PROSODIC STRUCTURE PATTERNS IN MULTISYLLABIC WORD PRODUCTIONS OF GRANADA SPANISH-SPEAKING CHILDREN WITH TYPICAL VERSUS PROTRACTED PHONOLOGICAL DEVELOPMENT

by

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Abstract

The primary aim of this study was to determine whether monolingual Granada Spanish-speaking children with protracted phonological development (PPD) perform differently from their typically-developing (TD) peers on measures of word stress, word length and word shape in multisyllabic words (MSWs). Previous research has shown that MSW productions can indicate PPD in English-speaking children (James, 2006). However there is no evidence to date of direct comparisons between monolingual Spanish-speaking children with typical and protracted phonological development on MSW productions. Fifty-nine monolingual Spanish-speaking children ages 3;0 to 5;11 were recruited for an original cross-linguistic study in Granada, Spain: 30 with TD and 29 with PPD. All MSW productions in the original data were extracted to create an analysis set for the current study. A total of 36 multisyllabic and 6 disyllabic single word elicitations were analyzed for each participant. A multisyllabic rubric based on principles of non-linear phonology was used to score MSW productions on word stress, word length and word shape. The rubric produced three types of mismatch scores for each child, including a word structure mismatch score, a segment-structure interaction mismatch score and a combined word structure and segment-structure interaction mismatch score. Descriptive and inferential analyses were performed on all three types of mismatch scores. Overall, children in the PPD group showed significantly more mismatches than their aged-matched TD peers. Word structure mismatch scores decreased as age increased, while mismatch scores increased with increased word length. No effect of gender was found. Common mismatch patterns in both the PPD and TD groups were syllable deletion, single vowel deletion and assimilation. Consonant deletion was also frequent, both for singleton consonants and for consonants in word-initial and word-medial sequences. Mismatch patterns were more common in initial unstressed syllables than in

non-initial stressed syllables. The results of this study underscore the importance of using MSWs in analysis of children's phonological productions, because group and age effects were found in 3- and 4-syllable targets that were obscured in 2-syllable targets. Further research is necessary to allow generalization of the results to other populations and to find potential clinical applications of the scoring rubric.

Preface

The research presented in this thesis is a component of a collaborative international crosslinguistic study co-led and supervised by B. M. Bernhardt and J. P. Stemberger. It has been approved by the UBC Behavioural Ethics Review Board with ethics certificate number H09-03040.

Data were collected and transcribed by D. Perez, C. Ávila, G. Carballo, E. Mendoza and D. Fresneda in Granada, Spain. R. Hanson and the author, C. Schretlen, completed preliminary data entry into analysis software. All data analyses and written text are the original, unpublished work of the author.

Preliminary findings of the current study, including portions of the method, results and discussion, were presented in poster format at the CASLPA 2013 Conference in Victoria, BC.

Table of Contents

Abstract ii

Preface iv

Table of Contents v

List of Tables ix

List of Figures x

List of Abbreviations xi

Acknowledgements xii

Dedication xiii

Chapter 1: Introduction 1

1.1 Structure of multisyllabic words 2

1.2 Children's production of multisyllabic words 5

1.3 Overview of Spanish word prosody 7

1.3.1 Spanish stress and word length 8

1.3.2 Spanish syllable structure 8

1.4 Phonological acquisition in Spanish-speaking children 10

1.4.1 Acquisition by typically-developing Spanish-speaking children 11

1.4.2 Acquisition by Spanish-speaking children with protracted phonological development 15

1.5 Approaches to measuring productions of multisyllabic words 17

1.5.1 Percent consonants correct metric 17

1.5.2 Whole word approach 18

1.5.3 The multisyllabic rubric 20

1.6 Research questions 20

1.6.1 Research question 1: Participant factors 21

1.6.2 Research question 2: Mismatch patterns in multisyllabic words 22

1.6.3 Research question 3: Prosodic factors 22

Chapter 2: Method 24

2.1 Study background 24

2.2 Procedures of the original study 24

2.2.1 Participants 24

2.2.2 Data collection and transcription 25

2.3 Procedures of the current thesis study 26

2.4 Coding procedure: A rubric for multisyllabic words 31

2.4.1 Rubric design 31

2.4.2 Challenges of the multisyllabic rubric 35

2.5 Reliability 39

2.6 Data analyses 40

Chapter 3: Results 41

3.1 Participant factors: Group and age 41

3.1.1 Descriptive analysis of group and age 41

3.1.2 Inferential analysis of group and age 45

3.1.2.1 Effect of group on word structure mismatch scores 46

3.1.2.2 Effect of group on segment-structure interaction mismatch scores 46

3.1.2.3 Effect of group on combined mismatch scores 47

3.1.2.4 Relationship between age and word mismatch scores 48

3.2 Mismatch patterns in multisyllabic words 49

3.2.1 Mismatch patterns for word stress and word length 50

3.2.2 Mismatch patterns for word shape 51

3.2.3 Mismatch patterns for segment-structure interactions 56

3.3 Prosodic factors: Stress and word length effects 57

3.3.1 Inferential analysis of unstressed versus stressed syllables 58

3.3.1.1 Word structure mismatches in unstressed versus stressed syllables 59

3.3.1.2 Segment-structure interaction mismatches in unstressed versus stressed syllables 59

3.3.1.3 Combined mismatches in unstressed versus stressed syllables 60

3.3.1.4 Relationship between age and mismatch difference scores 60

3.3.2 Descriptive analysis of word length 61

Chapter 4: Discussion 64

4.1 Evaluation of participant factors: Effects of group and age 65

4.1.1 Percent structure match on multisyllabic productions 65

4.1.2 Total mismatch scores 66

4.2 Evaluation of most frequent mismatch patterns 67

4.3 Evaluation of prosodic factors: stress and word length 71

4.3.1 Mismatch scores in unstressed versus stressed syllables 71

4.3.2 Trends in descriptive analyses of word length 74

4.4 Limitations of the current study 76

4.5 Conclusion 78

4.5.1 Research implications 79

4.5.2 Clinical implications 81

4.6 Areas for further research 82

References 85

Appendices 91

Appendix A List of analyzed targets by word length, stress, and word shape pattern 91

Appendix B List of codes with definitions and example of use in data 92

Appendix C Condensed sample multisyllabic coding rubric for target *princesa* 'princess' in PPD group 102

Appendix D Standardized total mismatch scores for TD group 103

Appendix E Standardized total mismatch scores for PPD group 104

Appendix F Standardized unstressed-stressed mismatch difference scores for TD group 105

Appendix G Standardized unstressed-stressed mismatch difference scores for PPD group .. 106

List of Tables

Table 2.1 Number of participants by group, gender and age in years 25

Table 2.2 List of targets analyzed for the current thesis study 27

Table 2.3 Frequency of imitated tokens by word and group for 2-syllable targets 29

Table 2.4 Frequency of imitated tokens by word and group for 3-syllable targets 30

Table 2.5 Frequency of imitated tokens by word and group for 4- and 5-syllable targets 30

Table 2.6 Example of ambiguous coding for multisyllabic target..... 38

Table 3.1 Raw total mismatch score means and standard deviations 46

Table 3.2 Frequency of deletion in consonant sequences within syllables..... 54

Table 3.3 Raw mismatch difference score means and standard deviations 58

List of Figures

Figure 1.1 The prosodic word hierarchy 2

Figure 2.1 Mismatch codes and values in categories by colour grouping 36

Figure 3.1 % match on word stress, word length and word shape in 2-syllable targets 42

Figure 3.2 % match on word stress, word length and word shape in 3-syllable targets 44

Figure 3.3 % match on word stress, word length and word shape in 4- and 5-syllable targets 44

Figure 3.4 Interaction of group and gender for segment-structure interaction mismatch scores 47

Figure 3.5 Frequency of syllable deletion in targets without consonant sequences 51

Figure 3.6 Frequency of syllable deletion in targets with consonant sequences 51

Figure 3.7 Frequency of single consonant deletion in targets without consonant sequences ... 52

Figure 3.8 Frequency of single vowel deletion in targets without consonant sequences 52

Figure 3.9 Frequency of assimilation in targets without consonant sequences 56

Figure 3.10 Frequency of assimilation in targets with consonant sequences 56

List of Abbreviations

MSW	multisyllabic word
PPD	protracted phonological development
TD	typical phonological development
C	consonant
C1	first consonant in a consonant-consonant sequence
C2	second consonant in a consonant-consonant sequence
V	vowel
V1	first vowel in a vowel diphthong sequence
V2	second vowel in a vowel diphthong sequence
Nuc	syllable nucleus
O	syllable onset
R	syllable rime
u	unstressed
S	stressed
IV	independent variable
DV	dependent variable

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I am grateful for the support and encouragement of my classmates, friends and family. Special thanks go to my parents for all they have given me.

