	12.67	12.20	18.69	15.75	14.73			
	11	20.57	14.37	21.70	16.54	19.44	12.03	20.20	13.99	21.00	21.21	18.00	13.02			
	12	28.08	23.79	26.53	22.94	29.83	25.00	29.00	23.08	17.75	23.60	35.40	32.64			
	13	36.52	22.51	40.66	23.49	32.26	20.96	36.76	22.71	35.30	21.08	47.67	30.86			
	14	40.24	21.71	39.79	24.10	40.92	17.90	46.32	21.33	29.14	19.56	29.92	18.94			
	15	46.62	19.86	49.00	19.82	43.96	19.94	47.49	19.78	46.20	15.21	43.75	28.45			
	Total	26.34	22.51	25.51	21.22	27.08	23.63	28.44	23.01	24.29	21.70	19.43	19.92			

All three short instruments presented accurate psychometric features, as shown by the reliability and validity analyses. Regarding reliability, all the scales presented high internal consistency, as determined using Cronbach's α coefficient, with $\alpha > 0.90$ values for all BCDI-1s, BCDI-2s (Garcia et al., 2011), and BCDI-3 scales (Garcia et al., 2014), except for the language use scale in the BCDI-3 ($\alpha = 0.74$). Moreover, score stability was analyzed using the test-retest procedure in the BCDI-3, with a small sample of 30 participants tested twice with an interval of 2 weeks. Significant and strong correlations were found between all the lexical, grammatical, and language use scales ($r > 0.92$).

The concurrent validity of the instruments has been confirmed. For the short and long BCDI-1 and BCDI-2 forms, some parents completed each form 2 weeks apart, with the order counterbalanced so that half the sample completed each form first (Garcia et al., 2011). The relationship between the short and long forms was statistically significant and strong, with the Pearson coefficient value (r) > 0.75 for the BCDI-1s ($N = 48$) and $r > 0.81$ for the BCDI-2s ($N = 98$). In the case of the BCDI-3, 19 participants completed both the BCDI-3 and the Peabody (Dunn et al., 2006) tests. The correlations across all the scales were statistically significant and strong, with some variation across scales, as shown by the Pearson coefficient values of $r > 0.60$ for vocabulary and language use scales and $r = 0.40$ for vocabulary and grammatical scales. The test-retest procedure was used to measure the BCDI-3 instrument's predictive validity. A group of 21 participants completed the BCDI-3 twice, with a 5-month interval between sessions. All between-scale correlations were significant and strong ($r > 0.52$). The validity of the three short instruments was also supported by high total and partial correlations between scales. Total r values ranged from 0.50 (between vocabulary scales in BCDI-1s) to >0.63 (all scales in BDCI-3) and, finally, to 0.80 (vocabulary and both MLU scales in BCDI-2s). Partial correlations controlling for age were slightly lower but remained high, with r values ranging from 0.32 (between vocabulary scales in BCDI-1s) to >0.58 (all scales in BDCI-3) and, finally, to >0.70 (vocabulary and both MLU scales in BCDI-2s).

Discussion

All short BCDI instruments appear to have been accurate for measuring communicative development between children aged 8 and 50 months since the effect of age was significant in the lexical scales of the three instruments and the rest of the scales of the BCDI-2s and BCDI-3. More specifically, age significantly affected both receptive and expressive vocabulary scales, and it was strong in the BCDI-1s (8–15 months), the only short instrument containing that scale, and in expressive vocabulary for the 16–30-month-old children. The effect of age was, however, weaker in the youngest (8–15 months) and the oldest children (30–50 months).

Interestingly, the magnitude of age effects found in the BCDI-1s and BCDI-2s samples up to 30 months of age was similar to those reported with the long Basque questionnaires, BCDI-1 and BCDI-2 (Barreña et al., 2008). It was also in line with previous studies conducted using short CDI-1 and CDI-2 instruments developed in Galician (Perez-Pereira and Resches, 2007), European Portuguese (Frota et al., 2016), and Mexican Spanish (Jackson-Maldonado

Expressive vocabulary (8–50 months)													
	Age	Expressive vocabulary		Sex				Amount of exposure to basque					
	Months	*N* of words		Girls		Boys		>60%		40–60%		<40%	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
BCDI-1s (90 lexical items)	8	0.07	0.26	0.10	0.31	0.04	0.20	0.10	0.30	0.00	0.00	0.05	0.23
	9	0.14	0.45	0.10	0.31	0.16	0.52	0.18	0.52	0.25	0.50	0.00	0.00
	10	0.74	2.71	1.13	3.68	0.32	0.77	1.18	3.53	0.00	0.00	0.20	0.52
	11	0.65	1.35	0.63	1.31	0.67	1.41	0.69	1.36	0.00	0.00	0.67	1.63
	12	1.33	2.81	1.10	1.84	1.53	3.46	1.31	3.04	1.50	1.29	1.80	2.49
	13	4.13	8.63	4.79	11.22	3.49	5.08	4.24	9.56	4.30	4.27	4.00	3.61
	14	3.25	3.93	3.88	4.52	2.84	3.48	3.51	4.37	3.43	1.90	2.42	3.58
	15	6.71	7.83	6.65	6.28	6.76	9.11	7.29	8.47	4.60	3.29	4.00	2.71
	Total	2.20	5.18	2.63	5.77	2.06	4.60	2.53	5.89	2.36	3.11	0.92	2.13
BCDI-2s (100 lexical items)	16	12.43	17.32	11.71	10.83	12.89	20.58	12.32	19.35	15.20	12.37	3.00	0.00
	17	9.53	8.90	11.81	10.51	5.90	4.69	9.70	9.00	11.40	8.91	7.00	10.44
	18	15.44	21.24	10.33	10.75	20.03	26.86	14.20	16.87	12.90	22.69	3.33	1.53
	19	20.93	17.61	18.42	12.63	23.10	20.99	23.26	18.32	12.80	10.45	7.60	3.78
	20	21.53	18.69	20.94	17.27	21.74	19.38	22.40	19.00	19.63	19.57	12.50	17.68
	21	29.13	22.10	29.80	22.52	28.66	22.11	32.18	24.54	24.82	15.87	19.88	14.92
	22	31.42	24.50	34.29	23.48	29.24	25.34	31.18	24.09	32.88	32.11	22.50	17.56
	23	39.32	22.97	44.76	21.14	33.57	23.72	40.26	24.23	34.63	19.28	35.20	20.27
	24	46.70	27.00	47.47	28.55	45.78	25.47	45.71	27.93	43.17	19.14	23.50	9.26
	25	52.87	26.09	58.06	29.76	48.98	22.54	51.97	27.14	65.33	23.86	54.00	20.20
	26	54.86	28.57	58.44	28.76	50.89	28.23	57.02	29.81	46.89	28.27	52.50	25.33
	27	67.37	25.79	72.26	23.56	61.41	27.47	72.15	25.16	55.15	22.02	56.50	40.52
	28	66.05	27.02	66.43	28.33	65.71	26.26	69.00	27.58	58.75	13.50	46.14	27.15
	29	67.45	22.75	70.64	19.57	65.19	24.83	68.91	24.86	67.18	21.51	55.40	15.85
	30	69.61	28.36	82.43	22.13	60.67	29.07	75.68	27.24	45.80	32.17	50.25	19.70
	Total	41.92	31.00	45.03	31.86	39.36	30.04	42.55	31.92	36.99	27.52	35.70	26.35

(Continued)

TABLE 2 (Continued)

Expressive vocabulary (8–50 months)													
	Age	Expressive vocabulary		Sex				Amount of exposure to basque					
	Months	*N* of words		Girls		Boys		>60%		40–60%		<40%	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
BCDI-3 (120 lexical items)	30-31	68.95	29.62	74.41	24.87	62.83	33.42	71.38	28.62	57.75	33.67	37.33	28.43
	32-33	70.48	29.17	73.10	27.48	67.98	30.81	74.06	26.24	72.33	23.81	23.71	21.34
	34-35	70.80	28.25	76.28	26.25	64.88	29.38	77.79	22.86	50.21	31.73	37.67	30.40
	36-37	78.26	28.25	75.63	29.71	80.58	26.97	84.62	25.59	69.36	20.01	50.30	32.52
	38-39	84.98	30.20	87.00	29.89	83.53	30.60	91.82	24.61	58.40	37.20	46.13	28.45
	40-41	88.77	26.88	91.38	25.68	86.78	27.81	91.47	24.76	97.30	27.33	59.45	27.38
	42-43	95.42	25.65	98.73	18.50	91.92	31.32	101.72	17.35	75.08	40.17	66.30	33.16
	44-45	94.27	24.75	92.24	24.06	96.15	25.45	101.33	17.73	89.00	22.48	44.67	25.54
	46-47	98.82	23.13	98.65	23.06	98.96	23.42	105.09	16.70	83.88	18.87	63.80	32.29
	48-50	92.55	27.67	93.78	28.99	91.16	26.24	101.28	20.22	74.14	33.77	54.80	20.14
	Total	84.79	29.47	86.09	27.90	83.55	30.86	92.41	25.02	84.24	25.84	62.76	32.65

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et al., 2013). From 30–50 months, age had a medium-large effect on the expressive vocabulary scale and the grammatical scales of BCDI-3, with a slightly higher effect observed on the language-use scale. These effect sizes of age on the Basque BCDI-3 scales were very similar to those reported for vocabulary in the original CDI-3 (Fenson et al., 2007), as well as in the Swedish (Eriksson, 2017) and the European Portuguese adaptations (Cadime et al., 2021).

Sex did not show any effects in the 8–15-month age range tested with both the short and the long BCDI-1 instruments (Barreña et al., 2008). This finding is in line with the null (Jackson-Maldonado et al., 2013) or very small effects found in the short English, CDI-1s (Fenson et al., 2000; Perez-Pereira and Resches, 2007; Frota et al., 2016). However, the effects of sex were significant, albeit very weak, in favor of girls in the expressive vocabulary scales of both short and long BCDI-2 instruments (Barreña et al., 2008). Similar minor effects were noted in long CDIs tested in 10 languages other than Basque (Eriksson et al., 2012) and in other short CDI-2s (Fenson et al., 2000; Perez-Pereira and Resches, 2007; Jackson-Maldonado et al., 2013). The effect of sex also remained weak in the oldest 30–50-month age range tested with the BCDI-3, which was similar to the findings observed in English, Swedish and Estonian studies (Fenson et al., 2007; Eriksson, 2017; Urm and Tulviste, 2021). Collectively, these findings indicate that the minimal impact of sex on CDI results is not unique to the Basque language. Moreover, considering the variation observed within both sex groups, these findings question the usefulness of maintaining separated percentile tables for boys and girls (Garcia et al., 2024).

The effect of the amount of exposure on vocabulary size increased with age, developing from null in the youngest age range tested with short (and long) BCDI-1 instruments to significant but very small in the 16- to 30-month age range tested with the BCDI-2s and to medium-large in the 30- to 50-month age group tested with the BCDI-3 (Ezeizabarrena and Garcia, 2023). The findings from the Basque data are not very different from those of Galician studies, where no input effects were found among children aged 8–30 months tested with the short CDI-1s and CDI-2s (Perez-Pereira and Resches, 2007). However, the lack of studies examining the effects of this variable on CDI-3 scales for older bilinguals over 30 months limits the ability to compare these results broadly. It is not surprising that greater exposure to the target language provides bilingual children with more linguistic experience over time, which can lead to a greater lexical repertoire in that language. The increase in the input effect with age is compatible with models of lexical development, which propose that the accumulation of linguistic experience, rather than other variables such as chronological age or the age of initial exposure, may accelerate word learning (McMurray, 2007). The lower scores of the groups with less exposure to Basque are compatible with an acceleration that may have occurred among the Basque-dominant children earlier than in the other two groups. The differences in vocabulary development across the input groups in the current study are also in line with studies conducted with older children, which explained the significant differences between age-matched bilinguals with similar ages of initial exposure, which was largely attributable to the varying amounts of exposure they had received in each language (Thordardottir, 2019). This finding highlights the critical role of language exposure in shaping the bilingual lexical development of children.

Additionally, short BCDI instruments showed high reliability and validity. First, Cronbach's alpha values in short BCDI instruments were as high as in other short CDI instruments (Fenson et al., 2000; Perez-Pereira and Resches, 2007; Frota et al., 2016; Urm and Tulviste, 2021). As for concurrent validity, short and long BCDI instruments showed high correlation values, in line with Fenson et al. (2000), Frota et al. (2016), Jackson-Maldonado et al. (2013), Perez-Pereira and Resches (2007), and Urm and Tulviste (2021). Moreover, the BCDI-3 showed a significant and high correlation with the Peabody test, as in the original CDI-3 (Fenson et al., 2007). Additionally, significant and strong between-scale correlations were found in the three BCDIs. A high correlation between receptive and expressive vocabulary in the BCDI-1s resembles the Galician data (Perez-Pereira and Resches, 2007), which was slightly slower than other versions (Frota et al., 2016). Between-scale correlations were higher in the BCDI-2s, similar or even higher than those reported for other languages (Fenson et al., 2000; Perez-Pereira and Resches, 2007; Frota et al., 2016), and they were also high in the BCDI-3, in line with Portuguese, Swedish, and Estonian adaptations (Eriksson, 2017; Cadime et al., 2021; Urm and Tulviste, 2021).

In summary, the similarities found in the factors affecting vocabulary size as measured by both the short (BCDI-1s, BCDI-2s, and BCDI-3) and long (BCDI-1 and BCDI-2) instruments, in addition to the similarly high reliability and validity of the three short instruments relative to the original short CDIs and their posterior adaptations to other languages, confirm the robustness of the findings and the usefulness of the short Basque instruments for assessing language development in the age range of 8 to 50 months. Those tools containing a short vocabulary checklist will facilitate professionals in assessing and identifying young Basque children at risk of developmental delays. Moreover, the availability of these assessment tools, which consider not only age and sex but also the amount of exposure, will help address the current lack of assessment tools for identifying (a)typical development, a need emphasized by professionals in language intervention within bilingual settings that involve minority languages.

Author contributions

M-JE: Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing—original draft, Writing—review & editing. IGF: Conceptualization, Formal analysis, Investigation, Methodology, Validation, Writing—original draft. AM: Data curation, Investigation, Methodology, Writing—original draft.

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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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Reference management in written narrative production by Spanish-Italian bilingual children

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This paper is an investigation of reference production in 84 Italian-Spanish bilingual children aged 8 to 12. The study explores whether such reference production is influenced by either the type of referential expression involved or language dominance by analyzing how these children manage reference. The children's relative proficiency in the two languages (and thus their language dominance) was assessed through a cloze-test, and their narrative production was evaluated using a retelling task. Results indicated a preference for null pronouns to refer to subjects and full referential expressions for objects, with Italian showing a higher occurrence of full referential expressions. Dominance in either language did not significantly impact reference production. This suggests that bilingual children can distinguish between language-specific patterns, a behavior consistent with adult monolingual groups. These results contribute to our understanding of bilingual reference management and shed light on the role played by language and language dominance.

