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Original Article

Diphthong Production in Spanish-Speaking Children with Down Syndrome

Denisse Pérez Herrera [a, *], Eva Acevedo Contreras [b], Catalina Albornoz Arriagada [b], Denis Alosilla Vargas [b], Brian Álvarez Vargas [b] and Sofía Silva Carmona [b]

[a] *Escuela de Fonoaudiología, Facultad de Medicina, Universidad de Valparaíso, Centro de Investigación del Desarrollo en Cognición y Lenguaje (CIDCL), Chile.*
[b] *Fonoaudiólogo/a independiente.*

ABSTRACT

Down Syndrome (DS) is a genetic disorder characterized by an extra chromosome on pair 21. Compared to neurotypical individuals, people with DS exhibit developmental delays, including language development. One of the most affected components is the phonetic-phonological level. There is a lack of research on this issue in Spanish-speaking children with DS, highlighting the need for further studies. This research aims to describe the production of rising and falling diphthongs in children with DS aged between 5.0 and 9.11 years from the regions of Valparaíso, Metropolitana, and Bío Bío. Data from the FONDECYT Project No. 11150658 were used to this end, comprising a sample of 35 children who were administered the Prueba de Fonología en Español (Spanish Phonology Test). The authors transcribed the words and analyzed those containing diphthongs. The results indicate that children with DS show delayed phonetic-phonological acquisition compared to the typically developing population. No age-related effect was found in the average correct production of diphthongs. Additionally, performance was better for rising than for falling diphthongs. Errors were primarily observed as first-segment omissions in rising diphthongs and second-segment omissions in falling diphthongs.

Keywords:
Down Syndrome, Diphthong, Phonological Acquisition of Spanish, Clinical Phonetics

Producción de diptongos en niños con Síndrome de Down de habla hispana

RESUMEN

El Síndrome de Down (SD) es un trastorno genético caracterizado por poseer un cromosoma extra en el par 21. La población con SD, en comparación a las personas neurotípicas, presentan un desfase del desarrollo, entre ellos del desarrollo lingüístico. Uno de los componentes más afectado es el nivel fonético-fonológico Actualmente, hay escasez de investigaciones sobre este aspecto en niños con SD de habla hispana, lo que genera la necesidad de realizar estudios. El objetivo de esta investigación es describir la producción de los diptongos crecientes y decrecientes en niños con SD, de entre 5.0 y 9.11 años, pertenecientes a las regiones de Valparaíso, Metropolitana y del Bío Bío. Para lograr el objetivo, se utilizó la base de datos del proyecto FONDECYT Nº11150658, que comprende una muestra constituida por 35 niños, a quienes se les aplicó la Prueba de Fonología en Español. Las palabras se transcribieron y luego se analizaron aquellas que contenían los diptongos. Los resultados nos indican que los niños con SD presentan una adquisición fonético-fonológica retrasada en el tiempo, en comparación con la población normotípica. No se observó un efecto de la edad en la media de la producción correcta de los diptongos y que existe mejor rendimiento en los diptongos crecientes que en los decrecientes. En cuanto a los errores, estos se centran en la omisión del primer segmento para los diptongos crecientes y en segundo segmento para los diptongos decrecientes.

Palabras clave:
Síndrome de Down, diptongo, adquisición fonológica del español, fonética clínica

**Corresponding Author: Denisse Pérez Herrera*
Email: denisse.perez@uv.cl

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INTRODUCTION

Down Syndrome (DS) is a genetic condition characterized by an extra chromosome on pair 21 (Mégarbané et al., 2009). The effect of this additional chromosome varies among individuals depending on how it is expressed, resulting in considerable variability in cognitive abilities, physical development, personality, and talents (Tracy, 2011). The genetic disturbance may specifically cause changes in development, organ function, and bodily systems, as well as phenotypic anomalies that can be detected during the prenatal period or at birth (*Confederación Española de Organizaciones en favor de las Personas con Discapacidad Intelectual* [FEAPS], 2016). The most significantly affected system is the nervous system, particularly the brain and cerebellum, resulting in an intellectual disability whose severity varies from person to person.