Dedication

Dedicated in memory of my sister, who in ten short years gave me a lifetime of inspiration.

Chapter 1: Introduction

Recent research suggests that structural mismatch patterns in English-speaking children's productions of multisyllabic words (MSWs)[1] can indicate protracted phonological development (PPD)[2] and provide greater depth of information on a child's development than shorter monosyllabic and disyllabic words (James, 2006). Limited evidence is available on the prosodic development of MSWs in monolingual Spanish-speaking children. The existing studies generally focus exclusively on segments, use small sample sizes and/or include only typically developing (TD) children or those with PPD (Acevedo, 1993; Goldstein, 2005; Barlow, 2006; Lleó & Arias, 2006; Astruc, Payne, Post, Prieto, & Vanrell, 2010). To date there is no evidence of direct comparison between Spanish-speaking children with typical and atypical phonological development for word stress, length and shape measures in MSWs. The current study aims to address this gap in the literature. A non-linear phonological rubric was used to analyze MSW productions in 29 monolingual Spanish-speaking children with PPD and 30 age-matched children with TD. The following sections will provide a brief review of the phonological components of MSWs and an outline of Granada Spanish including previous research on phonological acquisition among Spanish-speaking children. A particular focus throughout the review will be word stress, length and shape.

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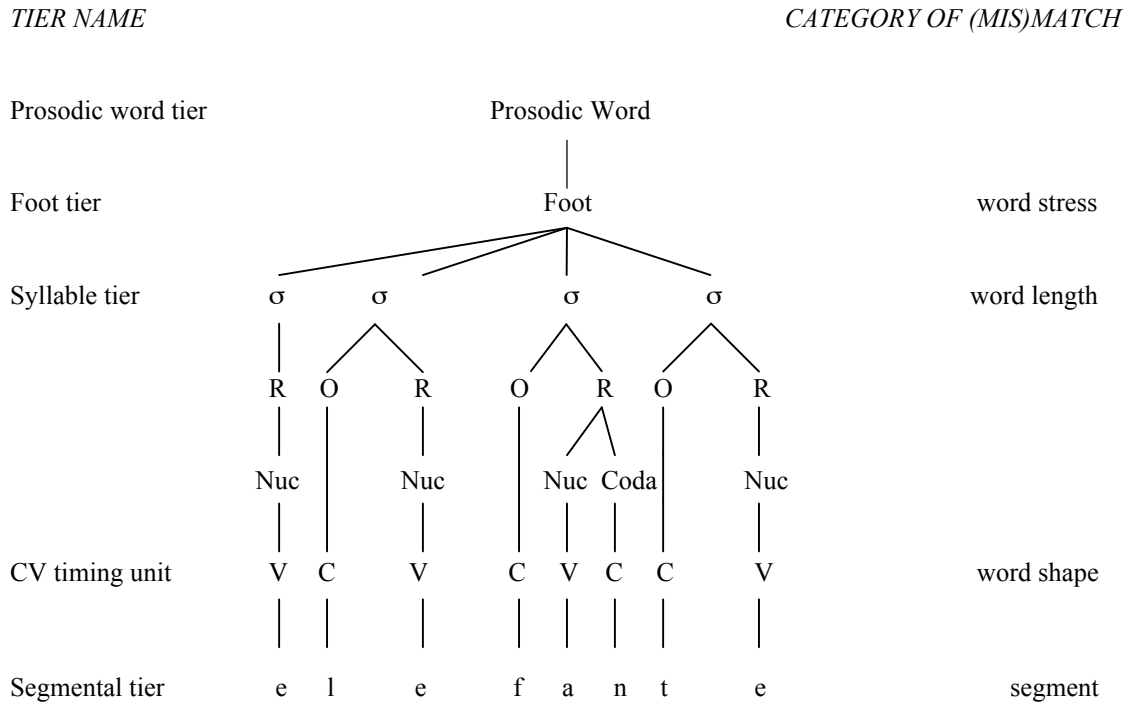
[1] Variation exists in the literature regarding terms for words with more than one syllable. In this thesis, "monosyllabic" refers to words with one syllable, "disyllabic" refers to words with two syllables and "multisyllabic" refers to words with three or more syllables. Words with two syllables are not included in the term "multisyllabic" in the current study. This use of "multisyllabic" is similar to the use of "polysyllabic" by other authors (James, 2006).

[2] The term 'protracted phonological development' (PPD) is used throughout this thesis as a synonym for 'speech sound disorder' and 'phonological impairment/disorder/deviation/delay'. This term has a more neutral impact in that it implies an individual may eventually acquire 'typical' speech (Bernhardt & Stemberger, 1998).

1.1 Structure of multisyllabic words

From a non-linear perspective, words are made of several different hierarchical tiers, or levels, which combine to form a 'prosodic word' (Bernhardt & Stemberger, 1998). See Figure 1.1 for a schematic of the prosodic hierarchy with the 4-syllable Spanish target, *elefante* /e.leˈfan.te/ 'elephant'.

Figure 1.1 The prosodic word hierarchy



The lowest tier in the prosodic hierarchy holds the segmental content of the target word including the phonological features (e.g. place, manner, voicing) of the phoneme. This tier is called the segmental tier and identifies the individual segments present in the word. Above the segmental tier are slots for consonant (C) and vowel (V) timing units. This CV timing unit tier provides information regarding syllable structure, or word shape: the number and order of consonant and vowels in each syllable is established at this level. The CV timing units link

upward to the syllable (σ) tier, which indicates the number of syllables – or word length – in a given prosodic word.

The mechanisms underlying syllable structure, including the onset, rime, nucleus and coda, are depicted between the CV timing unit and syllable tiers.[3] The vowel segment of each syllable links to the nucleus, while syllable-final consonants link to the coda. Together the nucleus and coda form a branching rime that links up to the syllable. The initial consonant(s) of a syllable join directly to the onset. Like the rime, the onset links up to the syllable. Language-specific rules influence how many Cs and Vs may link into the onset and rime of each syllable. For instance, in Spanish, there may only be two consecutive consonants in the onset of a syllable (Goldstein, 2007).