KEYWORDS

bilingualism, anaphora, narratives, Spanish, Italian

1 Introduction

Reference management and anaphora resolution in both the monolingual and multilingual contexts have been the subject of scholarly inquiry for many years. It has generally been assumed that languages that allow null subjects, that is, null-subject languages (NSLs) behave similarly regarding the interpretation of pronouns: null subject pronouns refer to subject antecedents, while overt subject pronouns refer to object antecedents and indicate a topic shift. This assumption has been confirmed in many studies where a similar pattern was found In various NSLs (Carminati, 2002 for Italian; Alonso-Ovalle et al., 2002 for Spanish; Papadopoulou et al., 2015 for Greek). However, other studies have yielded contrary results. For example, Filiaci (2011) detected differences in this regard between Italian and Spanish: following Carminati (2002), she confirmed through self-paced tasks that in Italian there is a strict division of labor between null and overt subject pronouns that is not as strong in Spanish, particularly with overt pronouns in subject position. Similarly, Leonetti and Torregrossa (in press) compared the interpretation of null and overt subject pronouns in Italian, Greek, and Spanish by means of an interpretation task. Here as well, Italian appeared to be the most syntactically "restrictive" of the three, as it showed a clear preference to associate null pronouns with subject antecedents and overt pronouns with object antecedents and rejected the contrary association (Rizzi, 1982). Greek showed a similar pattern but was less restrictive in accepting the less expected combinations. Regarding the findings for Spanish, it showed no preference whatsoever between null and overt pronouns in subject position referring back to subject and object antecedents, as in sentence (1), where it remains unclear who is performing the action

in the subordinate clause–closing the folder– with both the null and the overt pronoun.

(1) *El doctor pagó al arquitecto mientras (pro)/él cerraba la cartera.*

'The doctor paid the architect while (pro)/he was closing the folder.'

With regard to the bilingual context, a vast amount of literature has been produced in recent years focusing on the role played by factors such as cross-linguistic effects, language dominance, input or age of first exposure in early bilinguals, successive bilinguals and second language (L2) learners [see Meisel (2009) and Tsimpli (2014) for details]. Regarding child bilingualism, many elements of language have been analyzed, among them anaphora resolution in both NSLs and non-NSLs (Sorace, 2011; Torregrossa et al., 2020). Experiments on bilingual anaphora resolution have yielded very different results, prompting various explanations. For instance, studies involving English-speakers who were nearly native-speakers of Italian (Sorace and Filiaci, 2006; Belletti et al., 2007) found that while these individuals had the null subject grammar, they did not seem to have the necessary processing resources to felicitously apply it, resulting in an overproduction of overt pronouns compared to their monolingual peers.

Similar results have been found with bilinguals, as seen in Bel and García-Alcaraz (2016) for speakers of Moroccan Arabic and Spanish. Likewise, Sorace and Serratrice (2009) found an over-acceptance of overt subject pronouns in no-topic shift contexts in Italian–Spanish bilingual children. An equivalent outcome, but with an overproduction of full determiner phrases–DPs–, has also been found in Greek–Italian (Andreou et al., 2023) and Greek–Spanish (Giannakou and Sitaridou, 2022) bilinguals. Other studies (Torregrossa et al., 2020 for Greek–German; Torregrossa et al., 2021 for Greek–Albanian/English/German) have found both underspecification and overspecification in bilinguals, postulated as reflecting the impact of proficiency and language experience. On the other hand, native-like behavior has also been found in both bilinguals (Kraš, 2008 for Croatian–Italian; Di Domenico and Baroncini, 2019 for Greek–Italian; Giannakou, 2023 for Greek–Spanish) and L2 learners (Kraš, 2015 for Croatian–Italian). As we see, the bibliography is extensive and the possible reasons for these varied outcomes are many.

The general issue that arises with all these experiments is that differences among the methodologies applied and/or the linguistic backgrounds of participants have made it difficult to compare results. For this reason, the present study's contribution is to add the pair Spanish–Italian to an ongoing investigation of bilingual narratives[1] in different linguistic pairs, all applying an identical methodology, for which Torregrossa et al. (2020) work with German–Greek bilinguals is the starting point. It is intended that the resulting expanded compilation of findings will be compared and analyzed in the near future, providing an organized and systematized answer regarding bilingual narratives.

Following this approach, the main questions in this study are (1) whether bilinguals associate null and overt pronouns with specific antecedents following each language's pattern (RQ1) and (2) whether language dominance play any role in their decisions (RQ2).

2 Methods

The study was conducted during the 2021–2022 academic year at an Italian school in Madrid, the *Scuola Statale Italiana di Madrid*, which uses Italian as the main medium of instruction but offers some subjects in Spanish.

2.1 Participants

Eighty-four bilingual children (41 female) ranging in age from 8 to 12 took part in the study.

Prior to the experiment, a short questionnaire was sent to the participants' parents regarding the linguistic background of their children in terms of the language(s) spoken at home, during extracurricular activities, with parents and grandparents, etc.[2]. In terms of nationality, in some cases parents were both Spanish or both Italian while in others one parent was Spanish and the other Italian. Nevertheless, 67% of parents reported the family context to be more Spanish-dominant, although 80% of the families had exposed their children to Italian in some way since the age of 3. Following Montrul (2008), participants can therefore be described as either simultaneous or early successive bilinguals. According to the traditional characterization of micro- and macro-parameters, the Null Subject Parameter is considered a macro-parameter (Roberts, 2007). Following Clark (2009), children learn macro-parameters by the age of 6, which means that when monolingual natives enter school, they have already mastered the basic syntax of the Null Subject Parameter. On the other hand, according to Tsimpli (2014) and Paradis et al. (2011), simultaneous and early successive bilinguals have no learning constraints compared to their monolingual peers, if the input has been similar and sufficient in both languages. If bilingual children raised with two NSLs are perfectly able to acquire the Null Subject Parameter of both languages, and we know that children in the present experiment have had a balanced input for Spanish and Italian since age 3 or before, this would allow them to separate the syntactic particularities of anaphora, according to the aforementioned literature.

2.2 Materials and procedure

Participating pupils performed two experimental tasks, a cloze-test and a narrative retelling task for each language. Tasks in the respective languages were administered on paper during the children's regular Italian and Spanish classes. The order in which the two language versions were administered was randomized across groups, as was the order of tasks. Administration of one language version of the task set was separated by a gap of at least 1 week from administration of the other language version.

The cloze-test was intended to assess the children's proficiency in each language (see Hulstijn, 2010 for an overview of instruments of this sort), replicating the task used in Torregrossa et al. (2023) for

1 https://sfb1252.uni-koeln.de/en/projects/c03-reference-management-in-bilingual-narratives

2 Unfortunately, only 27 parents filled in the questionnaire, and many of those who did failed to provide the child's date of birth. The background information for children provided here must therefore be viewed as merely suggestive.

Portuguese,[3] which in turn is based on a textless cartoon story that forms part of the Edmonton Narrative Norms Instrument (ENNI; Story B3 – Balloon; Schneider et al., 2006)[4]. The story is written in such a way that it targets structures related to the syntax-discourse interface (e.g., pronouns, clitics, adverbial clauses). This makes it possible to assess the children's mastery of these structures, as well as their comprehension abilities (Torregrossa et al., 2023: 16). Excerpts from the Italian and Spanish versions of the test can be seen in (2).

(2) a. Il coniglio **ve**_ _ che la sua amica sta tirando un carretto con un **belli**_ _ _ _ _ palloncino. Il palloncino, il coniglio _ _ vuole prendere, per **gio**_ _ _ _ con la sua amica, ma la cagnolina **g**_ _ dice che prima devono slegarlo. (Italian)

b. El conejito ve que su amiga está tirando de un carrito con un globo muy **bo**_ _ _ _. El conejito quiere **coger**_ _, para **ju**_ _ _ con su amiga, pero la perrita _ _ dice que antes tienen que desatarlo. (Spanish).

The rabbit sees his friend pulling a wagon with a beautiful balloon tied to it. The little rabbit wants to take the balloon to play with his friend, but the little dog says that they need to untie it first.

Participants' word completions were then coded as 'correct', 'incorrect', 'missing' or 'unexpected' (meaning that the word completion was not the intended target but was nonetheless grammatically acceptable). For purposes of analysis, all 'correct' and 'unexpected' answers were assigned a value of 1, while all 'incorrect' and 'missing' answers were assigned a value of 0. Points were totalled for each language, resulting in a proficiency score out of forty.

These scores also made it possible to check for language dominance by subtracting one language proficiency score from the other, in this case the score for Spanish being subtracted from the score for Italian. Thus a positive score indicated dominance in Italian, while a negative score indicated dominance in Spanish. The closer the score is to zero, the more balanced the child's knowledge of both languages (Torregrossa and Bongartz, 2018). This dominance score will be used in the analysis of the narrative task.

Participants' ability to produce referential expressions in Spanish and Italian was tested using a story-telling task, again replicating the experiment carried out in Torregrossa et al. (2020). Narratives were elicited by asking the children to retell another ENNI story in both languages (Story A3 – Airplane; Schneider et al., 2006). The story consists of 13 pictures with no text, representing a series of events involving two characters, Elephant Girl and Giraffe Boy.

Following the procedure in Torregrossa et al. (2020), we primed the participants by first having them hear a narrator tell the story depicted in the cartoon drawing before they had to retell it, on the grounds that this would render the decoding of the pictures and the comprehension of the story easier for them (Gagarina, 2016). The task was administered as a sequence of Power Point slides on the classroom screen. The story pictures appeared two by two, accompanied by the voice of the narrator telling the story (the Spanish audio was created based on the Italian version, already available from Torregrossa et al., 2020). After they had viewed and heard the full story, the children were asked to rewrite it in their own words.[5]

All resulting child-produced texts were subsequently transcribed as digital text and then divided into clauses, based around the occurrence of any verb in the text. In the analysis process, each clause was entered in a table with an additional column indicating any referential expression (RE) contained in that clause. If the clause contained more than one RE, it received an additional column entry. Further columns indicated each of the possible characters with an assigned number, the type of RE (e.g., full, null, overt), its grammatical role (e.g., subject, object, etc.) and the number of characters intervening between the antecedent and the RE (except for the first appearance, labeled as "intro"). A sample of coding can be seen in Table 1. After coding all narratives, only distances of none or one intervening character between the RE and its antecedent were considered, as here immediate pronominal resumption was the main focus.

3 Results

Looking at the results for the full sample of 84 participants, the cloze-test revealed a balanced participant population with similar proficiency levels in Spanish and Italian. As shown in Figure 1, groups were separated by age, displaying proficiency levels in both languages. In fact, the mean language dominance score was −0.5, pointing to a slight (but not statistically significant) Spanish dominance. To calculate language dominance scores, the results of the cloze-test in Spanish were subtracted to the results of the cloze-test in Italian for each child; a negative number corresponded to a Spanish dominance, while a positive result indicated an Italian dominance.

Moving on to the narrative retelling task, Figure 2 represents the overall occurrences of null and overt pronouns and full referential expressions as referring to either a subject or an object antecedent. As can be seen, null pronouns are the preferred form used to refer to the subject in both languages.

For the statistical analysis, a linear mixed-effects model was applied using R software. The model, created for the response variable *frequency* (representing the frequency of specific REs produced by each child in relation to a specific antecedent), includes a random intercept and slopes for each participant and was fitted as a function of the dependent variable *type* (indicating the type of RE) in a second-order interaction with *reference* (distinguishing between reference to a subject antecedent vs. reference to an object antecedent) and *language* (Italian vs. Spanish). Additionally, the variables *group* (i.e., mean age) and *dominance* were also included as main effects. The model also included subject intercept and slope random effects (Table 2).

The model showed a main effect in Italian for the type of RE when referring to subjects, with significantly fewer occurrences of DPs ($\beta = -5.19$, $SE = 0.32$, $t = -16.02$, $p = <0.001$) and overt pronouns

3 We obtained an Italian version from the authors and translated it to Spanish with their permission.

4 http://www.rehabmed.ualberta.ca/spa/enni/about_the_enni.htm

5 In Torregrossa et al. (2018), the children retold the story orally and were audio-recorded doing so. The present experiment was carried out in a post-Covid environment in which the sanitary protocols of the school permitted us only to test the children by means of a written activity.

TABLE 1 Example of coding applied to a transcript from the narrative retelling task for Spanish.

	Character	RE		ANTECEDENT			
		Type		Type	Gramm.	Dist.	Interv. CH.
Un día Jirafito y Elefantita jugaban en la pistina. *[One day giraffe boy and elephant girl were playing in the pool]*	2	NP	SUBJ	Intro	Intro	Intro	Intro
Un día Jirafito y Elefantita jugaban en la pistina. *[One day Giraffe Boy and Elephant Girl were playing in the pool]*	1	NP	SUBJ	Intro	Intro	Intro	Intro
Jirafito habia traido un avión. *[Giraffe Boy had brought a plane]*	2	NP	SUBJ	NP	SUBJ	1	1
Jirafito habia traido un avión. *[Giraffe Boy had brought a plane]*	3	NP	OBJ	Intro	Intro	Intro	Intro

The speaker here was a 10-year-old Spanish-Italian bilingual. Units containing more than one referring expression are repeated as many times as the REs they contain. ('CHARACTER', appearing character; 'RE', referential expression (null, overt, full/subject, object); 'GRAMM.', grammatical role of antecedent; 'DIST.', number of intervening characters; 'INTERV. CH.', intervening characters).

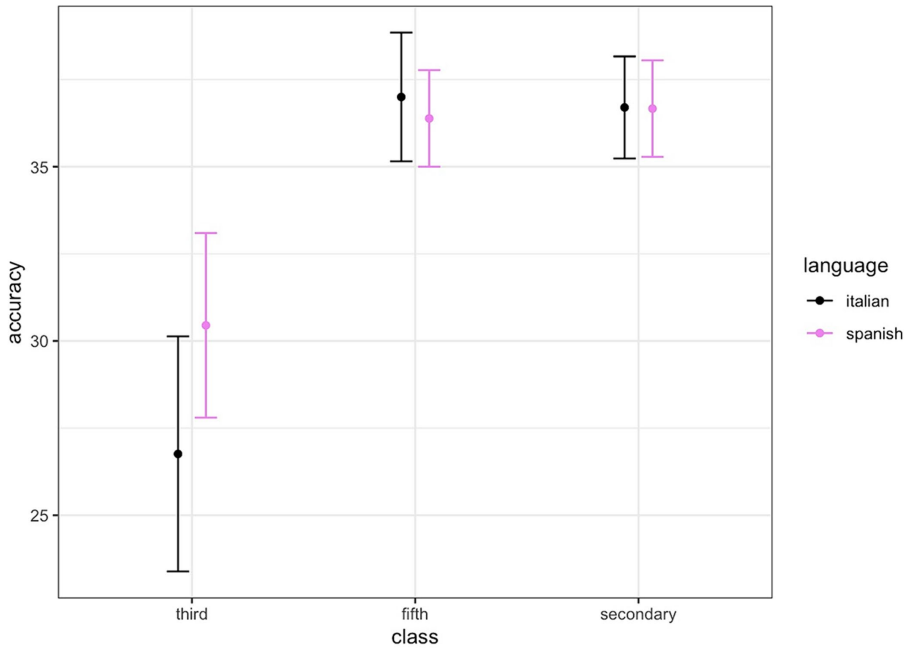

FIGURE 1
Language dominance scores calculated by subtracting cloze-test task results (/40) for Spanish from corresponding results for Italian.