Compared to neurotypical individuals, people with DS experience developmental delays that often include attention disorders, language difficulties, and impairments in executive functioning, among others (Ortiz et al., 2017). Concerning language, such delays may extend from several months to several years (Rondal, 2009). Although the trajectory of language acquisition in children with DS follows the same stages as in neurotypical development, it occurs over a significantly longer period (Santos Pérez & Bajo Santos, 2011). The phonetic and phonological levels are among the most affected components of language. Currently, research on phonological development in Spanish-speaking children with DS is scarce (Vergara, 2021), particularly regarding diphthong acquisition. This lack of research is partly attributable to the complexity of speech errors associated with the cognitive deficits inherent to DS, as well as to the syndrome's multifaceted symptomatology (Lott & Dierssen, 2010). It is also due to the absence of specialized assessment tools, insufficient clinical phonetics training, and the time-intensive nature of collecting, recording, transcribing, and analyzing pathological child speech samples (Ygual-Fernández et al., 2008). These limitations highlight the need for studies that specifically investigate the production of rising and falling diphthongs in individuals with DS. From a clinical perspective, such research contributes to a better understanding of the linguistic development of children with DS, supports the generation of new knowledge, and enables more accurate estimations of diphthong production and related speech errors. This, in turn, would enable speech-language therapists to refine their assessment and intervention strategies. To provide a comprehensive framework for this study, we now present a brief theoretical review.

Description of Diphthongs in Spanish

In Spanish, the grouping of vowels results in the phonological phenomenon known as diphthongs and hiatuses (Hidalgo Navarro & Quilis Merín, 2012). Understanding the difference between the two is essential for accurately analyzing this concept (Hidalgo Navarro & Quilis Merín, 2012). A diphthong occurs when two vowels are combined within the same syllable, as in /au-to/, /a-bier-ta/, or /fa-mi-lia/. In contrast, a hiatus consists of two adjacent vowels that belong to separate syllables, as seen in /Marí-a/, /mí-o/, or /o-ído/ (Hidalgo Navarro & Quilis Merín, 2012).

Diphthongs are phonological units formed by the combination of a strong vowel and a weak vowel or two weak vowels within a single syllable (Martínez Amador, 1961). According to Quilis (1993), the first vowel serves as the syllabic nucleus and is characterized by a wider oral opening, greater articulatory tension, increased intensity and perceptibility, and enhanced potential for transmission and duration. The second vowel, by contrast, functions as a marginal or delimiting element of the syllable. This specific role of the vowels in a diphthong can be observed, for example, in the word /pei-ne/, where /e/ is the nuclear vowel and /i/ is the marginal one.

To understand the structure of diphthongs, it is first necessary to recognize semivowels and semiconsonants (Calvo, 2008). These are referred to as glides, as they do not possess the full characteristics of either vowels or consonants; their articulation consists solely of a gradual transition from one sound to another (Calvo, 2008).

In Spanish, this classification centers on the phonemes /i/ and /u/ (Alarcos Llorach, 1994), which give rise to two types of diphthongs (Hidalgo Navarro & Quilis Merín, 2012). On the one hand, rising diphthongs are vowel groupings within a single syllable in which the articulatory movement progresses from a close vowel /i/, /u/ to a more open vowel /a/, /e/, or /o/. This pattern is evident in words such as /tjene/, which combines /i/ and /e/, or /bweno/, with the sequence /u/ and /e/. In these cases, the more open vowel occupies the second position as the syllabic nucleus. In contrast, the prenuclear margin is occupied by /i/ or /u/, which function as semiconsonants and are phonetically transcribed as [j] or [w] (Hidalgo Navarro & Quilis Merín, 2012). The semiconsonant quality is observed when the articulation has an intermediate position between a vowel and a consonant, producing weak and brief friction, as in diphthongs like /ja/, /je/, and /jo/ (Navarro Tomás, 1918). In the case of /u/ acting as a semiconsonant, the articulation involves a rapid transition from a relatively closed labiovelar position to the following vowel. This

occurs primarily when /u/ appears at the onset of the diphthong, as in /wa/, /we/, and /wo/ (Navarro Tomás, 1918).

On the other hand, falling diphthongs involve a movement from open vowels /a/, /e/, /o/ to the close vowels /i/ or /u/ (Hidalgo Navarro & Quilis Merín, 2012). Quilis (1993) provides examples such as /aɪ̯re/, demonstrating the /a/ + /i/ combination, or /eu̯ropa/, with /e/ + /u/. In such groupings, the vowel in the first position is the nucleus, while the post-nuclear margin is occupied by /i/ or /u/, functioning as semivowels and transcribed phonetically as [ɪ̯] and [u̯] respectively (Hidalgo Navarro & Quilis Merín, 2012). The /i/ functions as a semivowel when it appears in diphthongs such as /aɪ̯/, /eɪ̯/, and /oɪ̯/, where its articulation is brief and progressively reduces in palatal openness (Navarro Tomás, 1918). Similarly, /u/ functions as a semivowel when its articulation is brief following a preceding vowel, typically involving a brief or interrupted transition. This results in a narrowing of the linguovelar and bilabial articulators with an affricate-like tendency, though without losing its vocalic timbre, as in diphthongs like /au̯/, /eu̯/, and /ou̯/ (Navarro Tomás, 1918).