Moving up the prosodic hierarchy, the individual syllables link together into a foot. Stress, which refers to the prominence of syllables relative to each other, is assigned at the foot tier. In the current study, only lexical stress (i.e. stress within word boundaries) was considered. While there is some controversy in the literature regarding the realization of stress in Spanish, Lleó and Arias (2006) report that it is primarily realized acoustically with increased duration, increased amplitude and falling fundamental frequency of the prominent syllable relative to its surrounding syllables. Stressed syllables ('S') may also be referred to as 'strong' syllables. In

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[3] A common approach to syllable structure and timing unit in phonological literature is moraic theory. While many researchers have included the mora in their description of Spanish prosodic acquisition (c.f. Demuth, 2001; Prieto, 2006; Colina, 2009), the role of moras in Spanish-speaking children's prosodic words is not entirely without debate (c.f. Lleó & Arias, 2006). Moraic theory has been excluded from this paper in favour of a more conventional approach to syllable structure including the onset, rime, nucleus and coda hierarchy (Bernhardt & Stemberger, 1998) to provide a more transparent description of what consonants and vowels are present in the syllable structure of MSW productions. Further comments on moraic theory are beyond the scope of this paper.

contrast, a syllable without stress has relatively less duration and amplitude and is considered unstressed (‘u’) or ‘weak’.[4]

The foot is a grouping of syllables that contains one (and only one) stressed syllable, considered the ‘head’ of the foot. A foot typically has two syllables but may have more: in 3-, 4- and 5-syllable Spanish words, all syllables link up to one foot as Spanish permits just one stressed syllable at the word level (Gennari & Demuth, 1997). Each foot links upward to the prosodic word tier, which is the highest level of the prosodic word hierarchy addressed in the current study. The term ‘prosody’ in this context therefore refers to all of the suprasegmental content in the hierarchy: CV timing units, syllables, feet and the prosodic word are realized above (‘supra’) the segmental tier.

Following this model, multisyllabic words (MSWs) require the speaker to organize phonological information at multiple tier levels simultaneously for accurate productions. Moreover, sequences of consonants, vowels and syllables may occur in MSWs that are not possible in shorter words (James, 2006). For instance, in the Spanish word *hipopótamo* /i.poˈpo.ta.mo/ ‘hippopotamus’, the stress pattern ‘uuSuu’ includes sequences of unstressed syllables that are not permissible in mono- or disyllabic targets, given that every prosodic word requires a foot, and every foot requires one stressed syllable. The target *triángulo* /ˈtrjaŋ.{g/ɣ}u.lo/ ‘triangle’ illustrates the complexity of syllable structures that may compound in MSWs: the structure of the initial syllable (in isolation) is a complex CCVVC, yet within the MSW context it becomes a more complex sequence, CCVVC.CV.CV. Therefore MSWs place additional demands on the speaker’s phonological abilities at several levels of the prosodic

[4] In the current paper, the stress patterns of words will be described with ‘u’ and ‘S’: for example, a word with three syllables and word-medial stress will be referred to as a ‘uSu’ (unstressed-stressed-unstressed) target.

hierarchy. Children may have difficulty with one or more tiers of the hierarchy, resulting in mismatches at various and/or multiple prosodic levels.

An additional consideration for production of MSWs is the role of frequency and familiarity of targets at the phonological and lexical levels. Edwards and Beckman (2008) discussed the role that linguistic universals and language-specific tendencies play in segment sequence acquisition by young children from diverse language backgrounds. They concluded that both language-specific frequency and cross-linguistic universals of the phonological components of words impact 2- and 3-year olds' sequence production (Edwards & Beckman, 2008). At the word stress level, Prieto (2006) reported that input frequency of different stress patterns was correlated with Catalan- and Spanish-speaking monolingual children's early prosodic development. Moreover, the frequency of a prosodic word in a given language may impact the ease with which a child can produce it, if increased familiarity allows the child to allocate greater cognitive resources to the multiple phonological tiers involved.

1.2 Children's production of multisyllabic words

A large proportion of the existing studies on MSW productions by children are based on English data. For example, an extensive study by James (2006) provided information about monolingual English-speaking children. Following a thorough review of the literature, James found that production of MSWs can be a unique indicator of speech impairment on single-word picture naming tasks. Moreover, James' analyses of MSW productions by 283 typically-developing children aged 3;0 to 7;11 (years; months) showed that mismatch pattern use persisted for MSW targets longer than for mono- and disyllabic targets. Specifically, weak syllable deletion was used more frequently in MSWs than in words with two syllables and also persisted until 7;11 for the multisyllabic targets (James, 2006; James, van Doorn, & McLeod, 2008).

James (2006) suggested that using MSWs in picture-naming tasks may provide the most thorough description of children's phonological systems, since typically developing English children used mismatch patterns in MSWs that were rarely present in mono- and disyllabics.

Kehoe (2001) reported similar syllable length trends in early MSW productions by typically developing English-speaking children ages 1;6 to 2;10. She observed that when syllable deletion occurred, primary stressed syllables and final syllables were preserved more often than non-final unstressed syllables. Kehoe (2001) also noted that segmental content may affect internal unstressed syllable deletion. For example, the children in her sample tended to preserve all target syllables when internal unstressed syllables had obstruent onsets, as in "oc**t**opus," and instead use syllable deletion when internal unstressed syllables has sonorant onsets, as in "e**l**ephant". These findings suggested that for young English-speaking children, non-final weak syllables are more vulnerable than stressed and/or final syllables.

Further research on MSWs has suggested that a group effect exists between children with TD and PPD. Flipsen (2006) studied typical and atypical development in children between the ages of three and eight years. He compared syllables per word in English conversational speech sample data from 320 children with age-appropriate, typical speech (TD) and 202 children with PPD. The number of syllables per word increased significantly with age among the TD group but did not show any significant changes within the PPD group. However, Flipsen (2006) commented that results may have been confounded by the PPD group's potential language impairment and/or a tendency to use shorter, simpler words to increase conversational intelligibility. Despite these possible confounds, Flipsen's findings indicated the possibility of group differences in use of longer words within his English-speaking sample.

Thus, the data from English-speaking children underscore the significance of including MSWs in phonological analyses to fully understand a child's abilities at each level of the prosodic hierarchy. A common finding is that unstressed syllables in English MSWs are particularly vulnerable to mismatch (Kehoe, 2001; James, 2006). This pattern is unsurprising given that within a MSW, the prosodic environment of a syllable is more complex than that of a two-syllable word. The capacity of a child's phonological system may be exceeded by demands at multiple levels of the prosodic hierarchy: as the number of syllables increases, so too does the likelihood of increasingly complex stress patterns and syllable structures sequencing together in the word. The possibility of interactions between the segmental content and suprasegmental content also increases with increasing word length. If a child's system therefore reduces the sequential complexity of the target, i.e. by eliminating a syllable, the child may then be capable of producing the remainder of the target. The ability to organize and sequence the various components of the prosodic hierarchy can thus be assessed more effectively using complex targets – i.e. MSWs – rather than mono- and disyllabic words.

The following sections will provide an outline of (Granada) Spanish and a review of typical and atypical phonological development in Spanish. Emphasis will be placed on prosodic factors of MSWs including word length, word stress and word shape rather than segmental acquisition.

1.3 Overview of Spanish word prosody

Spanish is a Romance language noted to be the third most commonly spoken language in the world (Goldstein, 2007). Participants in the current study, from Granada, Spain, speak the Southern dialect of Iberian Peninsular Spanish, similar to most dialects in North and South America (Bernhardt et al., unpublished).

1.3.1 Spanish stress and word length

Spanish is a language of relatively long words. Among content words, disyllabic words are the most frequent (42%), while together words with three (20%) and four syllables (10%) make up the next largest group (30%), followed by monosyllabic words (28%) (Quilis, 1983). The basic foot in Spanish is the left-prominent trochee, and the majority of disyllabic words follow this stressed-unstressed pattern (Quilis, 1983). However, right and centre-prominent stress patterns also occur, as in *ratón* /raˈton/ 'mouse' (uS) and *chocolate* /tʃo.koˈla.te/ 'chocolate' (uuSu). Spanish stress assignment is well-known for the "three syllable window," in which stress may not occur further than three syllables from the right boundary of the word, as in *teléfono* /teˈle.fo.no/ 'telephone' (uSuu) and *pájaro* /ˈpa.xa.ɾo/ 'telephone' (Roca, 2006). Exceptions to this rule occur when clitics are added to lexical words, as in *dígamelo* /ˈdi.ɣa.me.lo/ 'tell me that', where the clitics *me* 'me' and *lo* 'that' are suffixed to the verb root *díga* 'say/tell'. Word stress may occur on or to the right of a branching penultimate syllable with both a nucleus and a rime (e.g. *saltando* /salˈtan.do/ 'jumping', uSu). Stress on the antepenultimate syllable is also permissible when the penultimate syllable is non-branching (e.g. *lampara* /ˈlam.pa.ɾa/ 'lamp', Suu) (Colina, 2009). At the single-word level, syllables are either stressed ('S') or unstressed ('u') and generally are considered not to carry secondary stress, which is assigned at the phrase level (Gennari & Demuth, 1997). Because Spanish is a syllable-timed language, there is no vowel reduction in unstressed syllables (Astruc et al., 2010).