($\beta = -8.38$, $SE = 0.31$, $t = -26.75$, $p = <0.001$) as compared to null pronouns. This effect was no different for Spanish for overt pronouns, as seen in the non-significant main effect of language or in the interaction of this variable with the variable *type (overt)*, although this was not the case for DPs, which were less frequently resorted to in Spanish as compared to Italian ($\beta = -1.00$, $SE = 0.36$, $t = -2.71$, $p = 0.007$).

Additionally, a main effect was also observed in Italian for the variable *reference* on the number of occurrences of null pronouns, which participants used fewer times when referring to objects than when referring to subjects ($\beta = -7.83$, $SE = 0.29$, $t = -24.21$, $p = < 0.001$). The interaction of *reference* with the type of anaphoric expression shows a different pattern in the use of DPs, which were more often used when referring to objects than null pronouns ($\beta = 6.98$, $SE = 0.36$, $t = 18.95$, $p = < 0.001$), differently from the trend observed when referring to subjects. Also, a significant interaction was observed for overt pronouns, showing a much smaller difference between null and overt pronouns, even though these were resorted to on very few occasions in reference to objects ($\beta = 7.56$, $SE = 0.36$, $t = 20.53$, $p = < 0.001$). The same applies to Spanish, as shown by the non-significant differences in the corresponding interactions. Finally, the model showed no effect for the variables of language dominance or age group.

4 Discussion and conclusion

The aim of this study was to test reference production in Spanish–Italian bilingual children by means of a narrative retelling task. Following the ENNI materials used in Torregrossa et al. (2020), this

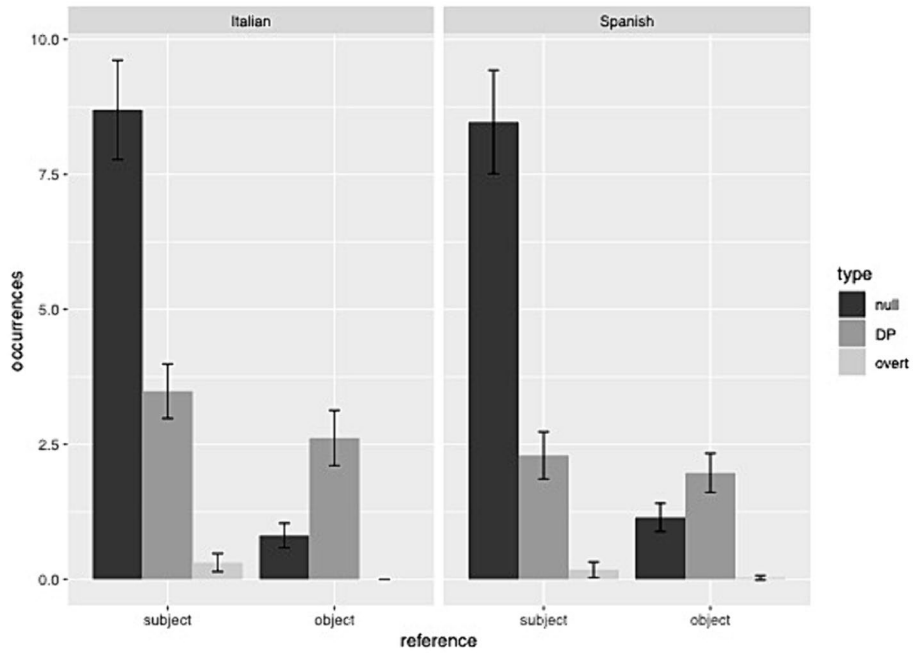

FIGURE 2
Overall occurrences of null and overt pronouns and full referential expressions as referring to either a subject or an object antecedent.

TABLE 2 Results of the linear mixed effects analysis.

Fixed effects	Estimate	SE	*t*	*p*
(intercept)	8.50	0.33	25.53	<0.001***
type (DP)	−5.19	0.32	−16.02	<0.001***
type (overt)	−8.38	0.31	−26.75	<0.001***
reference (object)	−7.83	0.29	−26.89	<0.001***
language (Spanish)	−0.16	0.27	−0.60	0.544
dominance	−0.00	0.01	−0.49	0.624
class (2)	0.06	0.22	0.30	0.764
class (3)	0.30	0.17	1.70	0.090
type (DP) x reference (object)	6.98	0.36	18.95	<0.001***
type (overt) x reference (object)	7.56	0.36	20.53	<0.001***
type (DP) x language (Spanish)	−1.00	0.36	−2.71	<0.007**
type (overt) x language (Spanish)	0.05	0.36	0.16	0.871
reference (object) x language (Spanish)	0.48	0.36	1.30	0.192
type (DP) x reference (object) x language (Spanish)	0.05	0.52	0.10	0.914
type (overt) x reference (object) x language (Spanish)	−0.34	0.52	−0.66	0.506

task prompted participating children to retell a story using their own words. The main focus was to see, on one hand, whether they would associate null and overt pronouns with specific antecedents following different patterns for Spanish and Italian (RQ1), as found in monolinguals in Filiaci (2011) and Leonetti and Torregrossa (in press), and on the other, whether language or language dominance would play any role in their decisions (RQ2).

The statistically significant differences in the occurrence of anaphoric expressions reveal a clear relationship between them and reference assignment (RQ1), with an interaction between null pronouns and the subject antecedent, and between full RE and the object antecedent in both languages. However, in Italian there is a higher occurrence of full REs, with both subject and object antecedents. As for overt pronouns, they are scarce in number but clearly associated with subject antecedents. This is similar to the results found in Lozano (2009) for English speakers of Spanish as an L1, where both native-speakers and L2-learners displayed a clear preference for full DPs in topic-shift contexts and used a small number

of overt pronouns, as well as the findings reported in Giannakou and Sitaridou (2022) for Greek–Italian bilinguals, who used overt pronouns only rarely.

Excerpts (3) and (4) below are taken from the transcribed productions of 12-year-old participants in the present study as they begin the narrative retelling task.[6] In the Italian sentence in (3) there are more occurrences of full REs (*Elefantina, Giraffino, aeroplanino*), while in the Spanish sentence in (4) there are more null and clitic pronouns.

(3) Elefantina e Giraffino decidono di andare alla piscina. Giraffino gli fa vedere ad Elefantina il suo aeroplanino. Elefantina si innamora del aeroplanino di Giraffino. Elefantina gli rubba l'aeroplanno a Giraffino.
Elephant Girl and Giraffe Boy decide to go to the pool. Giraffe Boy shows ElephaGirl his toy airplane. Elephant Girl falls in love with Giraffe Boy's airplane. Elephant Girl steals the airplane from Giraffe Boy.

(4) Un día Jirafito estaba jugando con un avioncito, y cuando Elefantita lo vio le dio envidia asi que se lo quito y casualmente se le cayo al agua y el Jirafito enfadado le chilla.

One day Giraffe Boy was playing with a toy airplane, and when Elephant Girl saw it, she got envious so she took it from him and it fell in the water, and Giraffe Boy was angry and yelled at her.

Regarding whether language or language dominance are relevant factors for reference assignment (RQ2), the statistical analysis showed no significant results for these two factors. This indicates that the referential choices made by the children were not influenced by one language or another, or by the child's being more dominant in Spanish or Italian. This result is not surprising considering the scores obtained in the cloze-test: while we would expect dominance in one of the two languages to translate into cross-linguistic effects [as in Sorace and Filiaci (2006)], the fact that differences between Spanish and Italian are maintained means that children can separate each referential choice in the two languages.

These results are consistent with some of those found in previous research. For example, Bel and García-Alcaraz (2016) observed that Moroccan Arabic–Spanish bilinguals performed very much native-like, in accordance with the Position of Antecedent Strategy (Carminati, 2002) in terms of associating null pronouns with subject antecedents and exhibiting no residual optionality, in other words, not overproducting overt pronouns in contexts where the preferred RE would be a null subject. Similarly, Di Domenico and Baroncini (2019) compared L2 and bilingual Greek and Italian speakers to monolinguals and found that the bilinguals behaved like the monolinguals; an effect of age, however, was found inside this bilingual group. Finally, Giannakou (2023) compared bilingual, heritage and L2 speakers of Greek and Spanish with monolinguals and found that the bilinguals performed like the monolinguals in linking null pronouns to subject antecedents and overt pronouns to object antecedent in Greek. Heritage speakers were closer to Spanish monolinguals because they produced more ambiguous null pronouns. As Giannakou (2023) points out, what arises from her study is that the interpretation of overt pronouns in Greek is more grammatically determined and restricted to more specific contexts, while in Spanish overt pronouns rely more on pragmatics and therefore can be used more flexibly.

The narrative task proposed in the present paper reveals that Italian–Spanish bilingual children, just like adults, show a clear preference to associate certain REs with specific antecedents. Nevertheless, this preference is not as strong as those found in previous adult monolingual studies, such as Leonetti and Torregrossa (in press), where Italian-speakers exhibited a sharp dichotomy between null pronouns associated to subject antecedents and overt material associated to object antecedents, while Spanish-speakers showed no preferences whatsoever. In the present study, a general tendency to associate null pronouns with subject antecedents and full REs with object antecedents seems to arise. However, when speaking Italian, participants more clearly associate each type of RE with a specific antecedent and produce a higher number of full REs overall. This could be an indicator of these bilingual children's sensitivity to language-specific patterns.

As mentioned, a surprising finding is the scarce use by these children of overt pronouns in both languages, which contradicts other research on Spanish–Italian bilinguals, such as Sorace and Serratrice (2009): although the authors associate this result with cognitive processing costs, it could be a further indicator of the actually different uses and interpretations of null and overt pronouns in these two languages. It has generally been assumed that null and overt pronouns are complementary and, like a coin, are a two-sided "self-sufficient" element regarding anaphora resolution: null for subject antecedents, overt for object antecedents; null when there is topic continuity, overt when the topic changes, and so on. But what these results show seems to put overt pronouns in a different, secondary position, as full REs seem to be preferred in these contexts. In this sense, such behavior has been found also in other linguistic pairs, such as English L1/Spanish L2 or in Greek-Spanish bilinguals (Lozano, 2009; Giannakou and Sitaridou, 2022).

The purpose of this study was to collect data regarding how Italian-Spanish bilingual children manage reference in a narrative retelling task context. Because other language pairings –such as German-Greek in Torregrossa et al. (2020)– are being studied using exactly the same methodology, this will give us data in both languages that allow null pronouns and languages that do not, that is, pro-drop and non pro-drop language combinations, which will all be directly comparable. The results of these comparisons will allow a more extended and complete analysis of bilingual narratives.

Our present investigation of Italian and Spanish bilingual children reveals that they choose to associate specific referential expressions with specific antecedents, namely, null pronouns with subject antecedents and full REs with object antecedents. Nevertheless, they are beginning to mirror the behavior seen in studies of adult monolinguals (Leonetti and Torregrossa, in press; Filiaci, 2011), that is, a more pronounced separation of duties for the Italian pronominal system, and an increased number of null pronouns referring to object antecedents for Spanish. Moreover, language dominance seems to play no role in such differentiations. This separation of patterns is consistent to a certain extent with the results found in some of the literature for other languages, such as Andreou et al. (2023) for Greek–Italian bilinguals or Giannakou (2023) for Greek–Spanish bilinguals. This work therefore represents a small contribution to our understanding of reference production in bilingual contexts.

6 All the examples provided maintain the child's original spelling.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Scuola Statale Italiana di Madrid Enrico Fermi. 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

VL: Writing – original draft, Writing – review & editing.

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Conflict of interest

The author declares 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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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).

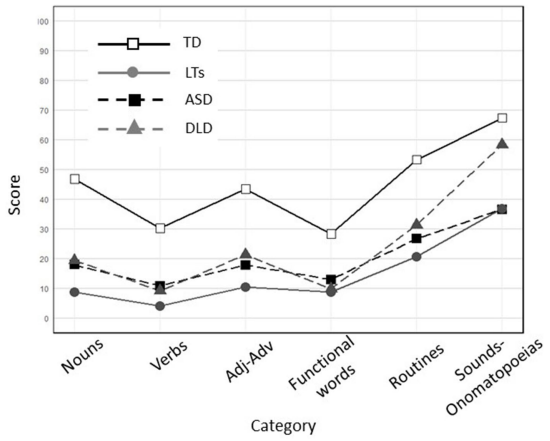


FIGURE 1
Profiles of four groups (TD, LTS, ASD, DLD) based on six vocabulary category scores. Each plotting symbol denotes the mean value for the score.

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).

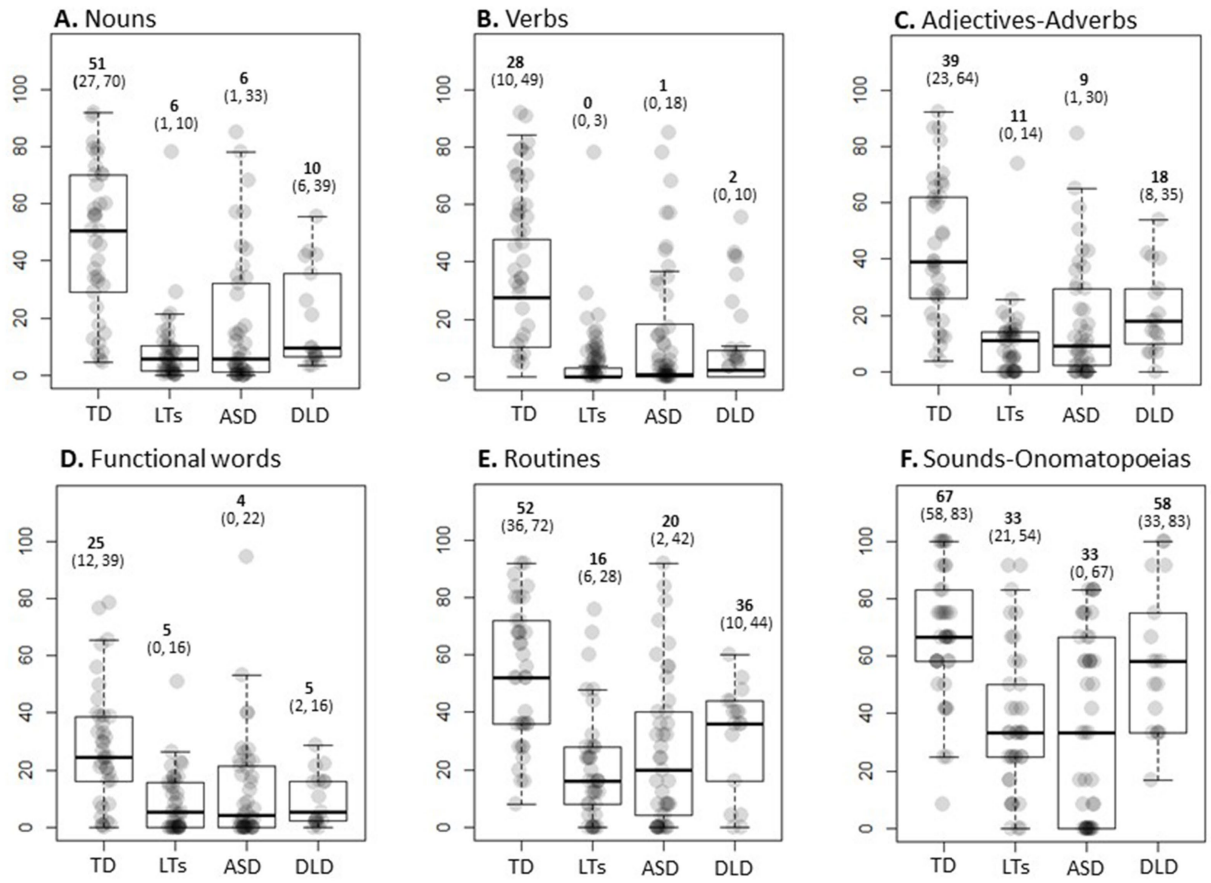


FIGURE 2
Comparison of variability among the four groups across six vocabulary categories. The values displayed at the top of each boxplot for **(A)** Nouns; **(B)** Verbs; **(C)** Adjectives-Adverbs; **(D)** Functional words; **(E)** Routines; **(F)** Sounds-Onomatopoeias, are median (interquartile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