Acquisition of Diphthongs in Spanish

Carballo's research (1995, as cited in Pérez, 2013, p. 16) identified the ages at which neurotypical children acquire diphthongs in Granada (Spain). The findings indicate the following acquisition timeline: "3.0–3.5 years: /ie/, /au/, /ue/; 3.6–3.11 years: /ei/, /ie/, /au/, /ue/; 4.0–4.5 years: /ei/, /ie/, /ua/, /au/, /ue/; 4.6–4.11 years: /ei/, /ie/, /ua/, /au/, /ue/; 5.0–5.5 years: /ei/, /ie/, /ua/, /au/, /ue/; 5.6–5.11 years: /ei/, /ie/, /ua/, /au/, /ue/; and at 6.0–6.6 years: /ei/, /ie/, /ua/, /au/, /ue/." Similarly, Acosta et al. (2021) studied the production of diphthongs in 867 children aged 3 to 6 years from Quito. The children were assessed using the *Prueba de Exploración del Lenguaje Comprensivo y Expresivo* (ELCE-R), which included diphthongs such as /ia/, /ei/, /ua/, /ue/, /ai/, /ei/, and /au/. Results showed that by age 3, children had mastered 90.4% of the diphthongs; by age 4, 94.8%; by age 5, 97.1%; and by age 6, 99.9%. The authors concluded that Ecuadorian children demonstrate a high rate of diphthong acquisition compared to findings from other Latin American studies.

In her doctoral dissertation, Vivar (2007) analyzed the phonological development of 72 Chilean children aged 3.0 to 5.11 years using the *Cuestionario para la Evaluación de la Fonología Infantil* (CEFI). The results revealed that only Group I (ages 3.0–3.5) showed lower performance in diphthong production, while from Group II onward (ages 3.6–3.11), typical productions exceeded 90%. The oldest age group (5.6–5.11 years) reached 95% accuracy. Regarding errors, substitution occurred in less than 4% of the cases and was most frequent in falling diphthongs, particularly affecting the second element, which is the unstressed vowel. Omission errors were highest in Group I, at 24%, while in older groups (Group IV: 5.0–5.5 years, and Group VI: 5.6–5.11 years), omission dropped to 3%. In falling diphthongs, omissions typically involved the second element; in rising diphthongs, omissions most often affected the first element, in both cases coinciding with the less sonorous segment.

Vergara (2014) assessed 30 typically developing children aged 3.0 to 5.11 years from the city of Puerto Montt (Chile). The results showed that for rising diphthongs, the 3-year-old group achieved a correct production rate of 95.3%, the 4-year-old group 94.7%, and the 5-year-old group 98.8%. Regarding falling diphthongs, the 3-year-old group reached 79.1% accuracy, the 4-year-old group 74.5%, and the 5-year-old group 93.6%.

It is also relevant to consider the study by Bernhardt et al. (in press), which included a sample of 59 children from Granada (Spain), aged 3 to 5 years—30 with typical development and 29 with protracted phonological development. The participants were administered a list of 103 words, from which 28 words containing rising and falling diphthongs were selected. The findings indicate that older and typically-developing children show better performance in both the correct production of the entire diphthong structure and its temporal units. Additionally, they exhibited fewer mismatches and rare errors than younger children and those in the protracted phonological development group, who showed more mismatches characterized by coalescence, reduplication, and metathesis. Another notable finding was that rising diphthongs are acquired earlier than falling diphthongs, which the authors attribute to the relevance of frequency: "The earlier acquisition of RDs (rising diphthongs) suggests that frequency may be very relevant. However, there were differences in mastery levels across diphthongs" (p. 28). The authors conclude that there may be challenges in acquiring vowel sequences in Spanish, both for children with typical development and those with protracted phonological development.

Finally, an important aspect addressed in this article concerns the ongoing debate regarding whether phonetic-phonological acquisition in children with DS is delayed or disrupted. To address this, we cite a classic study by Van Borsel (1996) that involved 20 adolescents and adults with DS aged 15 to 28 years (mean mental age of 5.8 years) and 20 typically developing children aged 2.6 to 3.4 years. Through detailed analysis and comparison of consonants, vowels, and diphthongs, the author confirmed that the similarities between adolescents and adults with DS and typically developing children outweigh the differences. This supports

Lenneberg's (1967) hypothesis of developmental delay in individuals with DS; when differences were observed, they did not necessarily contradict this hypothesis.