1.3.2 Spanish syllable structure

Spanish follows a universal syllable typology with a preferred, unmarked CV syllable type (Colina, 2009). Onsets are not obligatory and, in the majority of Spanish dialects, syllables may have a maximum of two consonants in the onset and up to two consonants in the coda: V,

VC, CV, CVC, CCV, CCVC, VCC, CVCC, or CCVCC (Goldstein, 2007). However, syllable codas are generally simple (C) rather than complex (Lleó, 2008). The nucleus of the syllable may contain a simple vowel (V) or complex diphthong (VV), but a maximum of three segments are permitted within the rhyme of any syllable: in other words, a complex coda cannot follow a diphthong (Colina, 2009).

Of the 18 Spanish consonants (/p/, /b/, /t/, /d/, /k/, /g/, /tʃ/, /f/, /θ/, /s/, /x/ (or /h/), /ʝ/[5], /m/, /n/, /ɲ/, /l/, /ɾ/ and /r/), syllable-initial onset clusters can be created with the obstruents /p/, /b/, /t/, /d/, /k/, /g/ or /f/ in the first consonant (C1) slot and either /l/ or /ɾ/ in the second consonant (C2) slot, as in *dragón* /dɾaˈɣon/ 'dragon' (Goldstein, 2007). A variety of medial consonant sequences can occur across syllable boundaries in heterosyllabic sequences, with common instances including /nt/, /nd/, /st/, /ns/, /sp/, /ɾt/, /ɾk/, and /mb/ (Goldstein, 2007), e.g. *princesa* /pɾinˈse.sa/ 'princess' and *saltando* /salˈtan.do/ 'jumping'.

In the Andalusian (Southern) region of Spain, allophonic variation allows deletion of certain consonant segments, therefore affecting the syllable structure. The deletion or aspiration [h] of word-medial and word-final coda /s/ consonants is permissible, with medial /s/ typically preserved only in formal speech; final /s/ is more commonly retained when present for morphological rather than lexical content (Salcedo, 2010). For example, *escalera* /esˈka.le.ɾa/ 'staircase' may be produced as [esˈka.le.ɾa], [eʰˈka.le.ɾa] or [eˈka.le.ɾa]. Nasal targets /n/ and /ŋ/ may also be deleted in coda position in words of two or more syllables, with the preceding vowel becoming nasalized, e.g. *ratón* /raˈton/ 'mouse' as [raˈton], [raˈtoŋ] or [raˈtõ] (Salcedo, 2010). Similarly, the liquids /l/ and /ɾ/ may be deleted in word-final position. Further acceptable instances of allophonic variation and neutralization in adult Granada Spanish are provided in the

[5] The segment /ʝ/ may alternate with /ʎ/ in some dialects.

target words listed in Table 2.2 and will not be discussed further because they affect segmental rather than structural content. See the original study from which the current data were drawn for additional examples (Bernhardt et al., unpublished).

The glides /j/ and /w/ can occur in both prevocalic and postvocalic positions (Colina, 2009). There is some debate in the literature about whether the glides pattern as part of the nucleus in CjV and CwV syllables. Colina (2009) suggests there is strong evidence that glides are part of the syllable nucleus in child speech. For instance, Barlow (2005) analyzed one child's use of consonant clusters in a single-subject case study and observed treatment effects only for clusters with two consonants. This monolingual Spanish-speaking child did not show generalization of these treatment effects to consonant-glide sequences, suggesting that for this child at least, the glides were slotted into the nucleus (Barlow, 2005). However, an instance of the glides behaving as onsets was reported by Kehoe, Hilaire-Debove, Demuth and Lleó (2008). The approach that glides pattern as diphthongs will be followed in the current study, as per the original study by Bernhardt et al. (unpublished). Diphthongs with an initial steady state glide /j/ or /w/ are considered equal to diphthongs with initial steady state /i/ or /u/ and are termed rising diphthongs, e.g. *abierta* /aˈβ{**ie/je**}ɾ.ta/ 'open'. In contrast, falling diphthongs are those with a vowel followed by a steady state /i/ or /u/ e.g. *bailando* /b**ai**ˈlan.do/ 'dancing' and *Europa* /**eu**ˈɾo.pa/ 'Europe'. Note that in rapid speech, speakers may reduce diphthongs; for instance, the target /**eu**ˈɾo.pa/ may be produced as [**u**ˈɾo.pa].

1.4 Phonological acquisition in Spanish-speaking children

While many researchers have investigated segmental acquisition among typically developing Spanish-speaking children, a shift to investigations of word stress, word length and word shape – i.e. syllable structure – has yielded a number of studies on typical word prosody

development. Far less evidence of atypical prosodic development has been reported to date. A review of both typical and atypical prosodic development in Spanish follows.

1.4.1 Acquisition by typically-developing Spanish-speaking children

At the word stress level, Lleó and Arias (2006) reported that Spanish-speaking children can correctly assign stress early in development. They investigated stress acquisition patterns in the early stages of word learning by two monolingual TD Spanish-speaking children at ages 1;0 to 2;0. The researchers examined 20 single-word utterances with trochaic stress (Su) from each child's spontaneous speech. Three- and four-syllable words with penultimate stress were also analyzed including three trisyllabic words (uSu) and two quadrisyllabic words (uuSu). Stress production mismatches occurred in a very small number of single-word trochaic utterances, in which the child used equal stress. An interesting finding was that at ages 1;8 and 1;9, both children began to change single-word utterance iambs (uS) into trochees (Su), even though they had each previously produced instances of iambic stress. Lleó and Arias (2006) suggested that this U-shaped development path was a phonological representation-based mismatch in which non-trochaic (i.e. iambic) stress patterns were temporarily not permitted within the system. This evidence of the earliest stress assignment underscored the Spanish preference for trochaic feet (Su). Nevertheless, iambic (uS) and trochaic (Su) stress plus select uSu and uuSu stress patterns were used early by both participants (Lleó & Arias, 2006).

In other research, typically-developing Spanish-speaking children have also been observed to use uS patterns from the beginning of prosodic word development and to use uSu words correctly from ages 1;10 – 1;11, likely due to the high frequency of these structures in the input (Prieto, 2006). Demuth (2001) reported data from an Argentinean Spanish-speaking child, Sofía, who used disyllabic trochees (Su) and iambs (uS) at age 1;8. Sofía also used occasional

uSu trisyllabic words at age 1;8, several months earlier than has been observed in English and Dutch-speaking children who typically begin to use uSu words after age 2;0 (Demuth, 2001). Note, however, there are individual exceptions to this pattern, with early acquisition of MSWs observed in some English-speaking children (Bernhardt & Stemberger, 1998).

Crosslinguistic studies have also provided evidence of Spanish-speaking children's MSW stress patterns appearing earlier than their non-Spanish-speaking peers. Astruc et al. (2010) studied the development of prosodic word types among monolingual Spanish-, Catalan- and English-speaking children at ages two, four and six. Using a spontaneous elicitation naming task, the researchers found that the 12 Spanish-speaking children produced a higher number of MSWs and more complex prosodic word types overall than the 12 English-speaking children. At age two, all the children used trochees most frequently when producing citation forms of a variety of increasingly complex stress patterns. However, at that same age, the Spanish- and Catalan-speaking children used less truncation and produced higher proportions of trisyllabic uSu words than the English-speaking children. Based on their results across age groups, Astruc et al. (2010) suggested that Spanish- and Catalan-speaking children can master complex prosodic words earlier than English-speaking children.