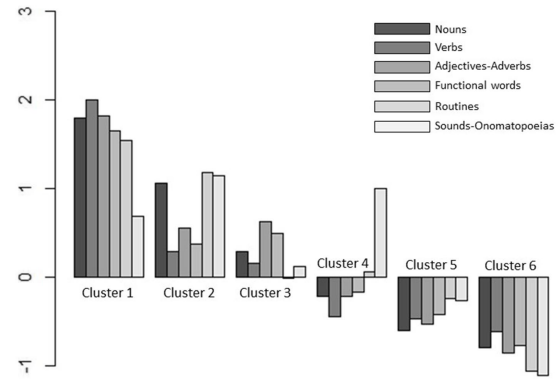
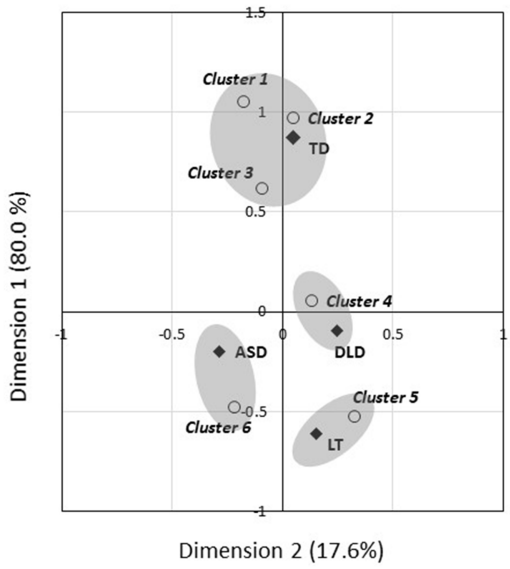


FIGURE 3
Contrasts in standardized scores across six clusters from hierarchical cluster analysis using six vocabulary categories as variables.

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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Protocol for the assessment of the development of pragmatic competencies in early childhood (PDP-PI)

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Introduction: The design of a Protocol for the Assessment of the development of pragmatic competences in early childhood (PDP-PI) and the preliminary data obtained in a comparative study in 3–5-year-old school children are presented.

Methods: The design of the protocol is based on a model of global understanding of pragmatics that considers essential to include linguistic, intersubjective and social aspects in order to make an adequate assessment of development. Based on the taxonomies of communicative functions, four basic competencies are described (Interactional, Referential, Subjective and Figurative). These competencies make it possible to categorize most of the linguistic emissions in early childhood. The PDP-PI presents two novelties with respect to other assessment systems: (a) it allows detecting the degree of a skill development (not only the presence/absence), (b) it includes items to assess the comprehension of pragmatics. The PDP-PI was used with 40 students of kindergarten education, divided into three groups according to school year.

Results: The results- Duncan's *post-hoc* test-confirm the existence of significant differences between the different age groups in all competencies, except for referential competence. Construct validity was assessed by means of an inter-rater test (Fleiss' Kappa = 0.76; Krippendorff's Alpha = 0.76), and content validity was assessed by analyzing the correlations between the four competencies of the protocol. Significant correlations were found between all the competencies, except the relationship between the Referential and Interactional competencies.

Discussion: The data obtained in this study are preliminary, but they show that there is an evolution in the management of pragmatic skills, throughout early childhood, toward more complex and context-appropriate interactions. It is necessary to advance in procedures that discriminate against this evolution to establish developmental profiles which favor the detection of pragmatic difficulties or disorders at early ages.

KEYWORDS

pragmatics, assessment, early childhood, communicative functions, language

1 Introduction

Pragmatics is one of the most complex areas of language to define given its close relationship with inter-subjective skills and knowledge of the context of the interlocutors. The lack of consensus on a common approach to pragmatics hinders an integrated view of the existing scientific contributions, giving rise to molecular formulations and partial theories that explain specific processes and limit the creation of a global framework.

This research presents a global comprehension model of pragmatics in which the activation of three aspects, which feedback on each other, giving rise to a specific *speech act*, is considered essential:

- The self and communicative intentionality. The person who emits a speech act has a representation of himself that allows him to establish his beliefs, knowledge, intentions, and interests (Belinchón et al., 2000).
- The other: intersubjectivity and Theory of Mind. The sender not only has a representation of his intentions, beliefs, and desires, but also a mentalistic representation of his interlocutor (second-order representation). This representation of the other includes information regarding aspects such as interests and beliefs, but also shared information, the relationship between the two and social distance (Baron-Cohen, 1995; Leslie, 1994), which would explain, for example, why the sender selects a topic of interest if he intends to please the interlocutor or tell only the end of a story if he knows that the beginning is known to both.
- The context: information and appropriateness. Finally, to guarantee communicative success–although there can always be misunderstandings-, the sender must make a representation of the communicative context that includes the processing of information on referential, cultural and conventional aspects to be considered in that context.

Therefore, the elaboration of a message starts with the communicative intention of the sender who uses mentalistic information to adjust the linguistic selection; and this selection must conform to certain rules such as: the principle of cooperation (Grice, 1975), speech acts (Searle, 1969), the theory of misfortunes (Austin, 1962), or the rules of politeness (Brown and Levinson, 1987). The result is an initial message based solely on the sender's perspective; but for the message to be successful it will need to be reworked considering the mentalistic information coming from the representations of the other and the context.

This conception of pragmatics has been supported by neuroimaging studies that place the areas of pragmatic processing in areas of the right hemisphere (Kupperberg et al., 2000) like those of mentalistic task processing (Kuhlen et al., 2015). There is sufficient data showing that during pragmatic performance both specific brain areas are activated (van Ackeren et al., 2012), as well as general processes (Apperly et al., 2005). In any case, neuroscientific research contributes to outline the close relationship between pragmatic and mentalistic skills.

However, despite the growing interest in the study of the acquisition of pragmatic skills in the early stages of language development, traditional language assessment tests are not very effective, since the multiplicity of skills that make up this domain make it incompatible with the use of standardized assessment methods (Conti-Ramsden et al., 1997). And in turn, the need for instruments that discriminate specific difficulties in this area is key for the early detection of disorders such as Social Communication Disorder (SCD) due to social reciprocity difficulties (Gibson et al., 2013; Loukusa et al., 2018) or pragmatic difficulties in Williams Syndrome (Díez-Ítza et al., 2016).

The question is how and with what instruments to assess the development of pragmatic skills at an early age to favor the detection of their difficulties and promote intervention from a normalized environment. From Psycholinguistics, we have proposals, although there is a premise that we should not forget: pragmatic symptomatology is not as objectifiable as other language components (González et al., 2015).

One of the most widely used approaches to assess pragmatic skills in early childhood is the Speech Act Theory (Searle, 1969) and its translation into classifications of Communicative Functions (Dore, 1974; Halliday, 1975; Bates, 1976; McShane, 1980; Ninio and Wheeler, 1984). These *classic* proposals continue to be representative lines of work in the exploration of the development of pragmatic skills since they are accessible and simple tools that do not require specific training of the evaluator and facilitate the elaboration of a general profile of communicative development. However, one of their limitations is that they evaluate skills in terms of the *presence or absence of* communicative functions, reducing the information obtained, because many functions can be satisfied with different levels of linguistic complexity. For example, a "demand" can be expressed with a simple gesture such as pointing or with an elaborate politeness formula. Therefore, it is not an all-or-nothing process, but a gradual process that denotes a differential use of possible communicative-linguistic formulations and the existence of levels of functional language development. This implies that the starting premise for assessing communicative functions is that they should not be studied as static elements, but that what is interesting is to check the degree of development, so that an adequate level for a three-year-old child may imply a delay in a five-year-old child.

Another limitation of these taxonomies is that they describe the *expressive* aspect of language without assessing *comprehension* or appropriateness to interaction or context. This conditions the assessment of development and prevents discrimination between performance or competence problems.

Taking as a starting point the model of global understanding of pragmatics (previously described) and the need to assess pragmatic skills between three and six years of age in order to detect possible difficulties, the aim of this work is to elaborate an assessment protocol, based on the taxonomies on communicative functions, that allows to collect data on the development of pragmatic skills in early childhood, including mentalistic skills and intersubjectivity. This evaluation system should make it possible to detect the existence of different levels of acquisition of the same pragmatic skill, showing that the management of the different communicative functions is a matter of degree and not of absence/presence. This age range was chosen for two reasons. Firstly, because most children in this age group attend early childhood centers and are likely to require a specific assessment for the detection of

difficulties in language development. Secondly, because there are no instruments that systematically assess pragmatic development, in its expressive and comprehension aspects, so many difficulties may go unnoticed.

2 Materials and methods

2.1 Design

For the elaboration of the Protocol for the Evaluation of the development of pragmatic competences in early childhood (PDP-PI) the following objectives were followed: (a) to use as criteria to define the categories the objective of the act and the type of interaction in which the act is emitted; (b) to include the comprehensive aspect of Pragmatics; (c) to assume that the content of the instrument should include the main speech acts that develop between three-six years of age, without pretending to be an exhaustive taxonomy since it would not be operative.

2.2 Procedure for preparing the PDP-PI

2.2.1 PHASE 1: Development of a pragmatic competence classification system

After carrying out a systematic analysis of the taxonomies on pragmatic competencies by Dore (1974), Halliday (1975), Bates (1976), Greenfield and Smith (1976), Togh (1987), Folger and Chapman (1978), Dale (1980), McShane (1980), Prutting and Kirchner (1983), Klecan-Aker and Lopez (1984), Ninio and Wheeler (1984), four categories were established: INTERACTIONAL, REFERENTIAL, SUBJECTIVE AND FIGURATIVE, integrated by different subcategories in their expressive and comprehensive aspects (See Table 1). The first three competencies are recurrent and are found in all the taxonomies reviewed, while Figurative is only referred to in Halliday (1975). This is explained by the fact that most of the classifications are aimed at very early ages in which intersubjectivity is usually valued as the expression of individuality and is therefore covered by Subjective competence.

The INTERACTIONAL category includes the earliest appearing linguistic functions, such as imperatives or intentionality. The language function underlying these speech acts is the regulation of behavior (one's own or another's) and is shown in joint action formats or as the structural basis of a communicative interaction.

The REFERENTIAL category is related to the narration of events and/or the organization of concepts and is linked to the interlocutors' knowledge of the physical world, which allows speakers to share or demand information about reality. These skills require a high cognitive load since they do not necessarily refer to immediate contexts but make it possible to operate on elements that are not present.

SUBJECTIVE competence as an expression of individuality appears in some taxonomies as a personal use of language. It is composed of intra- and interpersonal identification and expression skills, such as personal language linked to action–frequent in play situations–and utterances where children express their individuality at a cognitive and emotional level (emotions, desires, interests, and thoughts). This type of content does not refer to knowledge of reality, but to the personal subjectivity of everyone. Therefore, they are not perceptible contents through the senses but must be inferred through mentalistic and representational skills.

FIGURATIVE competence includes the use of language to simulate, pretend or represent reality. These speech acts systematically violate the maxim of quality since they are not truthful utterances, and this lack of truthfulness is produced by a specific intention of the sender that can be playful (fiction game), interested (instrumental lie), or to express a complaint in an indirect way (irony). Understanding and using this type of statement requires advanced mentalistic skills that facilitate the understanding of the other's intentions and the anticipation of their states or behavior.

Once the general categories were established, the skills for each one of them were determined, taking evolutionary development as a guideline; that is, skills that progress between three and six years of age. Finally, skills on the use and comprehension of non-literal statements (irony and metaphor) were incorporated, the assessment of which is increasingly proposed as necessary at these ages.

2.2.2 PHASE 2: Elaboration of the evaluation tasks according to the interaction "Format"

Once the skills of each pragmatic competence were arranged, they were transformed into tasks, according to the notion of *format* of Bruner (1976), understood as a triadic interaction between the child, the adult, and an object. In this case, the selection of the object or action was made by adapting it to the type of responses that were intended to be induced.

For INTERACTIONAL COMPETENCE, an *action format was* chosen, since it requires the exchange of orders, requests and other speech acts, whose illocutionary force is oriented to the execution of actions. The task designed was the *joint construction of a puzzle*, taking as a reference the research of Bock and Hornsby (1981). This playful task allows the organization of turns of responses similar to those produced in a dialog.

For the REFERENTIAL COMPETENCE, a "*story reading*" *joint attention format was* chosen, since it allows to induce, in a natural way, informative nuances such as naming, description and comments. For example, the adult asks the child to describe one of the characters in the story (proposed situation), the child describes it (induced response) and the expression of perceptual description is assessed (assessed competence).

The selection of a task to promote the use and understanding of SUBJECTIVE COMPETENCE was a more complex process, since the expression of playful language and the manifestation of rejection required an *action format*, while the expression of needs and desires required an *attention format*. The task provided was *a game with dolls that* made the *mixed format* (action and attention) possible. As an example: a doll holding a backpack with many items is shown (proposed situation) to assess the child's expression and understanding of interests and/or desires (assessed competence), for which the child is asked if these items are of interest or not, etc. (induced response).

For FIGURATIVE COMPETENCE, a *mixed format* was proposed through a task that includes a series of graphic vignettes that require the understanding and expression of everyday situations and the reasons that lead the characters to act in a certain way (humor,

TABLE 1 Taxonomy of pragmatic competencies.