Similarly, in a recent study on Arabic-speaking people with DS, Ayyad et al. (2021) report that "The children in the current study showed a variety of phonological mismatch patterns, many of which were similar to those of typically developing Kuwaiti children (Ayyad, 2011). This reflects earlier work on English-speaking children with DS (Stoel-Gammon, 2001) and is consistent with the perspective that one source of phonological delay in children with DS is the development of a phonological system as a cognitive developmental task (independent of articulatory-motor concerns)" (p. 15). However, it should not be overlooked that there are aspects of speech acquisition that can be described as disrupted in this population, although these are not the norm, as noted in the study by Moya et al. (2010).

Based on the above, the following research questions arise: Is the developmental course of diphthong acquisition delayed or disrupted in children with DS? Is there a difference in the accurate production of rising and falling diphthongs in children with DS? Do the errors produced by children with DS in diphthong production follow typical neurodevelopmental acquisition patterns?

To address these questions, the general objective of this study is to describe the production of rising and falling diphthongs in children with DS aged 5.0 to 9.11 years from the Valparaíso, Metropolitana, and Bío Bío regions in Chile.

METHOD

Sample

This is a non-experimental, cross-sectional research with a descriptive scope and no control group. It utilizes a previously collected database from the FONDECYT Project No. 11150658, which has been approved by the Ethics and Scientific Committee (CEC-UV) of Universidad de Valparaíso (CECO 94-15). The database comprises a sample of 35 children with Down Syndrome, aged between 5.0 and 9.11 years, from the Valparaíso, Metropolitana, and Bío Bío regions in Chile. The sample was evenly distributed with seven children in each age group (5.0–5.11 years, 6.0–6.11 years, 7.0–7.11 years, 8.0–8.11 years, and 9.0–9.11 years). Parents provided informed consent before their children participated in the study.

The sample was selected according to the following inclusion criteria: (a) monolingual Spanish speakers whose native language is Spanish, (b) middle class based on data obtained from a parent/guardian survey developed by Vergara (2014), (c) speech intelligibility rated as “sometimes intelligible” on the Intelligibility in Context Scale with scores above 3 on a 5-point scale (McLeod et al., 2012), (d) hearing loss of 40 dB or less, assessed via pure-tone audiometry, (e) mild to moderate intellectual disability based on school records, and (f) children with DS without comorbid Autism Spectrum Disorder (ASD), as evaluated using the Prutting Pragmatic Protocol (Prutting & Kittchner, 1987).

Sample Assessment Instrument

The sample was assessed using *Prueba de Fonología en Español* developed by Bernhardt et al. (2016). This protocol consists of a list of 100 words that include the 22 phonemes of Chilean Spanish in balanced stimuli varying in syllabic count: 8 monosyllabic words, 57 bisyllabic words, 25 trisyllabic words, 9 polysyllabic words, and 1 word with 5 syllables. The inventory includes all phonemes and typical syllabic structures of Spanish, with each word represented graphically. From these 100 words, 23 words were selected per child: 13 words containing rising diphthongs (/ia/, /ie/, /io/, /ua/, /ue/) and 10 words containing falling diphthongs (/ai/, /ei/, /oi/, /au/). See Appendix 1 for a detailed description of falling diphthong simuli and Appendix 2 for rising diphthongs. For this study, diphthongs /ou/ and /uo/ were omitted due to the scarcity of familiar words containing these sequences.

Procedures

Each child’s production was recorded using a high-fidelity TASCAM DR-40 recorder with an integrated microphone positioned on the table in front of the child. Before recording, the equipment was introduced to the child, and general instructions were given (e.g., not to touch the device, not to shout). Subsequently, the recordings were transcribed by two phoneticians in accordance with the International Phonetic Alphabet (IPA) standards and reviewed by a third expert listener. To ensure reliability, one point was assigned for each phoneme that matched between transcribers and half a point for matching diacritics. A concordance rate of over 80% was established for consonants with diacritics and over 90% for vowel and consonant phonemes without diacritics to assign the final transcription of each word. The transcriptions were then entered into the PHON 2.1.8 software (Rose & MacWhinney, 2014), which performs a series of automatic analyses of segmental and suprasegmental phonological units, facilitating the analysis of atypical speech. A

corpus was created by inputting the children's transcriptions and recordings into the program. A review was then conducted, selecting those words containing syllabic structures with rising or falling diphthongs. The correct productions and phonological errors produced by children with DS were determined using PHON. Errors were conceptually operationalized as follows:

- Substitution: According to Pavez et al. (2013), "substitution processes consist of simplifying the word by replacing phonemes belonging to one class with members of another class" (p. 50). Substitution error categories include: (a) substitution of the first segment (Sub S1), (b) substitution of the second segment (Sub S2), and (c) substitution of both the first and second segments (Sub S1S2).
- Omission: Defined as a specific subprocess related to syllable structure in which a segment of the syllabic structure is omitted. Omission error categories include: (a) omission of the first segment (Om. S1), (b) omission of the second segment (Om. S2), and (c) omission of the entire diphthong (Om. dip) (Vergara, 2014, p. 66).
- Distortion: Identified when the child produces an articulatory output that does not correspond to the correct phoneme of the syllable or any other phoneme (Cervera & Ygual, 2001). Distortion error categories include: (a) distortion of the first segment (Dis S1), (b) distortion of the second segment (Dis S2), and (c) distortion of both the first and second segments (Dis S1 S2).
- Metathesis: Defined as "the change or permutation of the position of a phoneme or group of phonemes within a word" (Díez-Itza & Martínez López, 2003). This error affects both S1 and S2 and is categorized as "Met."
- Hiatization: This process involves producing a hiatus where a diphthong is usually produced, thus affecting diphthong production and categorized as "Hiat." (Real Academia Española [RAE], 2011, p. 351).
- Vowel Coalescence: In this process, two sounds merge to form a single sound (Kehoe et al., 2008, p. 41). It alters the diphthong structure and is classified as "V. Coal."
- Other: This category includes any additional phonological processes that may appear during sample analysis and is designated as "other."

Data Analysis

First, correct productions of diphthongs were analyzed by age group using measures of central tendency (mean) and standard deviation. Second, a comparison of the results between the two types of diphthongs and the age groups was conducted to determine the presence of significant differences ($p < .05$). For this purpose, an analysis of variance (ANOVA) was performed using parametric tests after verifying the assumptions of normality and homoscedasticity with the Shapiro-Wilk and Levene's tests ($p > .05$). Third, a descriptive analysis was conducted on the main errors produced by the children in both rising and falling diphthongs.

RESULTS

This section presents the results obtained throughout the research process, corresponding to the description of diphthong production in children with Down Syndrome (DS).

The values shown in Table 1 indicate a higher mean value in rising diphthongs (RD) with correct structural production compared to falling diphthongs (FD) with correct structural output. Additionally, greater production accuracy is observed in children aged 6.0 to 6.11 years for both RD and FD compared to other age groups. Finally, no effect of age on performance was found for either RD or FD in the sample of children with DS. Subsequent analyses will determine whether significant differences exist in the correct production of RD and FD.

Table 1. Correct Production of Rising and Falling Diphthongs by Age Group

	Age	M	SD		M	SD
	5.0-5.11	4.86	2.48		1.86	1.07
	6.0-6.11	8.86	3.39		4.14	2.34
RD	7.0-7.11	7.57	3.55	FD	3.57	2.44
	8.0-8.11	6.86	3.53		1.86	1.35
	9.0-9.11	6.86	2.67		3.71	1.38

Note: Description of the mean value obtained in each age group, RD= rising diphthongs with correct structure; FD = falling diphthongs with correct structure

Rising Diphthongs (RD)

The Shapiro-Wilk test yielded a p-value of .018 ($p < .05$), indicating a violation of the normality assumption. In contrast, Levene's test yielded a p-value of 0.444, indicating homogeneity of variance. Based on these assumption checks, a statistical analysis of variance was conducted using ANOVA to determine significant differences in the rising diphthongs.

Table 2. Variance analysis in rising diphthongs.

	F	df1	df2	*p*	η^2
RD	1.48	4	30	.234	.141

As shown in Table 2, the analysis of variance yielded a *p*-value of .234. Based on this, there are no significant differences by age group. The effect size was estimated using eta squared (η^2), yielding a value of 0.141. According to Cohen's (1988) criteria, this can be interpreted as a large effect size.

Falling Diphthongs (FD)

In the variable normality test, the Shapiro-Wilk test yielded a *p*-value of 0.316 ($p > 0.05$), indicating that the assumption of normality was met. Similarly, Levene's test yielded a *p*-value of .215, indicating homogeneity of variances across groups. Based on these results, a one-way ANOVA was conducted to examine significant differences in the production of falling diphthongs.

Table 3. Variance analysis in falling diphthongs.

	F	df1	df2	*p*	η^2
FD	2.55	4	30	.059	.149

As with the rising diphthongs in Table 2, the *p*-value obtained in the analysis of variance is .059. Based on this, there are no significant differences by age group. The eta-squared effect size (Effect Size η^2) was also estimated at .149, which can be considered large according to Cohen's (1988) criteria.

Descriptive Analysis of Errors by Diphthong Type

These figures describe the phonological errors found in each age group for rising (Figure 1) and falling (Figure 2) diphthongs.