Lleó (2006) conducted a case study on the acquisition of stress patterns by three Spanish monolingual and three Spanish-German bilingual children within a naturalistic setting. She found that among the monolingual Spanish-speaking children, trochaic disyllables (Su) emerged first, centre-prominent trisyllables (uSu) and iambic disyllables (uS) emerged second, and monosyllables (S) emerged third in their spontaneous speech. The Spanish-speaking monolingual children had fewer monosyllabic productions than their German- and Spanish-

speaking bilingual peers. Lleó (2006) suggested these results reflected word stress input frequency in Spanish.

Piñeira and Manzano (2000) studied both the stress patterns and word length (i.e. number of syllables) used by children acquiring Spanish in Cuba. The authors transcribed the spontaneous conversational utterances of 200 typically-developing children ages 11.16 months to 49.16 months. The children spoke to their peers and the two researchers during half-hour observation sessions. Literal transcriptions were used when collecting the samples. The resulting database included 15,428 word tokens with 1,259 word types (Piñeiro & Manzano, 2000). The stress pattern observed most commonly in the children's word types was penultimate (e.g. Su, uSu; 75.1%), followed by words with ultimate stress (e.g. uS, uuS; 21.8%) and, rarely, antepenultimate stress (Suu; 2.9%). The authors report that these proportions roughly match that of adult Spanish stress patterns. For word length, the number of syllables in the children's words ranged from one to five with a mean of 2.46 (SD = 0.82), suggesting that on average Spanish words are relatively long – two to three syllables – even in early acquisition.

Overall these findings reveal early acquisition of word stress and word length patterns in small sample studies of Spanish-speaking children. The trends reflect the importance of prosodic forms in the children's phonological input: because Spanish is a language with relatively long words, children exposed to it appear to acquire longer words relatively early. The use of prosodic forms in child-directed speech has been reported as follows: Su (41%), S (26%), uSu (17%) and uS (11%) with both Suu and uuS forms at less than 5% (Prieto, 2006). Another study, by Roark and Demuth (2000), reported near-equal rates of approximately 30% for both S monosyllabic words and Su disyllabic words in child-directed speech. However, the authors included closed-class monosyllables in their analysis: the words *con, en, es, no, por, qúe, sí, ver, y, ya* accounted

for 88% of the monosyllabic S counts. This analysis approach was problematic because some of these monosyllables can appear in phrases as unstressed clitics in multisyllabic words rather than single stressed monosyllables. Nevertheless, in spite of this different approach to calculating input frequency, the most common stress patterns in child-directed speech in both studies were uS, S, uSu and uS forms (Prieto, 2006; Roark & Demuth, 2000).

At the syllable level, children's typical acquisition also tends to show patterns similar to that of syllable frequency in adult Spanish. The first prosodic elements to emerge are usually open CV and V syllables, followed by singleton coda CVC syllables and, later, complex onsets (Morales-Front, 2006). As with stress pattern acquisition, the pattern of syllable acquisition appears to be strongly predicted by the frequency of syllable types in the children's environment, i.e. in child-directed speech (Prieto, 2006; Morales-Front, 2006).

Syllable complexity seems to increase gradually among children acquiring Spanish. Barlow (2006) examined the consonant sequences of two typically-developing children, 'Fabiola' age 3;4 and 'Joaquín' age 2;1-2;10 and reported reduction of tautosyllabic sequences to a single consonant. Both children also reduced some heterosyllabic sequences but allowed others to occur: Fabiola produced heterosyllabic sequences when a sonorant plus voiceless obstruent was present, while Joaquín produced heterosyllabic sequences with an initial nasal segment. Otherwise heterosyllabic sequences were reduced to a single consonant.

Similarly, Goldstein and Iglesias (1996) observed phonological patterns in an elicited sample of 78 single words from 54 Puerto Rican Spanish-speaking preschoolers with typical development, including 35 simple mono- and disyllabic targets, 10 targets with initial clusters and 33 multisyllabic targets. Developmental patterns observed among the 3- and 4-year-old children included cluster reduction, liquid simplification, final consonant deletion, weak syllable

deletion, assimilation and initial consonant deletion. With the exception of cluster reduction in 3-year-olds, all of these patterns occurred in less than 10% of the possible opportunities and most occurred in less than 5%: for example, weak syllable deletion was used in just 2% of opportunities by 3- and 4-year-olds. The simplification of consonant clusters was a particularly common pattern, used in 15% of possible occurrences in 3-year-olds and 6% in 4-year-olds (Goldstein & Iglesias, 1996).

1.4.2 Acquisition by Spanish-speaking children with protracted phonological development

Minimal research has been reported on the acquisition of prosodic forms by Spanish-speaking children with protracted phonological development (PPD). At the syllable shape level, Barlow (2006) found that two children with PPD and no other developmental concerns (SD1, female age 3;4 and SD2, female age 3;9) had different patterns for consonant sequences. SD1 used tautosyllabic sequences but reduced all heterosyllabic sequences to a single consonant. SD2 reduced all sequences (both tauto- and heterosyllabic) to a single consonant. SD2 may have had an interaction between the CC syllable shape and voicing (Barlow, 2006). These patterns suggested that children with PPD may follow patterns of acquisition similar to their TD peers, albeit at a slower time frame, yet may also show idiosyncratic mismatch patterns.

Goldstein, Fabiano and Iglesias (2004) analyzed productions of 12 Spanish-speaking children with PPD age 3;1 to 4;9. The children were considered to be incipient bilinguals who spoke Puerto Rican Spanish exclusively at home and spoke both Spanish and English at school with less than 4 months exposure to English. The researchers elicited 36 target words for each child, primarily mono- and disyllables, and analyzed only the tokens with spontaneous and imitated single-word productions by the same child. This process resulted in 121 targets (242

productions across the sample). The researchers observed similar mismatch patterns in this group with PPD as noted in previous research on children with TD, such as final consonant deletion, initial consonant deletion, weak syllable deletion, and cluster reduction (Goldstein & Iglesias, 1996). However, the children with PPD used these patterns at a (far) higher rate than observed in TD Spanish-speaking children (Goldstein, Fabiano, & Iglesias, 2004).

Chávez-Peón et al. (2012) ran a pilot study for the original study by Bernhardt et al. (unpublished) from which the current MSW data set was drawn. Chávez-Peón et al. investigated Spanish speech productions by two 4-year-old children with PPD: RP1, who spoke Argentinean Spanish, and RP2, who spoke Mexican Spanish. Both children had emigrated to Canada and had been exposed to English yet were functionally monolingual. Using a similar 100-word list and the same elicitation protocol as for the study from which the current data were extracted, Chávez-Peón et al. found while that word length and stress patterns were relatively well preserved although in both participants, weak syllable deletion occurred more frequently with increasing word length. RP2 also used stress shift twice for strong-initial words and three times for weak-initial words.

On measures of syllable structure, Chávez-Peón et al. reported that both RP1 and RP2 preserved codas comparatively more frequently than onsets. This pattern contradicted expected developmental trends, in which onsets are typically acquired before coda consonants (Chávez-Peón et al., 2012). Results of the pilot study showed that both children preserved 100% of coda consonants but omitted onset consonants in weak-initial syllables and – more rarely – strong-initial syllables.

Chávez-Peón et al. also found that the children used few contiguous consonant sequences. Word-initial consonant sequences were particularly uncommon. RP1 and RP2 used

several strategies, including cluster reduction – as would be expected developmentally – and other patterns such as harmony, metathesis and glottal stop replacement. In addition, contiguous vowel sequences were reduced or substituted in 50% of the words produced by each child.