Category 1. INTERACTIONAL COMPETENCE		
Speech acts aimed at directly influencing one's own or others' behavior and occurring in a shared action format.		
Subcategories		
Management of outside assistance	**Requests**	**Self-regulations**
Function: to influence the behavior of another		Function: to influence one's own behavior
Comprehension aspect: speech acts aimed at		
- Respond verbally or behaviorally to the call for attention. - Attention check - Understanding a shift format	- Respond to requests (execution or protest) - Repair of shift in the face of lack of understanding	Absence of response to others' self-instructions (understanding that it is not language directed at others).
Expressive aspect: speech acts oriented toward		
- Drawing the attention of others - Directing the attention of others - Check the attention of others	- Someone else to do something Types: - Direct requests: imperatives - Indirect requests: politeness formulas, questionsand suggestions.	- Planning and controlling one's own behavior. Types: - Following verbal instructions - Self-instructions - Planning
Category 2. REFERENTIAL COMPETENCE		
Speech acts aimed at naming, describing or referring to a situation in the physical world to exchange information about it.		
Subcategories		
Denominate–describe	Relate concepts	Comment/share information
Function: labeling an element of reality	Function: to establish correspondences between different labels (inclusion, opposition, etc.)	Function: to exchange contents about reality (actions, activities).
Comprehensive aspect		
Decode messages that identify objects and situations	Extract information related to: - Opposition/equality - Membership	Decode messages referring to actions that occur in reality.
Expressive aspect		
Speech acts intended to label or describe reality.	Speech acts that include the management of relationships between concepts such as: - Antonymy/synonymy - Polysemy - Inclusion of categories	Speech acts referring to autobiographical information about knowledge and experience.
Category 3. SUBJECTIVE COMPETENCE		
Speech acts referring to the expression of the individuality of the self and the understanding of the subjectivity of others. They do not include objective aspects of reality; only intra- and interpersonal subjective elements: emotions, thoughts or interests.		
Subcategories		
Language linked to action	Language linked to the expression of individuality.	
Function: Statements that accompany actions and lack communicative intent.	Function: Express and understand intrapersonal or interpersonal subjective content.	
Comprehensive aspect		
Absence of response to playful expressions or similar responses from others	Speech acts or behaviors that involve the identification and understanding in other people of: - Physiological states - Desire or rejection - Emotions - Thoughts and beliefs	
Expressive aspect		
Use of humming, rhyming, and repetition during play activities	Personal expressions of the following states: - Physiological states - Desire or rejection - Emotions - Thoughts and beliefs	

(Continued)

TABLE 1 (Continued)

Category 4. FIGURATIVE COMPETENCE		
Speech acts in which language does not represent reality directly. They are used in situations in which meanings are suspended for different purposes. Their use is linked to concrete context, and they have a high socio-cultural component.		
Subcategories		
Representational language	Lies and deceit	Non-literal language
Function: Emissions in which the suspension of meanings is linked to playful activities.	Function: Broadcasts in which meaning is suspended for the purpose of generating false beliefs in a competitor.	Function: Speech acts in which the literal meaning is suspended by causing a situation of divergence between the locution and the illocution of the speech act for aesthetic or humorous purposes, or with the intention of covering up or minimizing a thought or belief.
Comprehensive aspect		
Understanding the use of: - Roles - Fantasy - Representation	Understanding the interlocutor's intentions in situations of: - Error - Instrumental lie - White lie	Understanding of the meaning, sense and intention of the - Metaphor - Hyperbole - Phrases
Expressive aspect		
Role-playing, fantasy and role-playing in play tasks	Lie management with intent to: - Make a profit - Avoiding damage	Use of non-literal statements such as: - Metaphors - Hyperboles - Phrases Other purposes (humorous, aesthetic, etc.)

irony, lies, hyperbole) and that have been validated for the detection of mentalistic difficulties (White et al., 2009). The adaptations of Happé's (1994) Strange Stories were: the inclusion of visual support, to favor the comprehension of the instructions in children of infant age (Aguilar et al., 2014), and the design of questions to assess the comprehension of the story, asking the child to explain what it means.

2.2.3 PHASE 3: Development of the response coding system

The coding system of the responses to the tasks has different levels that allow for the assessment of the degree of acquisition of communicative skills, considering the milestones of pragmatic development and the competencies that underline the correct execution of each task.

For example, to assess the *comprehension of irony*, the evaluator first shows a picture with a scene (Figure 1) to the child with the following statement: "This boy has not picked up his toys. His dad comes into his room and says", "How tidy your room is!" "What does what the daddy said mean?."

The child's response, as shown in Table 2, can have five levels: from no response or utterance of an unrelated response to understanding the sender's intention in an ironic utterance. This breakdown of levels results in ordinary coding on a Likert-type scale. As this system entails difficulty in assigning the utterances issued in the different alternatives, examples of possible responses in each alternative, identified as "type responses," were included in the protocol to facilitate correction.

2.2.4 PHASE 4: PDP-PI structure

As can be seen in Table 3, the PDP-PI was composed of 30 items assessing the use and comprehension of pragmatic skills. Interactional Competence (six items) and Subjective Competence (10 items) are used in all age groups. The Referential Competence, composed of four items, is expected to be used in the two older age groups because the content included requires a cognitive and semantic level above three years of age to solve the tasks (Deák and Maratsos, 1998). The Figurative competence consists of 10 items and its use is foreseen in all age groups, except for two items of greater difficulty that require a meta-representational management typical of ages above 48 months (Recchia et al., 2010).

2.2.5 Analysis of the adequacy of the content

To check the adequacy of the content, an expert judgment test was carried out,[1] using a specific questionnaire to assess the appropriateness of each item in its category and the agreement between their ratings for each of the items. The results show a mean percentage of agreement of 82.64% (range 79.17: 89.58%). The Fleiss Kappa statistic was 0.76 and the Krippendorff Alpha was 0.76 indicating adequate reliability. Therefore, the judges identify the items with the competency they are assessing adequately, so that the content of the items appropriately assesses the competency for which they have been designed.

2.3 Participants

This study involved a sample of 40 students in the second cycle of infant education (see Table 4) attending a public school in the Community of Madrid. The exclusion criterion was to be detected as a special educational need student (developmental delays, difficulties in language development...). The participation of the students was voluntary, and the informed consent of the parents

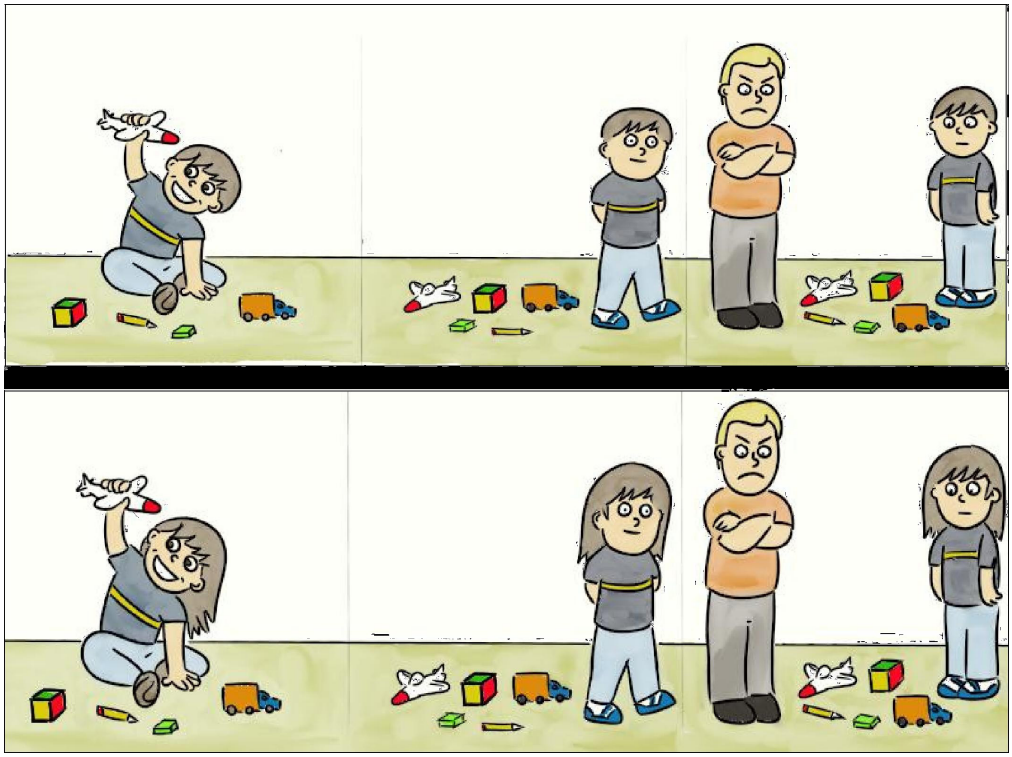

FIGURE 1
Scene to assess the understanding of irony.

TABLE 2 Levels of response and type responses of the task "Understanding Irony."

Competencies involved	Sample responses
Failure to respond or issuance of an unrelated response	No response or not related
Literal understanding of the statement	That it is very well collected
Detection that there is a divergence between what is said and what is implied, interpreting it as an error.	He made a mistake; he said it backward.
Understanding that what is said is the opposite of what is implied without inferring the sender's intention	That she's dirty, she's scolding you
Understanding of the sender's intention in an ironic statement	What do you want me to pick up

was obtained, as well as the approval of the school's management team.

2.4 Method

For the inclusion of the participants in the sample, circulars were sent to the families informing them of the study and requesting the authorization of the parent/guardian for the participation of their children. Also, information sessions were arranged with the management and teaching teams to explain the objective of the research and the evaluation procedure. The students participated in the evaluation during the school day, so that the school calendar and the school's own activities were respected.

All participants were evaluated with the PDP-PI individually, but to favor an ecological assessment and their collaboration, its application was integrated as part of the classroom routine. For this purpose, a corner, called "*play corner*" was set up at one end of the classroom, with a small table, two chairs and the PDP-PI materials (puzzles, puppets, pictures...). School materials were removed from the table so that there were as few distracting elements as possible. Students went to the play corner at the discretion of their tutors. The duration of each evaluation session was 30 minutes.

3 Results

3.1 Analysis of differences between groups

Table 5 shows the results obtained by Duncan's *post-hoc* test (normality and homogeneity of variances were verified) which confirm that, in general, the scores of the three age groups are significantly different from each other: children in group 1 obtain the lowest scores, those in group 2 obtain average scores and those in group 3 obtain the highest scores.

In Interactional, Subjective and Figurative Competences, a significance index for mean differences of less than 0.01 is obtained (Figure 2). Therefore, in these tasks, older children show a better performance in the tasks, characterized by a better appropriateness of the utterances and a better understanding of

TABLE 3 Structure of the PDP-PI.

Competition	Number of items			Age (in months)
	Expression	Comprehension	Total	
Interactional	3	3	6	36–72
Referential	2	2	4	48–72
Subjective	5	5	10	36–72
Figurative	5	5	10	48–72 36–48 (only 8 items)

TABLE 4 Descriptive data of the sample.

Group	Course	Sample	Average age (in months)	Age range (in months)
1	1st EI	17 (10 boys; 7 girls)	43.47	38–49
2	2nd EI	15 (6 boys; 9 girls)	58.89	52–64
3	3rd EI	8 (4 boys; 4 girls)	69.25	64–76
Total		40	54.72	38–76

EI, early childhood education.

TABLE 5 Duncan *post hoc* analysis of group difference (expressive and comprehensive aspects).

	Group	*N*	Media	SD	SEM	F
Interactional Competence						8.6970**
	1	17	1.25	0.255	0.062	
	2	18	1.05	0.25	0.059	
	3	8	1.47	0.198	0.07	
Referential Competence						2.0820
	2	18	0.83	0.409	0.096	
	3	8	1.06	0.21	0.074	
Subjective Competence						11.7560**
	1	17	0.8	0.395	0.096	
	2	18	1.13	0.465	0.11	
	3	8	1.64	0.207	0.073	
Figurative Competence						9.8030**
	1	17	0.45	0.317	0.077	
	2	18	0.8	0.426	0.1	
	3	8	1.13	0.35	0.124	

**Significance level 0.01.

the linguistic situations. In Subjective Competence these differences are especially marked, so that the development of these skills is especially discriminating in the three-six age range. The only competence in which no significant intergroup differences are obtained is Referential Competence (F = 2.0820). It should be remembered that this skill was only evaluated in children aged four and five years, and that it is the one with the fewest items.

3.2 Validity of protocol content

To confirm the content validity of the PDP-PI, the correlations between the competencies were analyzed. The results, shown in Table 6, show significant correlations between all competencies except Interactional and Referential. One possible explanation is that to share an action where referents are present in the communicative situation (and therefore shared by the interlocutors) it is not necessary to explicitly allude to these referents. In general, these results are a good indicator of content validity, since most of the competencies correlate with a bilateral significance level of 0.05, the relationship between Subjective and Figurative being much clearer.

3.3 Descriptive analysis of results

Given the novelty of the items and tasks that make up the protocol, we proceeded to a qualitative analysis, based on the percentage of responses obtained by each age group in the different items; this count would help to better compare and identify the

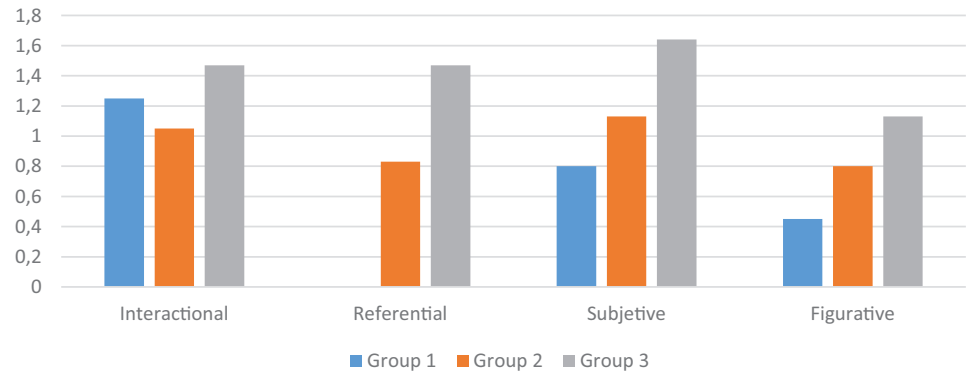

FIGURE 2
Differences between age groups in the assessed competencies.

TABLE 6 Correlation indexes between competencies.

	Interactional	Referential	Subjective
Interactional			
Referential	0.295		
Subjective	0.301*	0.483*	
Figurative	0.309*	0.486*	0.636**

*The correlation is significant at the 0.05 level (bilateral). **The correlation is significant at the 0.01 level (bilateral).

differences in the performance of the three age groups evaluated. The scores are obtained by summing the responses of all the subjects in each group divided by the number of subjects. As for the mean score of each competency, it was extracted from the sum of the global results of all the tasks divided by the number of participants in the sample and the number of tasks that make up each competency. With these weighted averages, the differences between tasks and between groups can be analyzed qualitatively. The most significant results for each of the competencies are presented below.

First, the results obtained on the development of interactional skills (see Table 7) partially support the development of these skills associated with interactive contexts. The score achieved by the participants in group 2 prevents us from establishing a developmental profile, perhaps due to the high level obtained by the youngest age group (three-four years). Nevertheless, it is considered appropriate to continue with the evaluation of the development of more complex interactional skills, such as the expression and comprehension of requests, reformulation, and recovery of conversational turn, between three-six years of age, since significant differences in the management of these skills were observed in the different age groups.

In addition, the qualitative analysis (see Table 8) performed on the comprehension task of *reformulating an utterance in a conversational context* shows that 70.59% of three-year-old participants can emit gestural responses (e.g., picking up a piece after being ignored) while 23.53% emit verbal responses. Therefore, assessing simpler formulas such as repetition (Manfra et al., 2016), would allow detecting early developmental levels of this skill involving verbal but not syntactic reformulation.

TABLE 7 Mean scores obtained by the three groups in interactional competence.

Interactional skills		G1	G2	G3
Care management	C	1.52		
	E	0.88		
Mental-linguistic comprehension	Permission		0.64	1.62
	Attention		0.80	1.62
	Request		1.05	1.25
Requests	C	1.58	1.11	1.38
	E	1.08	1.61	1.81
Reformulation and shift repair	PR	0.88	1	1.12
	RF	1.52	1.41	1.5
Average score		1.25	1.05	1.47

G, group; C, comprehension; E, expression; RF, reformulation; RP, shift repair.

TABLE 8 Results of the item reformulation in Group 1 (three-four years).