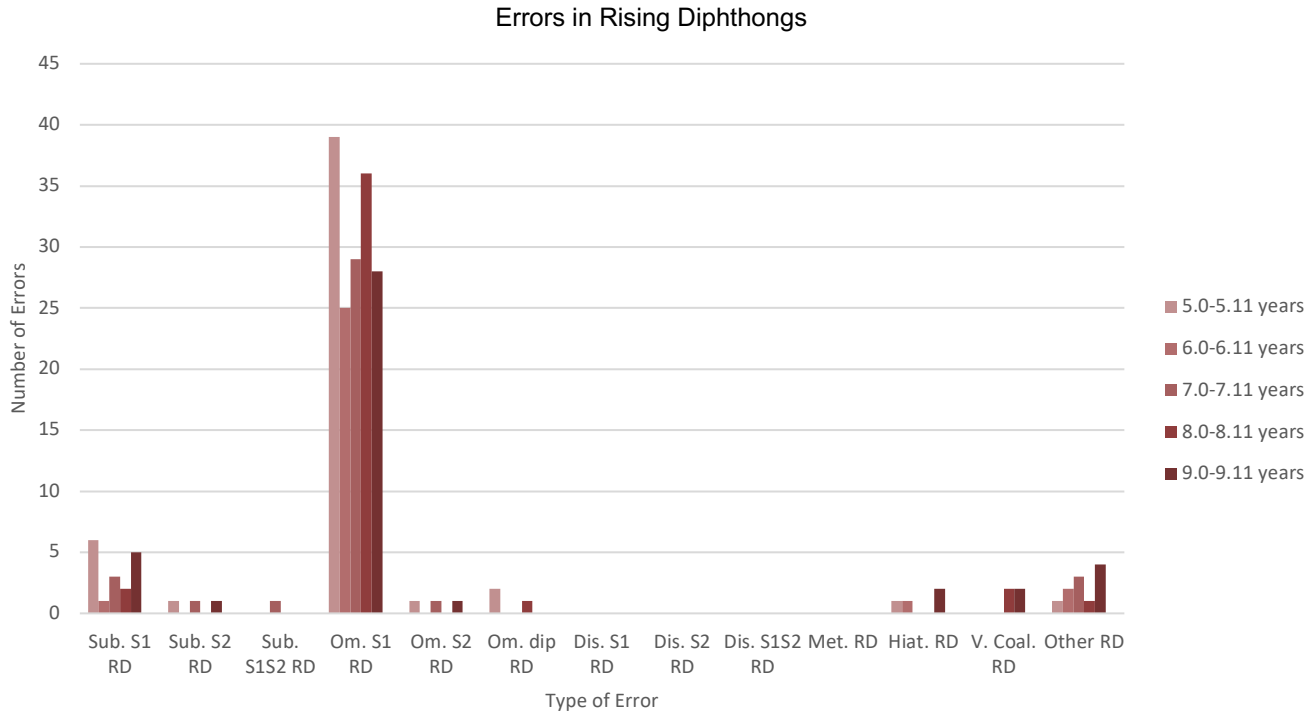

Figure 1. Types of errors found in rising diphthongs by age group.

Figure 1 shows the presence of phonological errors for rising diphthongs produced by children with DS in each age range. First segment omission errors (Om. S1 RD) are present in all age ranges, being highest in the 5.0 to 5.11 age group (39 errors); this is followed by the 8.0 to 8.11 age group with 36 errors; then the 7.0 to 7.11 age group with 29 errors; the 9.0 to 9.11 age group with 28 errors; and finally, the 6.0 to 6.11 age group with 25 errors. All other types of errors in the different age groups are marginal. Table 4 details some examples.

Table 4. First segment omission errors examples.

Omission Error Examples		
	Adult Word	Child with DS
	['njẹ βẹ]	['nẹ βẹ]
	[ˊj̩wẹ βẹ]	[ˊbẹ βẹ]
	[ˊfwẹ ɣ̩o]	[ˊfẹ βo]
Examples of Other Error Types		
Type of Error	Adult Word	Child with DS
Substitution S1	[ˊj̩wẹ βẹ]	[ˋtie βẹ]
Vowel Coalescence	[ˊwẹ so]	[ˊi ʃo]
Substitution S1	['njẹ βẹ]	['bwẹ βẹ]