Similar to the findings of Goldstein, Fabiano and Iglesias (2004) and Barlow (2006), the results of the pilot study suggested that Spanish-speaking children with PPD may follow developmental patterns – at higher frequencies than typically developing children – in addition to less common patterns, such as onset deletion. However, the small sample size (n=2) limits the possibility of generalization of the results.

No other direct studies were found on the subject of word stress, word length and word shape acquisition in Spanish-speaking children with PPD. Further research is necessary to gain a clearer understanding of prosodic development in this population.

1.5 Approaches to measuring productions of multisyllabic words

In order to investigate children's prosodic acquisition, it is crucial to be able to measure the relevant participant and prosodic factors appropriately. A significant challenge in the study of children's MSWs is determining how to measure the productions. In the field of phonological acquisition, two global analysis methods are in current use: percent consonants correct (PCC: Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997), and the whole word approach, e.g. Ingram and Ingram (2001). Because they are commonly used, these methods are discussed briefly below, with their limitations for evaluation of MSWs presented as a rationale for the methods in this study.

1.5.1 Percent consonants correct metric

In phonological acquisition research, the evaluation of segment match is a long-attested analysis method. The percentage of consonants correct metric (PCC), initially proposed by

Shriberg (1993), has been used as a measure for assessing severity of PPD. The PCC measure involves a count of correct (exact target match) consonants in a child's conversational speech sample. Vowels are not counted and analysis is restricted to a simple match/mismatch score for consonants attempted. Distortions are considered incorrect. Shriberg et al. (1997) described numerous extended measures used in concert with PCC, including the PCI: percentage of consonants in the inventory (a weighted relational measure of consonants in a child's inventory), the ACI: articulation competence index (a measure of differentially weighted distortion errors), the PCC-A: percentage of consonants correct—adjusted (a PCC measure that accepts common distortions as correct while uncommon distortions are incorrect), PCC-R: percentage of consonants correct—revised (a PCC measure that accepts both common and uncommon distortions), the PVC: percentage of vowels/diphthongs correct (equivalent to PCC for vowels), the PVC-R: percentage of vowels/diphthongs correct—revised (a PVC measure that accepts all distortions), the PPC: percentage of phonemes correct (equivalent to PCC for all segments) and lastly the PPC-R: percentage of phonemes correct—revised (PPC that accepts all distortions).

However, the PCC and its extensions fail to incorporate any information beyond the segmental level and omit any information on what type of mismatches are made. For multisyllabic targets, the PCC measure obscures the complex patterns of mismatches that occur at the suprasegmental levels of the prosodic hierarchy.

1.5.2 Whole word approach

Ingram and Ingram (2001) proposed a different approach for analysis of children's words in conversational speech samples. Rather than focusing solely on correctness of individual segments, Ingram and Ingram advocated the use of a whole word approach to complement segmental analyses. Their whole word analysis includes measures of (1) whole word correctness,

(2) word complexity, (3) proximity to the adult target and (4) variability of production. Whole word correctness is calculated by comparing each of the child's productions to the respective adult targets. The number of matches is divided by the total number of targets to produce the proportion of whole word correctness, or PWW. The word complexity measure involves calculating the phonological mean length of utterance (PMLU) by counting the number of consonants and vowels present in the child's production and adding one point for each consonant that is an exact segmental target match. The proportion of whole-word proximity (PWP) is measured by diving the child's PMLU by the total PMLU of the adult target. This calculation was designed to approximate the intelligibility of a child's production: in other words, the more proximal the child's production is to the adult target, the more intelligible it is likely to be. The final measure in the whole word approach is whole word variability for productions repeated by the child. A separate word repetition task is necessary for analyzing whole word variability in addition to the conversation sample analysis using PWW, PMLU and PWP. See Ingram (2002) for an in-depth account of these whole word measures.

The whole word approach was designed to capture a greater degree of information than segmental analyses alone. It allows estimation of a child's phonological developmental stage, provides a comparison of children between and within languages, and can identify children with PPD. As a global measure, the whole word approach is valuable as a reasonably fast method of gaining an overall sense of a child's phonological abilities at the word level. For example, Bernhardt et al. (unpublished) have used a variation of the whole word correctness analysis adapted for a single-word elicitation task to confirm the placement of research participants with TD and with PPD in their respective analysis groups.

However, in actual practice, there are several limitations to the whole word approach for phonological analysis. Ingram (2002) noted that the measure is not able to provide specifics about an individual child's phonological system, such as match and mismatch patterns at the segmental or syllable level. Moreover, there are no clear guidelines as to whether the measures should be applied to phonemic versus phonetic transcriptions. For example, it is unclear whether or not the absence of a diacritic in a word would result in a non-match with the adult target. The whole word approach is likely to be applied inconsistently across studies and ultimately provides only general information about children's phonological abilities.

Thus, neither the PCC nor the whole word approach was suitable for the current analysis of MSWs: the PCC and subsequent metrics limit analysis to the segmental level, while the whole word approach provides only global information about word production.

1.5.3 The multisyllabic rubric

Given the limitations of the whole word approach and PCC metric described above, a novel scoring approach was adpoted for the current study. A multisyllabic rubric was adapted and developed to evaluate elicited single MSW productions at multiple levels of the prosodic hierarchy. Based on the work of Mason, Bernhardt and Masterson (2011), this rubric captured information across the prosodic hierarchy tiers to create a global mismatch score while also detailing individual and group mismatch patterns. Further information on the design of the multisyllabic rubric is provided below in Section 2.4.

1.6 Research questions

Due to the lack of existing evidence regarding acquisition of word stress, word length and word shape in multisyllabic word productions of Spanish-speaking children with TD versus PPD, the current study set out to examine word prosody patterns in MSWs by monolingual 3-, 4-

and 5-year old speakers of Granada Spanish. A total of 29 participants were previously identified with PPD and 30 participants were typically developing. The current MSW production data, including 6 disyllabic iambic targets and 36 multisyllabic targets per participant, were extracted from the full Granada Spanish phonological sample (see Bernhardt et al., unpublished). A non-linear multisyllabic scoring rubric was developed for the Spanish data, based on Mason, Bernhardt and Masterson (2011), to allow a richer and more extensive analysis than possible with measures such as the PCC or whole word approach (Shriberg, 1993; Ingram & Ingram, 2001).

The current investigation was driven by two primary research goals: (1) to determine the role of participant factors including diagnostic group and age in Spanish MSW productions and (2) to explore the phonological trends in word prosody (stress and length) among these Spanish-speaking preschoolers. A series of descriptive and inferential analyses were used to address these goals as outlined in the research questions below.

1.6.1 Research question 1: Participant factors

Research question 1: Among Spanish-speaking children, how do children with PPD versus TD compare on prosodic measures in MSW productions and how does their performance on these measures change with age?

Background rationale: Previous evidence from Spanish-speaking children has shown effects of group and age (Astruc et al., 2010; Goldstein, Fabiano, & Iglesias, 2004). Studies of English-speaking children have reported similar effects (James, 2006; Flipsen, 2006).

Therefore the experimental hypotheses were (1) that prosodic percent match would increase with increasing age and (2) that children with TD would have greater percent match than children with PPD.

1.6.2 Research question 2: Mismatch patterns in multisyllabic words

Research question 2: What types of mismatch patterns occur most frequently in MSW productions among Spanish-speaking children and how frequently do these mismatch patterns occur across group and age?

Background rationale: According to the literature, Spanish-speaking children with TD and PPD use weak syllable deletion and the deletion of consonants in sequences within disyllabic and MSW productions (Goldstein & Iglesias, 1996; Barlow, 2006; Astruc et al., 2010; Chávez-Peón et al., 2012). Of the phonological patterns noted in TD Spanish-speaking children by Goldstein and Iglesias (1996), consonant deletions – including cluster reductions – and assimilations were the most common patterns occurring beyond the segment level and applicable to the current study (i.e., patterns such as velar fronting, a segmental mismatch, were disregarded). The limited evidence of MSW production in Spanish-speaking children suggests that they use mismatch patterns at a greater rate than their TD peers (Goldstein, Fabiano, & Iglesias, 2004). An effect of age has been noted for patterns such as weak syllable deletion among English- and Spanish-speaking children (James, 2006; Astruc et al., 2010). Thus the research hypothesis for this analysis was that patterns involving deletion and assimilation would occur with both groups' productions with a greater frequency among younger participants and those with PPD.