Response levels	Counting	Percentage	Cumulative Percentage
1. No response or inadequate response	1	5.88	5.88
2. Nonverbal attempt to repair the shift	7	41.18	47.06
3. Gestual response "picking up piece"	5	29.41	76.06
4. Mitigated rephrasing "give it to me, please"	3	17.65	94.12
5. Protest demonstration, complaint, or reparation of the shift	1	5.88	100.00

Referential competence was the most complicated to define and operationalize. Perhaps because its mastery depends more on the subject's knowledge of reality, and this knowledge derives more from semantic aspects (labels, vocabulary, etc.) and the

TABLE 9 Mean scores obtained by groups 2 (four-five years old) and 3 (five-six years old) in the referential competence.

Referential skills			G 2	G 3
Reference communication	C			1.75
	E			0.93
Categorization	C	Categorical	0.80	1.63
		Unknown element		0.87
	E	Categorical	0.52	0.75
		Infer categories (1)	0.94	1.25
		Infer categories (2)		0.44
		Category Description		0.38
Analogies	C		1.05	1.5
Average score			0.74	1.05

G, group; C, comprehension; E, expression.

development of cognitive processes (cognitive operations to establish relationships such as equality or difference between elements and categories), than from the more purely mentalistic aspects and understanding of the communicative context. Thus, when analyzing the errors committed in the tasks, it was detected that the problem was not due to the lack of skill in the process but rather to the content; in fact, the children explained that they could not answer because they "*did not know the words*." Even so, there were significant differences in favor of the older students in all the skills assessed, which would support the progressive development of these skills (see Table 9).

In Subjective Competence, it was found that children between three and six years of age can communicate, without difficulties, physiological states, primary emotions, and desires (preferences), data congruent with those found by Wellman and Bartsch (1994). Table 10 shows the differences between the three age groups, which are more striking than in the previous competencies, so that this competence seems to be particularly sensitive to development in these years. This may be due to two factors: either these are skills whose development is more abrupt at these ages, or the selection of tasks and levels of response, arranged in the protocol, has been very discriminative.

The results on the expression and understanding of *primary emotions* corroborate that at three-four years of age (70%) children understand the emotional states of other people (Lenti et al., 1999) and that this acquisition would be defined at five-six years of age (producing a ceiling effect); therefore, from five years of age the evaluation should focus on the expression and understanding of *secondary emotions*. It is also evident that the expression and understanding of thoughts and beliefs is more limited at three-four years of age (11.76%), and its development begins around four-five years of age (44.44%) (Bartsch and Wellman, 1995).

In this study, for the *expression "rejection*," it was necessary to generate a scenario that favored the use of alternative formulas to "*no*" in isolation, showing a progressive use of these linguistic formulas between the ages of three-four years (29.41%), four-five years (50%) and five-six years (100%).

TABLE 10 Mean scores obtained by the three groups on subjective competence.

Subjective skills		G1	G2	G3
Physiological states	C	0.94		
	E	0.94		
Primary emotions	C	1.64	1.57	2
	E	1.64	1.54	2
Desires and interests	C	0.61	1.44	1.68
	E	0.73	1.30	1.75
Rejection	C	0.41	0.72	1.06
	E	0.31	1	2
Thoughts and beliefs	C	0.5	1.19	1.56
	E	0.26	1.16	1.82
Secondary emotions	C			1.43
	E			1.37
Average score		0.80	0.96	1.66

G, group; C, comprehension; E, expression.

As for figurative competence, according to the results obtained in this study, the development of figurative use of language is located between five-six years of age (see Table 11). However, it should be noted that some children between three and five years of age respond to these tasks, although their comprehension and use is partial.

Regarding the understanding and use of pseudo-lies, majority of children aged three-four years (75%) do not understand these situations and do not say them either; while those aged five-six years understand them perfectly well (more than 76%) but do not express them (only 12% and not in a complex way). A similar profile appears among the four-five-year olds, although they show a greater mastery than the five-six year olds, an effect that may be due to the influence of the "social desirability" factor, in the sense that older children are more aware of those lies that should not be told, as opposed to the spontaneity of the four-five year olds.

Instrumental lying shows a progressive development (5% at three-four years; 27% at four-five years; and 75% at five-six years). In the older age group, it was found that many participants responded: "*it is wrong to lie*" or "*lying is wrong*." In other words, although they understood the context and the objective of the task, they did not complete it because of the negative social burden associated with the use of lying. And with respect to the pious lie, the most striking result is that, although most of the five-six-year-old participants (75%) do not solve the task, 25% understand the intentionality of this type of lie and affirm that "they are capable of lying in order not to hurt someone."

Considering the results obtained, it can be said that the development of metaphorical language begins at an early age (almost 50% of the participants aged three and four years understand a metaphorical expression) and whose progress will be continuous at later ages, beyond the age of six years. The

TABLE 11 Mean scores obtained by the three groups in figurative competence.

Subjective skills		G1	G2	G3
Simulation	C	0.82	0.88	
	E	0.41	1.28	
Pseudo-lie	C	0.23	1.22	1.37
	E	0.14	0.66	0.56
Lie	C	0.11	0.69	1.5
	E	0.23	0.72	1
Metaphor	C	0.67	0.69	1.06
	E	0.79	1.16	1.5
Irony	C	0.64	1.08	1.72
	E	0.38	0.61	1.18
Phrases made	C		0.44	1
	E		0.22	0.75
Hyperbole	C			1.37
	E			1.12
White lie	C			0.62
	E			0.75
Average score		0.44	0.80	1.13

G, group; C, comprehension; E, expression. [1]The participants were: a graduate in Hispanic Philology, an expert in teaching Spanish as a foreign language, a psychologist and educational counselor, and a speech therapist specializing in language disorders.

age of inflection would be between four and five years of age, and by the age of six years most children (75%) show adequate mastery of this communicative use. The fact that children between three and six years of age seem to be more competent in making metaphors than in understanding them could be explained by the fact that in this period the verbal explanation of concepts resorts to analogy, so that these verbalizations adopt a form of simile, a pseudometaphor.

Regarding irony, the beginning of this figurative value of language appears around the age of four, but it becomes evident from the age of five-six: 100% of these children understand, and more than 75% are able to use language in an ironic sense, although with varying degrees of complexity.

Finally, within the figurative uses of language, it was found that the comprehension and expression of idioms undergoes a clear evolution between four and six years of age: 75% of children aged four -five years do not understand idioms and only 12% can make a sentence of this type. It is from the age of five-six that the development of this competence begins (more than 50% of children understand idioms and express at least one idiom).

4 Discussion

The present work is framed within the study of the development of pragmatic competence from a perspective in which the ability to tune in to the other person, read his or her mind and detect his or her interests are fundamental to explaining the adequacy of language to the communicative context.

4.1 Contributions

The main objective was to develop an instrument to assess the development of pragmatic competence in children between three and six years of age. For this purpose, an adaptation and adaptation of the taxonomies of communicative functions has been carried out in order to identify both the progressive acquisition of a competence and the mastery or difficulty in one or more specific skills.

The PDP-PI can contribute to complete the assessments in the pragmatic area by providing a different perspective and assessment methodology compared to other existing instruments such as the *Children's Communication Checklist* (CCC-2) by Bishop (2003), the PEP-L (Romero et al., 2014), the *ABaCO* (Angeleri et al., 2012), or the *Pragmatic Observational Measure* (POM) (Cordier et al., 2014) that resort to information collection techniques such as direct observation or interviews with caregivers (parents and teachers). In this sense, the PDP-PI is integrated by performance tasks that favor the creation of natural contexts from the provision of *interaction formats* -games and/or narration of pictures or stories- as they avoid the negative effect of evaluation in favor of a comfortable context for children (Acosta et al., 1996; Botana and Peralbo, 2023).

Another of the main limitations of most pragmatic competence assessment instruments is that they only assess the expressive aspect. The lack of research on the comprehension of language uses represents a basic problem for traditional assessment in the elaboration of a complete developmental profile. However, this information is key in both the diagnosis and intervention of communicative-linguistic disorders. For this reason, the PDP-PI includes tasks to assess comprehension of utterances and contexts.

The last of the key elements of the PDP-PI is the response coding system that attempts to overcome dichotomous coding (presence/absence, appropriate/inappropriate) by favoring the determination of a more sensitive and exhaustive baseline.

The preliminary results obtained with the PDP-PI are congruent with the development of skills related to Communicative Functions (Nuñez and Riviere, 1994; Lee and Rescorla, 2002; Pascual et al., 2008; Airenti and Angeleri, 2011; Manfra et al., 2016). This implies that the type of tasks and the scoring method designed are relevant in the assessment of the pragmatic component of language. It is corroborated that the acquisition of Interactional Competence is circumscribed in this period and can serve as a reference for the detection of difficulties. The development of Referential Competence would be linked to the development of cognitive processes of interest for the detection of semantic-pragmatic difficulties. And the deployment of the Subjective function becomes evident from the age of 4 years, continuing from the age of 5 years, in parallel to the development of mentalistic skills, an age at which signs of figurative use of language are already detected.

A high correlation has been found between the four competencies assessed (Olivar et al., 2004), except for the Interactional and Referential Competencies. There are two possible explanations for these data: the marked pragmatic-semantic character underlying the nature of referential competence, which necessarily implies that the processing of linguistic and conceptual content can generate gaps; or that the reduction of skills that make up this competence in the PDP-PI, in favor of guaranteeing more

pragmatic rather than mathematical functions, has affected the internal validity of this competence.

The correlation of Subjective competence with the rest of the competences is positive in all cases, highlighting the high correlation with Figurative competence. The data are consistent with research defending the high relationship between the use of mentalistic verbs and the resolution of theory of mind tasks (Lohmann and Tomasello, 2003) and the understanding of secondary emotions (Villanueva Badenes et al., 2000). The high correlation found between the Subjective and Figurative competencies refers to the delimitation of the pragmatic component of language and its close relationship with mentalistic skills.

4.2 Limitations and foresight

This research is not without limitations. The results obtained are not directly extrapolated due to the size and diversity of the sample. It would be necessary to use the PDP-PI with sufficiently large samples to address specific age profiles and to have robust data on the validity and reliability of the instrument.

A larger study with a more homogeneous population is also required to perform a factor analysis to determine the variance of each competency explained by each of the tasks, so that adjustments can be made to the design of the instrument.

Likewise, it would be interesting to check the existence of correlations with other pragmatic assessment instruments such as the CCC-2 in its adaptation to Spanish (Crespo-Eguílaz et al., 2016). This type of comparison is frequent in the validation of new instruments and provides data on their adequate design. For example, for the validation of the EDPRA (Botana and Peralbo, 2015), correlation with the Pragmatic Profile (Dewart and Summers, 1995) was used as an indicator of validity and reliability.

It would also be convenient to review the operationalization of the Referential Competence in the different age groups or if a more interactive format for assessing this competence can be considered. This would imply the reformulation of the tasks included in this competency and their comparison with other tests that include the assessment of semantics, to determine the coherence of referential tasks that involve an assessment focused on processes instead of contents.

In view of the results, a larger sample would allow preliminary scales of the development of subjective and figurative skills between the ages of 3 and 6 years; scales that would serve to check if there are differences in the developmental profiles of people with ASD (Autistic Spectrum Disorder), SLD (Developmental Language Disorder) or SCD (Social Communication Disorder).

5 Conclusion

The results obtained after the application of the PDP-PI are encouraging with respect to its validity and its use in educational or speech therapy centers, as well as its replication in the field of research on language pragmatics.

Although the reliability and validity data of the protocol are preliminary, they are sufficiently significant to consider the PDP-PI as a valid alternative in the assessment of the development of pragmatic competence in early childhood. The results obtained represent a change in the conception of the assessment of communicative competence. What is essential is not to identify which functions appear, but rather the degree of development that children demonstrate. This protocol provides a first initial evolutionary pattern of the development of Interactional, Referential, Subjective and Figurative competencies between three and 6 years of age, and not only in terms of language use but also in terms of comprehension of language functions.

Therefore, the Protocol for the Assessment of Pragmatic Competence in Early Childhood is not closed but is emerging as an active line of research in which data are still being collected and adjustments are being made.

Thus, the assessment of pragmatic skills in schools through the PDP-PI could be applied with three objectives: a preventive assessment, detection of students with suspected pragmatic difficulties, an optimizing assessment aimed at promoting or improving the pragmatic skills of students in general, and a diagnostic assessment in students with disorders or delays in the development of communication and language.

Data availability statement

The original contributions presented in this study are included in this article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Management team of Primary School and Council of Science and Education. 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

CJ: Data curation, Formal analysis, Writing – original draft. BZ: Conceptualization, Methodology, Supervision, Validation, Writing – review and 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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Narrative microstructure and macrostructure in adolescents with Down syndrome and Williams syndrome

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Down syndrome (DS) and Williams syndrome (WS) are genetic neurodevelopmental disorders associated with intellectual disability, showing contrasting linguistic profiles with asymmetries in grammatical (DS weakness/WS strength) vs. pragmatic abilities (DS strength/WS weakness). The aim of the present study was to explore the linguistic profiles of 14 adolescents with DS and WS, and 14 typically developing controls (matched by chronological and verbal age) by comparing the microstructure and macrostructure of narratives and their possible dissociation. Participants watched an episode of the Tom and Jerry cartoon series and were asked to retell it. The videotaped narratives were transcribed and analyzed with the tools of the CHILDES Project and the Pragmatic Evaluation Protocol for Corpora (PREP-CORP). Microstructure was assessed by productivity at the grammatical level (number of utterances) and lexical level (number of word tokens), and complexity at the grammatical level (MLU) and lexical level (number of word types). Macrostructure was assessed by the number of story elements recalled at three levels: scenarios (global), episodes (integrated), and events (detailed). Results confirmed asymmetries in the linguistic profiles of both groups, with relative strengths of adolescents with DS in macrostructure despite relative weaknesses in microstructure. Conversely, adolescents with WS exhibited strengths in narrative microstructure, but failed to show better performance than the DS group in macrostructure. Following regression analyses, microstructure predicted macrostructure in typically developing adolescents, while no association was found between both levels in the profiles of adolescents with WS and DS, which was interpreted as an atypical dissociation.

KEYWORDS

Down syndrome, Williams syndrome, intellectual disabilities, genetic syndromes, atypical language profiles, pragmatic assessment, narrative microstructure and macrostructure

1 Introduction

Down syndrome (DS) and Williams syndrome (WS) are genetic neurodevelopmental disorders that cause intellectual disability and have distinct behavioral phenotypes (Antonarakis et al., 2020; Kozel et al., 2021). Regarding their linguistic profiles, specific opposing strengths and weaknesses have been described: grammatical weakness vs. pragmatic strength in DS, and grammatical strength vs. pragmatic weakness in WS (Abbeduto et al., 2016).

Several studies have confirmed special difficulties in expressive language in DS, particularly in syntactic complexity (Abbeduto et al., 2003; Chapman, 2003; Chapman et al., 1998; Chapman and Hesketh, 2000; Diez-Itza and Miranda, 2007; Fowler, 1990; Miller, 1999; Roberts et al., 2007; Vicari et al., 2000). In turn, WS has been characterized by a special grammatical

strength (Bellugi et al., 1988, 2000; Brock, 2007; Mervis, 2006; Mervis et al., 2003), although it was overestimated by comparisons with DS; a number of studies point out that this strength is relative and not necessarily obvious when compared to mental age or chronological age matched controls (Diez-Itza et al., 2017; Diez-Itza et al., 2019; Joffe and Varlokosta, 2007; Stojanovik et al., 2004).