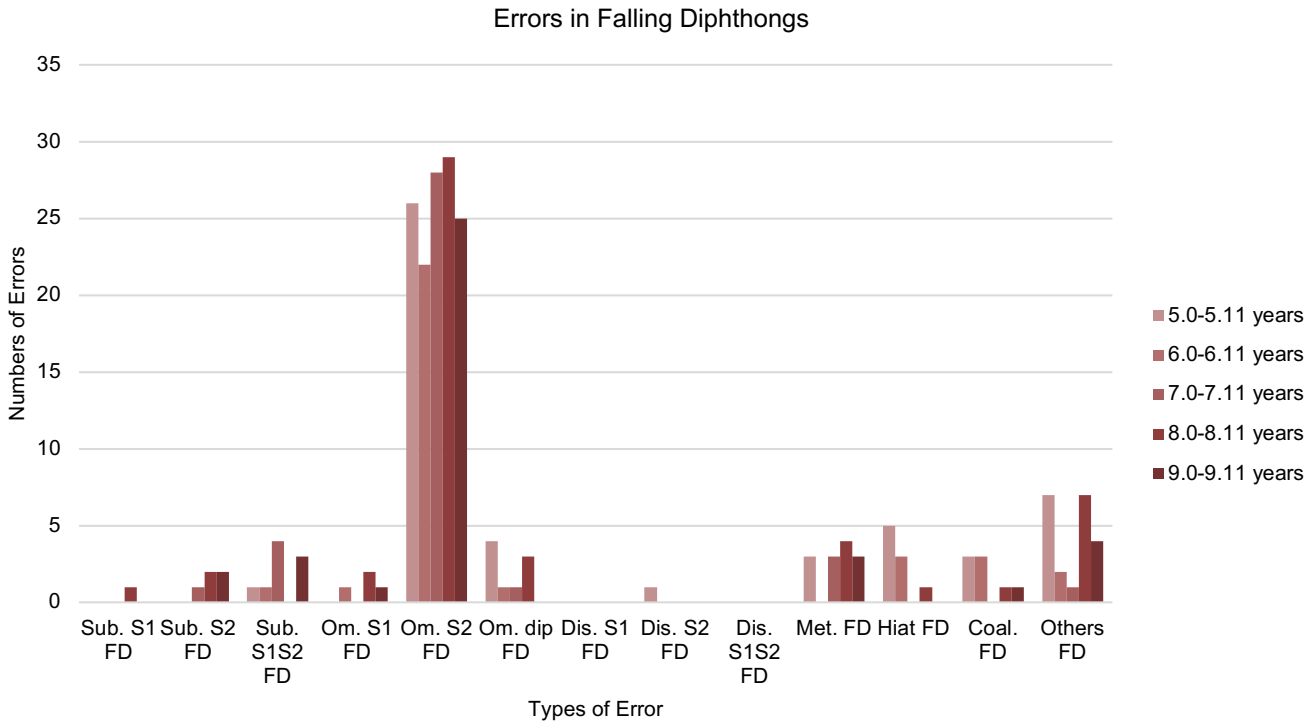

Figure 2. Types of errors found in falling diphthongs by age group.

Figure 2 shows the phonological errors produced by children with DS in falling diphthongs for every age range. Second-segment omission errors (Om. S2 FD) are particularly notable and present across all age ranges, with the highest incidence in the 8.0 to 8.11 age group (29 errors). This is followed by the 7.0 to 7.11 age group, with 28 errors; the 5.0 to 5.11 age group, with 26 errors; the 9.0 to 9.11 age group, with 25 errors; and finally, the 6.0 to 6.11 age group, with 22 errors. As with rising diphthongs, all other types of errors across the different age groups are marginal. Some examples are shown in Table 5.

Table 5. Second segment omission errors examples.

Omission Error Examples		
Type of Error	Adult Word	Child with DS
	['aɪ̯ ɾɐ]	['a ɾɐ]
	[baɪ̯ ˊlãn̪ doˌ]	[ba ˊna noˌ]
	['peɪ̯ neˌ]	['peˌ neˌ]
Examples of Other Error Types		
Type of Error	Adult Word	Child with DS
Substitution S2	[diˌ noˌ 'saʊ̯ ɾjoˌ]	[ːla ra 'saiˌ joˌ]
Metathesis	[ˊbɐɪ̯n̪ teˌ]	['bje te]
Diphthong Omission	[baɪ̯ ˊlãn̪ doˌ]	['la to]

The following section connects the empirical data obtained in this research to the theories and findings of other studies, providing an explanation for certain phenomena.

DISCUSSION

The data from this study supports the findings reported by Van Borsel (1996). We believe that people with Down syndrome exhibit delayed phonetic-phonological acquisition, as evidenced by the production patterns of children in this sample, which are comparable to those of younger typically developing peers when producing diphthongs. Moreover, these structures are considered to be acquired early, as indicated in both theoretical models and prior research from Chile (Vergara, 2014; Vivar, 2007) and internationally.