1.6.3 Research question 3: Prosodic factors

Research question 3A: Is there a difference in number of mismatch patterns used in initial unstressed syllables relative to non-initial stressed syllables in Spanish-speaking children with PPD versus children with TD?

Background rationale: Previous research in English has highlighted the vulnerability of initial unstressed syllables in MSWs (Bernhardt & Stemberger, 1998; Kehoe, 2001). The research hypothesis predicted larger discrepancies between initial unstressed and non-initial stressed syllables among children with PPD compared to children with TD.

Research question 3B: Is there a difference in frequency of prosodic mismatch patterns across targets with 2-, 3- and 4+-syllables?

Background rationale: Studies of typically-developing English and Spanish-speaking monolingual children have shown less word structure accuracy in longer 3- and 4-syllable words than in mono- and disyllabic targets (Astruc et al., 2010; James, 2006). Therefore the research hypothesis was that as word length increased, the frequency of mismatch patterns would also increase.

Chapter 2: Method

2.1 Study background

The research presented in this thesis is based on an existing data set from Granada, Spain, which was collected as part of an ongoing international crosslinguistic project (Bernhardt et al., 2010; 2011). (See Bernhardt et al. (unpublished) for further details of the original study.)

A pilot study for the Spanish component of the crosslinguistic project was completed by Chávez-Peón et al. (2012), described above. The overall findings suggested that the children with PPD produced patterns similar to those of typically developing children, but given the small sample size (n=2), more research was necessary. Consequently, the original study (from which the current data were drawn) was performed with a sample of 30 children with TD and 29 children with PPD.

2.2 Procedures of the original study

2.2.1 Participants

The current thesis study used data from 59 Granada Spanish-speaking participants. For the original study, a native Spanish speaker recruited 60 monolingual Spanish-speaking participants in three age groups (3, 4 and 5 years old) from local preschools in Granada, Spain, 30 with typical development and 30 with protracted phonological development and no other developmental concerns (Bernhardt et al., unpublished). Each participant was assessed using a hearing screening (25dB from 250 to 4000 Hz), an oral mechanism screening, and language comprehension and production tests including La Prueba de Lenguaje Oral Navarra – Revisada (Aguinaga, Armentia, Fraile, Olangua, & Uriz, 2004), the Test de Comprensión Estructuras Gramaticales de 2 a 4 Años (Calet, Mendoza, Carballo, Fresneda, & Muñoz, 2010), the Peabody Picture Vocabulary Test III: Test de Vocabulario en Imágenes (Dunn, Dunn, & Arribas, 2006),

and the Test Breve de Inteligencia de Kaufmann (Kaufman & Kaufman, 2009). A whole word match (WWM) analysis adapted from Ingram (2002) led to the movement of one child from the PPD to the TD group. Another child in the TD sample was excluded from the analysis because she did not complete the phonology elicitation task. The final PPD group included seven 3-year-olds, fourteen 4-year-olds and eight 5-year-olds with a total of 17 boys and 12 girls. The final TD group included ten 3-year-olds, nine 4-year-olds and eleven 5-year-olds with a total of 14 boys and 16 girls. See Table 2.1.

Table 2.1 Number of participants by group, gender and age in years

	Protracted Phonological Development (PPD)			Typical Phonological Development (TD)		
Age	Male	Female	Total	Male	Female	Total
3 years old	4	3	7	2	8	10
4 years old	8	6	14	4	5	9
5 years old	5	3	8	8	3	11
Total	17	12	**29**	14	16	**30**

2.2.2 Data collection and transcription

All the children in the original study participated in a single word picture elicitation task with 103 targets from which words were selected for the current thesis. The task included a variety of representative Spanish word lengths (from monosyllabic to 5-syllable words), stress patterns and syllable structures. Indirect imitation was used when the child did not appear to know the word. For example, for the target *dinosaurio* 'dinosaur', the researcher would ask the child if it was a *dinosaurio* or a *mesa* 'table'. The researcher requested direct imitation if the child still did not identify the word after indirect imitation.

All elicitation sessions were audio recorded using a Microtrack II digital tape recorder with a built-in microphone (2010). Native speakers of Granada Spanish performed the primary transcriptions using the International Phonetic Alphabet (IPA) following crosslinguistic project transcription conventions. Reliability of transcription for the TD sample was conducted by a Canadian team of native and non-native speakers of Spanish, with 89.01% agreement for the TD sample. Reliability for the PPD sample was not computed because a large proportion of the data were transcribed by discussion and consensus between the two teams. There were few word structure disagreements relevant for the current thesis (such as occasional use of epenthesis, or segment lengthening/shortening). Audio and transcription data was entered into PHON 1.5 (Rose & Hedlund, 2011).

2.3 Procedures of the current thesis study

A subset of 42 targets was extracted from the full 103-target elicitation set for analysis in the current study of multisyllabic words. The analysis set excluded monosyllabic words (S) and trochaic disyllabic words (Su) because these targets were part of a larger analysis in Bernhardt et al. (unpublished) and were less relevant for the current study. MSWs with 3, 4 and 5 syllables as well as iambic disyllabic words (uS) were retained in the analysis set. A total of 42 word targets with varying stress patterns and word shapes were analyzed for each participant (see Table 2.2).[6] Twenty individual production tokens were eliminated from the sample set prior to analysis because noise in the recording compromised the accuracy of transcription.

Note that throughout the coding process, characteristics of the Granada Spanish dialect were taken into account. For instance, no mismatch codes were assigned for the omission of consonants in word-final position, because word-final codas are not obligatory in longer words

[6] For a full list of targets including word shape, see Appendix A.

Table 2.2 List of targets analyzed for the current thesis study

Syllables	Stress	Orthography	Adult Target	Translation
2 (n=6)	uS	azul	aˈ{s/θ}u{l/ɾ/ø}	blue
		dragón	dɾaˈɣo{ŋ/n/ø}	dragon
		jamón	{x/h}aˈmõ{ŋ/n/ø}	ham
		nariz	naˈɾi{s/ʰ/θ/ø}	nose
		ratón	raˈto{ŋ/n/ø}	mouse
		reloj	reˈl{o/ɔ}{x/ʰ/ø}	clock
3 (n=26)	Suu	lámpara	ˈlampaɾa	lamp
		pájaro	ˈpa{x/h}aɾo	bird
		triángulo	ˈtɾjaŋɣulo	triangle
	uSu	abierta	aˈβ{je/ie}{ɾt/tː}a	open
		bailando	baiˈlan̪do	dancing
		caballo	kaˈβa{d͡ʒ/ʝ/j}o	horse
		chocando	t͡ʃoˈkan̪do	crashing
		conejo	koˈne{x/h}o	rabbit
		estanque	e{s/θ/ʰ/ø}ˈtaŋke	pond
		Europa	euˈɾopa	Europe
		guitarra	giˈtara	guitar
		hermano	e{ɾˈm/ˈmː}ãno	brother
		hirviendo	i{ɾˈβ/ˈβː}{je/ie}n̪do	boiling
		jirafa	{x/h}iˈɾafa	giraffe
		juguete	{x/h}uˈɣete	toy
		llorando	{d͡ʒ/ʝ/j}oˈran̪do	crying
		martillo	ma{ɾˈt/ˈtː}i{d͡ʒ/ʝ/j}o	hammer
		muñeca	mũˈɲeka	doll
		pescado	pe{s/θ/ʰ/ø}ˈka{ð/ø}o	fish
		princesa	pɾin̪{ˈθ/s}e{θ/s}a	princess
		regalo	reˈɣalo	gift
		saltando	{s/θ}a{l/ɾ}ˈtan̪do	jumping
		sombrero	{s/θ}omˈbɾeɾo	hat
		tortuga	to{ɾˈt/ˈtː}uɣa	turtle
		zapato	{s/θ}aˈpato	shoe
	uuS	pantalón	pan̪taˈlo{n/ŋ/ø}	pants
4, 5 (n=10)	uSuu	teléfono	teˈlefono	telephone
	uuSu	chimenea	{t͡ʃ/ʃ}imẽˈne.a	chimney
		chocolate	t͡ʃokoˈlate	chocolate
		cocodrilo	kokoˈðɾilo	crocodile
		dinosaurio	dinoˈ{s/θ}auɾjo	dinosaur
		elefante	eleˈfan̪te	elephant
		escalera	e{s/θ/ʰ/ø}kaˈle{ɾ/r}a	staircase
		primavera	pɾimaˈβeɾa	spring
		zanahoria	{s/θ}anaˈoɾja	carrot
	uuSuu	hipopótamo	ipoˈpotamo	hippopotamus