The study of narrative competence in both syndromes is one of the main sources of evidence about relative strengths and weaknesses at grammatical and pragmatic levels. The analysis of narratives has been conducted in modern studies through the assessment of microstructure (i.e., grammatical and lexical productivity and complexity) and macrostructure (i.e., episodic structure, characters, story grammar) and the relative strengths and weaknesses at each level. The results of these studies have been interpreted in terms of possible dissociations, asymmetries and asynchronies in the linguistic profiles of the syndromes which have been an important source for the comprehension of neurodevelopmental disorders (Karmiloff-Smith, 1998; Thomas et al., 2009).

Pioneering studies of children and adolescents with DS focused on syntactic and lexical production in narrative microstructure, observing fewer utterances and lower mean length of utterance (MLU) and lexical diversity than typically developing (TD) controls matched by mental, syntactic and lexical age (Chapman et al., 1990; Hesketh and Chapman, 1998).

Subsequent analyses of narrative macrostructure found that DS narratives were longer and structurally more complex than those of their MLU-matched TD controls (Boudreau and Chapman, 2000); such relative strength in macrostructure was further confirmed by Miles and Chapman (2002) who found that children and adolescents with DS outperformed their MLU-matched TD controls when narrating the main plot, the story outline, and the adventures of the characters. However, Kay-Raining Bird et al. (2008) found that children with DS matched by reading skills with TD controls produced longer narratives, but with similar linguistic complexity and episodic structure.

More recently, Channell et al. (2015) confirmed relative strengths in the macrostructure as children and adolescents with DS narrated the story structure at the level of non-verbal mental age TD controls, despite a general impairment in expressive grammar and a specific deficit in the production of verbs. Based on the retelling of a picture story book, Zanchi et al. (2021) also found that children and adolescents with DS produced stories comparable to those of TD children at both the macrostructural and microstructural levels, except for syntactic complexity. Conversely, Martzoukou et al. (2020) explored narrative skills in adults with DS, who presented relative weaknesses in lexical diversity and grammatical complexity but they also produced less content related to the story structure than their TD controls matched by expressive vocabulary; in the same vein, Mattiauda et al. (2022) also reported that adults with DS scored below their vocabulary matched TD controls on measures of story structure and story comprehension, as well as lexical diversity.

Research on narrative competence in WS has included in some cases DS control groups. That was the case in the first study by Reilly et al. (1990), who observed greater coherence and narrative complexity in the narratives of adolescents with WS than in DS controls. Losh et al. (2000) found a higher proportion of morphological errors and lower syntactic complexity in children with WS than in chronological age and gender-matched TD controls. In a longitudinal study, Reilly et al. (2004) observed that children with WS acquired the morphology and syntax of English at the same rate and level as controls with a diagnosis of Specific Language Impairment (SLI). However, when comparing the groups on narrative measures, children in the WS group were consistently delayed in aspects which tap cognitive skills such as making inferences about characters' relationships and motivations throughout the story and integrating the local episodic elements with the more global theme of the story. From these "divergent profiles" they concluded that language develops independently of other cognitive abilities in both groups, and that in the WS group structural language is a relative strength contrasting with a weakness in the integration and inferencing in the narratives linked to their lower IQ.

Studies in languages other than English confirm atypical characteristics in WS, with specific strengths in grammatical skills, but weaknesses in structural coherence and complexity of the narrative process, suggesting asymmetries and dissociations between microstructure and macrostructure (Antón et al., 2007; Diez-Itza and Miranda, 2005; Diez-Itza et al., 2016, 2018; Garayzábal et al., 2007; Gonçalves et al., 2004, 2010; Lacroix et al., 2007; Marini et al., 2010; Perovic et al., 2024; Reilly et al., 2005; Shiro et al., 2019).

Studies of narrative competence used different procedures for eliciting narratives and analyzing the components of microstructure and macrostructure: the more widespread is a procedure based on the wordless picture book "Frog, where are you?" by Mayer (1969) usually named "The Frog Story" (Channell et al., 2015; Garayzábal et al., 2007; Gonçalves et al., 2004, 2010; Kay-Raining Bird et al., 2008; Lacroix et al., 2007; Losh et al., 2000; Reilly et al., 1990, 2004, 2005; Miles and Chapman, 2002); the elicitation of personal narratives and the description of pictures or photographs (Chapman et al., 1990; Diez-Itza and Miranda, 2005; Hesketh and Chapman, 1998; Marini et al., 2010; Zanchi and Zampini, 2021); the retelling of oral narratives using the *Multilingual Assessment Instrument for Narratives* (Martzoukou et al., 2020); or the retelling of a wordless film (Antón et al., 2007; Boudreau and Chapman, 2000; Diez-Itza et al., 2016), which is the method used in the present study, where the narrative structure is not given verbally to the subjects, and therefore it may better replicate the cognitive task of constructing a mental model of the story involved in narrative competence (Bruner, 1991; Stein and Glenn, 1982).

In the context of the SYNDROLING Project (Diez-Itza et al., 2014), a procedure developed by Diez-Itza et al. (2001) based on the retelling of a wordless film, namely an episode of the Tom and Jerry cartoon series, was used to elicit the narratives; in addition, a Pragmatic Evaluation Protocol for Corpora was developed (PREP-CORP; Fernández-Urquiza et al., 2017) as a tool for tagging pragmatics in speech corpora based on a previous clinical protocol (PREP; Gallardo-Paúls, 2009). The original PREP and the PREP-CORP include three levels of pragmatic analysis (enunciative, textual and interactive); the present study focuses on textual pragmatic items to analyze the macrostructure of the narratives based on the sequence of events considered at three levels: single events (complex/detailed), events grouped in episodes (intermediate/integrated), and events taking place in scenarios (basic/global) (Diez-Itza et al., 2018; Shiro et al., 2019).

We use these procedures in the present study to address the research question of the existence of possible asymmetries and dissociations in the narrative profiles of individuals with neurodevelopmental disorders. The objective then is to explore the

narrative profiles in adolescents with DS and WS, based on the analyses of the microstructure (productivity and complexity) and the macrostructure (levels of organization). The literature has pointed out that linguistic profiles of both syndromes are uneven, so the first hypothesis is that the profiles will present asymmetries in the form of strengths and weaknesses; it has also been discussed if microstructure and macrostructure could be dissociated, so a second hypothesis would be that, if the profiles are uneven, this will yield a dissociation between microstructure and macrostructure.

2 Method

2.1 Participants

The study included 28 participants divided into four groups of 7 Spanish-speaking participants each (3 males/4 females): a group of adolescents with DS; a TD control group matched to the DS group by verbal age (MLU); a group of adolescents with WS; and a TD control group matched to the WS group by chronological age. MLU was calculated based on the number of words per utterance in the narratives. The participants were selected from a larger group within the SYNDROLING Project (Diez-Itza et al., 2014) and had been diagnosed by the genetic services of the Central University Hospital of Asturias (HUCA). All of them or their legal tutors signed an informed consent. Table 1 shows the chronological and verbal age of the participants.

2.2 Procedure

Narratives were elicited from each participant after viewing an episode of the "Tom & Jerry" cartoon series (*The Puppy Tale*). They were instructed to retell the cartoon to the researcher while being videotaped. Narrative corpora were transcribed and analyzed with the tools of The CHILDES Project (CLAN programs) (MacWhinney, 2000) and the PREP-CORP Protocol (Fernández-Urquiza et al., 2017). Coding was conducted independently by two researchers, and both analyzed the entire sample, while conflicting cases were solved by a third researcher to reach 100% agreement. They used as "gold standard" a coding scheme which analyzes the macrostructure at three levels: (i) scenarios: basic or global level, corresponding to the locations or spaces in which the initiating event, complication, high point, and resolution of the story took place; (ii) Episodes: intermediate or integrated level, corresponding to sets of actions whose sequencing constitute the plot of the story; (iii) Events: complex or detailed level, corresponding to the sequence of single actions making up the story (see Diez-Itza et al., 2018, pp. 7–8).

TABLE 1 Chronological and verbal age of the participants.

	DS Mean (SD) Range	WS Mean (SD) Range	TD-CA Mean (SD) Range	TD-VA Mean (SD) Range
CA	17.03 (1.42) 15.58–19.83	21.32 (2.97) 18.08–26.10	21.25 (3.21) 18.32–26.60	3.58 (0.36) 3.08–4.08
VA (MLU)	4.88 (1.32) 2.71–6.76	8.28 (2.44) 4.94–13.03	11.34 (1.52) 9.16–13.11	4.91 (1.32) 3.28–6.64

CA, chronological age; VA, verbal age; MLU, mean length of utterances; DS, Down syndrome; WS, Williams syndrome; TD-CA, chronological-age-matched control group; TD-VA, verbal-age-matched control group; SD., standard deviation.

2.3 Data analyses

The microstructure of the narratives was analyzed based on the following variables: productivity (grammatical: number of utterances; lexical: number of word tokens) and complexity (grammatical: MLU; lexical: number of word types). The macrostructure variables of the study were: global level (4 scenarios), integrated level (10 episodes), and detailed level (25 events).

Shapiro–Wilk and Levene tests were used to confirm statistical normality and homoscedasticity. To assess group differences, one-way ANOVAs and HSD Tukey *post hoc* tests were conducted. Effect sizes (*d* Cohen and *r*) were calculated following Lenhard and Lenhard (2022). Furthermore, linear and logarithmic regression analyses were performed to assess relationships between microstructure and macrostructure.

3 Results

Table 2 reports means and standard deviations of microstructure (utterances, tokens, MLU, and types) and macrostructure (scenarios, episodes, and events) variables, as well as the results of the one-factor ANOVAs performed to assess differences between groups. Differences were found in all the variables both at the microstructure and macrostructure, with large effect sizes.

Table 3 shows mean differences between groups and the results of the post-hoc Tukey's HSD test. Statistical differences between the syndromic groups corresponded to lower grammatical (MLU) and lexical (word types) complexity in DS group, but no differences were further observed in grammatical (utterances) and lexical (word tokens) productivity and in the macrostructure variables.

Adolescents with DS did not differ from their verbal-age controls in the microstructure, but they did recall a greater number of scenarios at the global level of the macrostructure. Compared to chronological-age controls, they showed lower lexical productivity (word tokens) and lower grammatical (MLU) and lexical complexity (word types) in the microstructure, as well as lower recall at the levels of episodes and events in the macrostructure.

The adolescents with WS showed greater productivity and complexity in the microstructure, and greater recall of all levels of the macrostructure than the children in the VA-TD group, but they exhibited lower grammatical complexity (MLU) in microstructure and lower recall of the detailed level (events) in macrostructure than their CA-TD controls. The children in the VA-TD group had lower values in all variables than the adolescents in the CA-TD group, except for number of utterances (see Table 3).

To analyze the relationships between microstructure and macrostructure, simple regression analyses were conducted, taking microstructure variables (utterances, tokens, MLU and types) as independent variables. In the CA-TD group and, to a lesser extent, in the VA-TD group, model adjustments to curvilinear (logarithmic) regression models were observed. Conversely, in the groups of adolescents with DS and with WS, regression models failed to predict macrostructure from microstructure variables (see Table 4).

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TABLE 2 Comparisons of means (ANOVAs) and effect size for microstructure and macrostructure variables.

		DS-G Mean (SD)	VA-G Mean (SD)	WS-G Mean (SD)	CA-G Mean (SD)	*F*	*p*	*d*	*r*
Microstructure	UTT	29.1 (10.1)	16.3 (5)	32.4 (10.1)	26.4 (9.5)	4.291	0.015	1.196	0.513
	TOK	140.6 (53.9)	80.1 (27.3)	259.6 (86.9)	302.1 (123.8)	11.197	0.000	1.932	0.694
	MLU	4.9 (1.3)	4.9 (1.3)	8.3 (2.4)	11.3 (1.5)	22.970	0.000	2.767	0.810
	TYP	64.7 (24.8)	44 (12.8)	103.7 (26.3)	124.6 (34.3)	14.119	0.000	2.169	0.735
Macrostructure	SCN	3.4 (0.5)	2.1 (0.9)	3.6 (0.5)	3.7 (0.5)	9.059	0.000	1.738	0.655
	EPS	5.6 (1.4)	3.3 (1.3)	7 (2.2)	8.9 (1.7)	13.660	0.000	2.134	0.729
	EVT	8.4 (2.2)	4.4 (1.3)	10.7 (4)	16.6 (4.9)	15.408	0.000	2.266	0.749

G, group; DS, Down syndrome; WS, Williams syndrome; CA, chronological age; VA, verbal age; SD, standard deviation; *d*, Cohen's *d*; UTT, number of utterances; TOK, number of tokens; MLU, mean length of utterances; TYP, number of types; SCN, scenarios; EPS, episodes; EVT, events.

TABLE 3 *Post-hoc* analysis (HSD Tukey) of mean differences in microstructure and macrostructure.

		DS – WS (*d*)	DS – VA (*d*)	DS – CA (*d*)	WS – VA (*d*)	WS – CA (*d*)	CA – VA (*d*)
Microstructure	UTT	−3.3 (0.33)	12.9 (1.62)	2.7 (0.28)	16.1* (2.04)	6 (0.61)	10.1 (1.34)
	TOK	−119 (1.65)	60.4 (1.42)	−161.6** (1.69)	179.4** (2.79)	−42.6 (0.75)	222*** (2.48)
	MLU	−3.4** (1.73)	0 (0)	−6.5*** (4.54)	3.4** (1.72)	−3.1* (1.51)	6.4*** (4.52)
	TYP	−3.9* (1.53)	20.7 (1.05)	−59.9*** (1.99)	59.7*** (2.89)	−20.9 (0.68)	80.6*** (3.11)
Microstructure	SCN	−0.1 (0.27)	1.3** (1.74)	−0.3 (0.56)	1.4** (1.93)	−0.1 (0.28)	1.6*** (2.17)
	EPS	−1.4 (0.77)	2.3 (1.72)	−3.3** (2.13)	3.7** (2.05)	−1.9 (0.94)	5.6*** (3.77)
	EVT	−2.3 (0.71)	4 (2.21)	−8.1*** (2.13)	6.3* (2.12)	−5.9* (1.31)	12.1*** (3.37)

DS, Down syndrome; WS, Williams syndrome; CA, chronological age; VA, verbal age; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; UTT, number of utterances; TOK, number of tokens; MLU, mean length of utterances; TYP, number of types; SCN, scenarios; EPS, episodes; EVT, events; *d*, Cohen's *d*, effect size.

TABLE 4 Logarithmic regression model for CA-TD controls.

IV	DV	R^2	*F*	*p*	Ct	b1
UTT	SCN	0.791	18.913	0.007*	0.179	1.101
	EPS	0.754	15.319	0.011*	−3.001	3.691
	EVT	0.918	55.712	0.001*	−21.892	11.974
TOK	SCN	0.620	8.173	0.035*	−1.203	0.873
	EPS	0.648	9.186	0.029*	−8.399	3.063
	EVT	0.847	27.645	0.003*	−41.449	10.299
MLU	SCN	0.001	0.003	0.956	3.937	−0.092
	EPS	0.008	0.040	0.849	6.228	1.086
	EVT	0.041	0.212	0.665	−0.930	7.230
TYP	SCN	0.728	13.352	0.015*	−3.086	1.420
	EPS	0.701	11.696	0.019*	−14.066	4.786
	EVT	0.802	20.268	0.006*	−55.546	15.057

IV, independent variable; DV, dependent variable; Ct, constant; SCN, scenarios; EPS, episodes; EVT, events; UTT, number of utterances; TOK, number of tokens; MLU, mean length of utterances; TYP, number of types; * $p < 0.05$.