An additional finding consistent with typical development is the differential accuracy observed between diphthong types in people with DS, who exhibit higher accuracy in producing rising diphthongs compared to falling diphthongs (Vergara, 2014). This difference is more pronounced in the participants of this study, but it approaches the performance observed in the group with protracted phonological development, as reported by Bernhardt et al. (in press), reflecting phonological deficits in both groups.

An interesting finding of this study is that no age effect was observed in the mean accuracy of both rising and falling diphthong production in children with DS. This phenomenon is usually observed in typical development, where skills improve over time, and younger children tend to show lower performance, which progressively increases with age. Although the groups in this study spanned a wide age range, no age-related progression was observed. This may be explained by the fact that, regardless of chronological age, the children with DS in this study demonstrated diphthong production accuracy comparable to that of typically developing children under the age of three (see Acosta et al., 2021, for Ecuador; see Vergara, 2014, for Chile). We hypothesize that age-related differences in diphthong production accuracy may emerge later, during adolescence, an effect that we will evaluate in a longitudinal follow-up study.

It was also found that children with DS present various types of errors. Regardless of age, these errors were primarily characterized by the omission of S1 in rising diphthongs and S2 in falling diphthongs, corresponding to the semivowel and semiconsonant glides, which, as discussed in the introduction, exhibit lower sonority. Therefore, the omission of these elements is a predictable and typical phonetic error consistent with the patterns observed in younger, typically developing children, as described by Vivar (2007). From a structural perspective, these errors simplify the diphthong (CVV) into the simpler and earlier-acquired canonical structure (CV) (Saceda Ulloa, 2005). Additionally, other error patterns were observed in the production of falling diphthongs, including metathesis, hiatization, vowel coalescence, and others, similar to what Bernhardt et al. (in press) describe in children with protracted phonological development. This highlights the difficulties children with clinical disorders face in producing this type of structure.

Finally, it is essential to note that although the speech of children with DS may often be unintelligible, their phonetic and phonological acquisition generally follows a typical developmental sequence, albeit chronologically delayed. This delay may extend over several years. However, they continue to acquire formal linguistic structures beyond the so-called critical period. From a speech-language therapy perspective, we support, based on available evidence, the continuation of therapeutic intervention into adolescence, with a focus on addressing typical error patterns, particularly emphasizing falling diphthongs. From the standpoint of clinical phonetics, we hope that this research contributes to the understanding of the phonetic-phonological development of Spanish-speaking children with Down syndrome.

CONCLUSIONS

The objective of this study was achieved, as it successfully provided an empirical description of both the correct productions and the error patterns observed in children with Down syndrome aged 5.0 to 9.11 years. The results indicate that children with DS exhibit delayed diphthong acquisition, demonstrate better performance in rising diphthongs compared to falling diphthongs,

and display error patterns similar to those produced by younger, typically developing children. The limitations are consistent with those commonly encountered in clinical phonetics research, particularly the restricted sample size, which limits the generalizability of the findings. As a result, significant age-related differences could not be established, although the effect sizes were large for both diphthong types. The projections stem directly from these findings. As discussed in the previous section, future longitudinal research should be conducted to examine the developmental trajectory of diphthong production during adolescence, determine the error percentage, and assess whether omissions remain the predominant error pattern. Additionally, it should investigate whether the gap between rising and falling diphthong accuracy narrows with age.

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APPENDIX 1. Falling Diphthongs.

Stimulus	Accent	Structure
hoy	S	ˈVV
jaula	Sw	ˈCVV.CV
oigo	Sw	ˈVV.CV
ruido	Sw	ˊCVV.CV
peine	Sw	ˊCVV.CV
veinte	Sw	ˈCVVC.CV
aire	Sw	ˊVV.CV
paula	Sw	ˊCVV.CV
bailando	wSw	CVVˈCVC.CV
dinosaurio	wwSw	CV.CVˈCVV.CVV

APPENDIX 2. Rising diphthongs.

Stimulus	Accent	Structure
gracias	Sw	ˈCCV.CVV(C)
pierna	Sw	ˈCVVC.CV
agua	Sw	ˈV.CVV
nieve	Sw	ˈCVV.CV
fuego	Sw	ˈCVV.CV
llueve	Sw	ˈCVV.CV
guante	Sw	ˈCVVC.CV
cuatro	Sw	ˊCVV.CCV
cuadro	Sw	ˊCVV.CCV
hueso	Sw	ˈ(C)VV.CV
familia	wSw	CV.ˊCV.CVV
abierta	wSw	VˈCVVC.CV
zanahoria	wwSw	CV.CVˈV.CVV
dinosaurio	wwSw	CV.CVˈCVV.CVV