Table 4 shows adjustments to curvilinear (logarithmic) regression models in the group of CA-TD controls. Microstructure variables, except for grammatical complexity (MLU), explain high proportions of the variances observed at all macrostructure levels. In the case of VA-TD controls, adjustments to logarithmic regression models were only observed in grammatical (utterances) and lexical (word tokens) productivity: number of utterances predicted recall of scenarios ($R^2 = 0.595$, $F = 7.342$, $p = 0.042$, Ct = −2.767, b1 = 1.795) and of episodes ($R^2 = 0.777$, $F = 17.395$, $p = 0.009$, Ct = −4.531, b1 = 2.857); while number of word tokens predicted recall of events ($R^2 = 0.603$, $F = 7.585$, $p = 0.040$, Ct = −3.663, b1 = 1.884).

4 Discussion

The aim of the present study was to explore the narrative competence of adolescents with Down syndrome (DS) and William syndrome (WS), comparing them with two groups of typically developing (TD) participants matched by verbal and chronological age. We analyzed the microstructure (productivity: number of utterances and word tokens; complexity: MLU and number of word types) and the macrostructure (scenarios, episodes, and events) of narratives elicited from the retelling of a cartoon episode, using the tools of the CHILDES Project (MacWhinney, 2000) and the PREP-CORP Protocol (Fernández-Urquiza et al., 2017). Furthermore, possible dissociations between microstructure and macrostructure were explored through regression analyses.

All participants in the study were able to narrate the story, and accordingly whole measurements of productivity and complexity of the microstructure and of macrostructure levels were obtained. Thus, the narrative analysis methodology proved to be feasible for the naturalistic assessment of pragmatic competence in neurodevelopmental disorders (Barokova and Tager-Flusberg, 2018). Specifically, the PREP-CORP Protocol (Fernández-Urquiza et al., 2017) provided a practical coding

system at the level of textual pragmatics as previous studies had revealed (Diez-Itza et al., 2018; Shiro et al., 2019).

4.1 Narrative microstructure

The length of the narratives (number of utterances) of the adolescents with DS and WS was comparable to that of their CA-TD controls, indicating special strengths in grammatical productivity (i.e., utterances) of the microstructure in both syndromes. No differences were found in lexical productivity (i.e., word tokens) between the syndromic groups, although special strength might only be attributed to the WS group since the adolescents with DS produced fewer word tokens than their TD peers.

In the WS group, the strengths observed in grammatical and lexical productivity were as expected since WS has been characterized by its especially preserved language (Bellugi et al., 1988, 2000; Brock, 2007; Mervis et al., 2003). Conversely, strength in grammatical productivity was not expected in the DS group, since verbal production has been described as an area of relative weakness in this syndrome when considering non-verbal cognitive level (Abbeduto et al., 2003; Chapman et al., 1998; Chapman and Hesketh, 2000; Vicari et al., 2000). Specifically, the narratives produced by adolescents with DS were found to be shorter than those of Fragile X syndrome (FXS) and TD controls matched by mental and lexical age (Channell et al., 2015; Chapman et al., 1990; Kover et al., 2012). However, different studies have found relative strengths in the grammatical productivity of individuals with DS. Chapman et al. (1998) observed a greater production of utterances but a lower MLU in the narratives of children and adolescents with DS when compared to TD controls matched by non-verbal mental age; Kay-Raining Bird et al. (2008) also found longer narratives in adolescents with DS than in TD children matched by reading level even though controls had better lexical comprehension. Enhanced production of shorter utterances in narratives of adolescents with DS could be explained by their fair understanding of the story schema while lacking enough linguistic competence to narrate the plot in a more elaborated way. In the same vein, Del Hoyo Soriano et al. (2020) observed a longitudinal increase in talkativeness and a decrease in grammatical complexity (i.e., MLU) and lexical complexity (i.e., word types) in adolescents with DS and FXS.

Those findings are consistent with the results of the present study showing lower grammatical and lexical complexity in the DS group than in the WS group, suggesting that it is in complexity rather than in productivity where lies the particular weakness in expressive language displayed by individuals with DS (Chapman, 2003; Chapman and Hesketh, 2000; Diez-Itza and Miranda, 2007; Fowler, 1990; Miller, 1999). Their development of grammatical complexity is seriously limited by the tendency to omit grammatical morphemes (Chapman et al., 2002; Diez-Itza and Miranda, 2007; Fowler et al., 1994). Expressive language is usually below receptive language and what would be expected for non-verbal mental age (Diez-Itza et al., 2019; Laws and Bishop, 2003; Martin et al., 2013). Some studies indicate that weakness is more pronounced in syntax than in vocabulary, but others based on the analysis of narratives did not observe more weakness in grammatical complexity than in lexical complexity, in line with the results of the present study (Chapman et al., 1990, 1998; Finestack and Abbeduto, 2010; Keller-Bell and Abbeduto, 2007; Martzoukou et al., 2020).

The narratives of the WS adolescents presented shorter utterances than those of their CA-TD controls, thus grammatical complexity (MLU) was the only variable in the microstructure that showed relative weakness, which contrast with the special strength observed in lexical complexity (types). These results are consistent with previous studies that opposed the hypothesis of grammar preservation in WS, as discussed in Diez-Itza et al. (2017, 2019). Conversely, the observed lexical strength is consistent with the specific profiles of WS described in many studies that emphasize the breadth of their vocabulary, especially of concrete words (Abbeduto et al., 2016; Bellugi et al., 1990, 2000; Kozel et al., 2021; Mervis and Becerra, 2007; Mervis and John, 2008).

Overall, the analysis of narrative microstructure revealed that the syndromic linguistic profiles are not homogeneous: in DS, the strength in grammatical productivity (i.e., utterances) did not correspond to greater length (MLU) and lexical diversity (types) of utterances; in WS, grammatical complexity (i.e., MLU) was lower than expected considering grammatical productivity (i.e., utterances) and lexical complexity (i.e., types). The narrative profiles of both syndromes would present specific asymmetries different from typical development, and thus suggesting asynchronous developmental trajectories (Levy and Eilam, 2013; Karmiloff-Smith, 2007).

The observed asymmetries also shed light on the debate about estimating verbal age from expressive syntax (MLU) and lexical comprehension (Channell et al., 2015; Miles et al., 2006). The MLU-based verbal age matching used in many studies may underestimate grammatical (utterances) and lexical (tokens) productivity of adolescents with DS and WS, and lexical complexity (types) in the latter (Miles et al., 2006; Thordardottir et al., 2002). On the other hand, vocabulary test scores would provide a better estimate of verbal age (Diez-Itza et al., 2019). In any case, the results of the present study highlight the need to assess narrative production using different measures and from naturalistic language samples (Abbeduto et al., 2020; Adams, 2002; Barokova and Tager-Flusberg, 2018).

4.2 Narrative macrostructure

Adolescents in the syndromic groups did not differ at any level of the narrative macrostructure: global (scenarios), integrated (episodes), and detailed (events), suggesting relative pragmatic strength in the adolescents with DS, despite their grammatical and lexical difficulties. They also outperformed the VA-TD controls at the global level of macrostructure, i.e., retelling as the CA-TD controls most of the scenarios of the story, which also underscored such strengths in DS and is consistent with previous studies (Boudreau and Chapman, 2000; Channell et al., 2015; Finestack et al., 2012; Hogan-Brown et al., 2013; Kay-Raining Bird et al., 2008; Miles and Chapman, 2002). However, the same strengths are not present at the integrated (episodes) and detailed (events) levels, which also suggests macrostructure asymmetries in the DS narrative profile.

In contrast to their strengths in microstructure, adolescents with WS displayed relative weakness at the detailed level of macrostructure (recall of events), which is consistent with most previous studies on narrative competence reporting weaknesses in story structure (Garayzábal et al., 2007; Gonçalves et al., 2010; Lacroix et al., 2007; Marini et al., 2010; Reilly et al., 2004); but it is not consistent with the results of our previous research, indicating relative strength in the

detailed level of events (Diez-Itza et al., 2002, 2006), which could be explained by the use of a different story ("Frog goes to dinner" film) and inclusion of both children and adult participants with WS in those studies. However, adolescents with WS in the present study exhibited particular strengths at the integrated (recall of episodes) and global (recall of scenarios) levels, revealing again asymmetries in the macrostructure. In this regard, atypical language profiles and nonlinear trajectories of relative strengths and weaknesses that may change with age have been observed in WS (Diez-Itza et al., 2017, 2019; Pérez et al., 2022).

Relative weakness of adolescents with WS when narrating story details would not correspond with their tendency to local processing in visuospatial construction tasks (Bihrle et al., 1989; Diez-Itza et al., 2016; Mervis, 2006). In children with WS, alterations have also been observed in visual perception of motion stimuli and in spatial localization memory (Atkinson et al., 1997; Nakamura et al., 2001), which are similar to those exhibited by individuals with Autistic Spectrum Disorder (ASD) in dynamic spatial processing tasks (Bertone et al., 2005; Milne et al., 2002). In contrast to WS and ASD, individuals with DS show global processing strengths in visuospatial construction tasks and, therefore, the adolescents with DS in the present study may have benefited from the visual support implicit in the elicitation method based on the recall of a cartoon (Bertone et al., 2005; Miles et al., 2006).

The asymmetries and differences found in the macrostructure could also be related to the ability to understand and construct a "mental model" of the story and to organize events sequentially and causally (Bruner, 1991; Diez-Itza et al., 2016; Garnham et al., 1982; Stein, 1982), that might be affected in different ways by the intellectual disability of the adolescents in the syndromic groups. Reilly et al. (2004) attributed the weakness in narrative structure of children with WS to their cognitive impairment, even though they showed better linguistic performance than their SLI controls. The cognitive processing profile in WS has been associated with that observed in ASD, including dissociations between structural and figurative language linked to weak central coherence, and alterations in the organization and causal coherence of narratives that have been reported in both neurodevelopmental disorders (Capps et al., 2000; Happé and Frith, 2006; Norbury et al., 2014; Gillam et al., 2015; Vulchanova et al., 2015).

4.3 Relations between microstructure and macrostructure

Regression analyses models failed to establish relationships between narrative microstructure and macrostructure in the syndromic groups, in contrast to what was observed in the TD groups. In the CA-TD group, logarithmic regression models were adjusted for grammatical (utterances) and lexical (tokens) productivity and lexical complexity (types) in the microstructure, explaining high proportions of the variance at all levels of the macrostructure. In the VA-TD group, model adjustments were only observed for productivity of utterances predicting global and integrated levels of the macrostructure, and for productivity of word tokens predicting detailed levels, which suggests that the relationships between microstructure and macrostructure change with age, pointing to emergent non-linear and dynamic trajectories of progressive functional integration (Karmiloff-Smith, 2009).

Only grammatical complexity (MLU) did not predict any of the levels of the macrostructure, that is, reduced MLU did not convey less elaborated levels of narrative macrostructure in either the syndromic groups or their TD controls, as already observed by Diez-Itza et al. (2018). For this reason, the adolescents with DS did not differ from those with WS on retelling the macrostructure of the story, although their utterances were shorter, suggesting that MLU may not be a good predictor of pragmatic skills and presents limitations as a matching variable, since it may change depending on the task (Miles et al., 2006). In contrast, lexical comprehension has been found to be the best predictor of narrative skills in DS (Kay-Raining Bird et al., 2008).

The CA-TD controls who produced more word tokens mentioned more events, but those who presented a greater diversity of vocabulary in their narratives showed better recall of story plot episodes and the global framework of story scenarios. This could suggest that lexical productivity (tokens) would be more related to the recall of story details, while lexical complexity (types) would be more related to the ability to construct the story schema at the cognitive level (Bruner, 1990, 1991; Stein and Glenn, 1982), which would be in line with studies that have linked vocabulary to cognitive level (Jensen, 2001; Smith et al., 2005). The special strengths in productivity (utterances and tokens) and lexical complexity (types) in participants with WS did not determine a better retelling of narrative macrostructure than those in the DS group, suggesting again atypical dissociations between language and cognition in WS, beyond the deficit in spatial cognition previously reported (Atkinson et al., 1997; Bihrle et al., 1989; Nakamura et al., 2001). Visuospatial cognition had been related to vocabulary characteristics in the WS group, with concrete vocabulary being a relative strength that justifies the observed dissociation; in contrast, relational vocabulary referring to more abstract concepts, which form the basis for the cognitive construction of narrative schemas, is very limited and is at the level of visuospatial construction ability (Mervis and John, 2008).

A number of limitations of the present study need to be acknowledged before drawing any conclusions: although the observed differences yielded large effect sizes, the sample size was small and sex differences were not assessed, hence the results can only be interpreted as exploratory; as mentioned above, MLU may not be an appropriate matching variable, so future studies could include lexical verbal age for that purpose; the emphasis on group mean differences and similarities may have obscured important individual differences that are generally present in neurodevelopmental disorders (Stojanovik et al., 2006); the correlations between cognitive and linguistic abilities observed in previous studies suggest that the absence of control groups matched for mental age or memory measures may have prevented ruling out the effect of these variables, yet it remains a controversial issue (Karmiloff-Smith, 2009; Shaffer et al., 2020).

5 Conclusion

The results of the present study provide further support for the findings that genetic neurodevelopmental syndromes exhibit asymmetrical linguistic profiles with specific strengths and weaknesses that can be identified in their narratives. In the microstructure, specific weaknesses stand out in the DS profile, except for productivity of utterances, while specific strengths emerge in the WS profile, except for grammatical complexity

(MLU). In the macrostructure, no differences were observed between the syndromes, but a particular strength of adolescents with DS in the global level of the scenarios, and a relative weakness of adolescents with WS in the detailed level of the events should be highlighted. Thus, in the DS group, weaknesses in microstructure did not parallel the relative pragmatic strength in the overall retelling of the story, while in the WS group, strengths in productivity (utterances and tokens) and lexical complexity (types) did not translate into a more detailed retelling. Evidence from the present study supports the hypotheses of uneven asymmetrical narrative profiles in the adolescents with Down syndrome and Williams syndrome, and of dissociations between microstructure and macrostructure, suggesting that they could be the result of atypical trajectories of development which have been reported in the wider literature.

The present study also yielded some results concerning the typically developing groups. As expected, in the adolescents with typical language development, microstructure and macrostructure were closely correlated; but this was not the case in the group of typically developing 3-year-old children, which suggests that the association between microstructure and macrostructure is achieved across typical development.

Furthermore, given the wide use of MLU in language acquisition studies, it is worthwhile to underscore that we found no relation between MLU and narrative macrostructure variables in the typically developing or syndromic groups, i.e., the structure of a story may be told equally with short or long sentences. Conversely, lexical diversity was the best predictor of the structure of the stories even in the early stages. These findings may also have methodological implications in relation to the controversial issue of selecting control groups in studies of neurodevelopmental disorders.

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 Ethics Committee of the University of Oviedo. 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

AV: Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. MF-U: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. ED-I: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, 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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