in this dialect. Furthermore, some word-medial consonants are optional, particularly in the case of fricatives in coda position of unstressed initial syllables. For example, in *escalera* /e{s/θ/ʰ/ø}kaˈle{ɾ/r}a/ 'staircase', the adult production may include a fricative in the initial syllable coda, may show reduction of the consonant to aspiration or even omit the consonant entirely. Word-medial nasal codas are obligatory; however, /l/ and /ɾ/ may become geminated, e.g. /lt/ to [tː]. Accepted segmental and structural variation in adult target form is presented in braces, "{}", in Table 2.2.

The complete multisyllabic analysis set included 2,519 tokens. A preliminary analysis showed that all participants in both groups (PPD and TD) produced "papa" /paˈpa/ with no prosodic mismatches. Consequently this target was removed from further analyses due to ceiling effects, leaving a total of 2,458 tokens for analysis. When two elicitations of a specific target were given at different points in the task – as occurred with several of the targets elicited with objects – only the second elicitation was included in the analysis set because the first was part of a warm-up set. An exception to this rule occurred when the second elicitation was imitated and the first elicitation was spontaneous, in which case the first elicitation was included in the analysis set.

A total of 675 productions were elicited with imitation, equal to approximately 27% of the current analysis set. The frequency of imitation between the PPD and TD groups was very similar, with 338 tokens imitated by the PPD group and 337 tokens imitated by the TD group. The data presented in Table 2.3, Table 2.4 and Table 2.5 demonstrate much similarity in imitation patterns between groups. These data suggest that certain target words were unfamiliar to both groups of children. For example, the target *hirviendo* 'boiling' was imitated by 26 of 29 children with PPD and 28 of 30 children with TTD, while the target *Europa* 'Europe' was

imitated by 26 and 24 children with PPD and TD, respectively. The children with PPD did not have greater difficulty identifying words than their age-matched peers with TD.

Evidence from Spanish-speaking preschoolers with PPD suggests that there may be minimal differences in accuracy of spontaneous versus imitated single-word productions elicited during a speech sample task. Goldstein, Fabiano and Iglesias (2004) compared spontaneous and imitated elicitation in Spanish-speaking children ages 3;1 to 4;9. Their primary analysis revealed that within their sample, 62% of words were produced in the same way for both spontaneous and imitated elicitation. Of the remaining 38% of words, a greater percentage were more adult-like (but not necessarily matched) in the imitation task (25%) than in the spontaneous task (13%). A secondary analysis determined whether mismatches in the initial spontaneous production were followed with more adult-like, identical or less-adult like productions in imitation. In only 7% of cases were mismatches in spontaneous productions followed by adult-like productions with imitation. In 57% of cases, mismatches were identical in both types of elicitation, while in 36% of cases a mismatch in spontaneous production was followed by a different mismatch pattern with imitation. For the current study, a decision to retain imitated tokens in the analysis set was made based on the evidence cited here in combination with the well-matched imitation rates between the PPD and TD groups.

Table 2.3 Frequency of imitated tokens by word and group for 2-syllable targets

Orthography	Translation	# Imitations PPD group	# Imitations TD group
azul	blue	4	1
dragón	dragon	11	14
jamón	ham	19	18
nariz	nose	1	0
ratón	mouse	13	8
reloj	clock	1	0
Total for 2-syllables:		**49**	**41**

Table 2.4 Frequency of imitated tokens by word and group for 3-syllable targets

Orthography	Translation	# Imitations PPD group	# Imitations TD group
abierta	open	3	4
bailando	dancing	9	4
caballo	horse	0	5
chocando	crashing	18	16
conejo	rabbit	6	5
estanque	pond	21	21
Europa	Europe	26	24
guitarra	guitar	3	2
hermano	brother	19	15
hirviendo	boiling	26	28
jirafa	giraffe	2	1
juguete	toy	25	28
llorando	crying	2	0
martillo	hammer	4	7
muñeca	doll	8	6
pescado	fish	8	6
princesa	princess	2	6
regalo	gift	1	3
saltando	jumping	7	8
sombrero	hat	9	10
tortuga	turtle	2	2
zapato	shoe	6	0
pantalón	pants	0	1
lámpara	lamp	6	9
pájaro	bird	6	3
triángulo	triangle	8	9
Total for 3-syllables:		**227**	**223**

Table 2.5 Frequency of imitated tokens by word and group for 4- and 5-syllable targets

Orthography	Translation	# Imitations PPD group	# Imitations TD group
teléfono	telephone	7	5
chimenea	chimney	9	9
chocolate	chocolate	2	2
cocodrilo	crocodile	13	12
dinosaurio	dinosaur	7	8
elefante	elephante	0	0
escalera	staircase	1	1
primavera	spring	10	18
zanahoria	carrot	1	4
hipopótamo	hippopotamus	12	14
Total for 4- and 5-syllables:		**62**	**73**

Transcriptions were entered into spreadsheets and coded with a rubric analysis (described below). Relevant data were entered into SPSS 12.0 for statistical analysis (SPSS Inc., 2003).

2.4 Coding procedure: A rubric for multisyllabic words

A spreadsheet-based rubric for scoring word stress, length and structure of MSW productions was developed to analyze the data. The rubric was based on a multisyllabic scoring system for English created by Mason, Bernhardt and Masterson (2011).

2.4.1 Rubric design

The multisyllabic scoring rubric was designed to address limitations of PCC and whole word measures, both of which emphasize segmental match and lack information regarding types of mismatch patterns. The rubric was derived from concepts of nonlinear phonology. Mismatches were analyzed at several different tiers of the prosodic word hierarchy, including the foot tier (i.e. word stress), the syllable tier (i.e. word length) and the timing unit tier (i.e. word shape) (Bernhardt & Stemberger, 1998). Thus, the word structure coding process evaluated (1) stress placement, (2) number of syllables, and (3) syllable shape (presence of consonants and vowels). A fourth area of evaluation captured changes in segmental features due to interactions between segments and word structure. These interactions between segments and word structure included codes such as reduplication, which was used when all the features of one segment were spread to another slot in the CV tier and the segment therefore was copied, or reduplicated, elsewhere in the word. Another type of segment-structure interaction code was assimilation, used with the partial rather than complete spreading of one segment's features to another segment. In the current study, mismatches at the segment level – such as a child's consistent substitution of /t/ for /k/ – were examined to determine whether a segment-structure interaction occurred. However, no mismatch points were assigned to (non-interaction) mismatches at the segment

level. Each of the 2,458 productions in the analysis set received codes for any observed mismatch patterns in the areas described above. The rubric system therefore yielded mismatch scores indicating the degree of difference between the adult target and the child's production: as mismatch scores increased, phonological similarity to the target decreased.

One key aspect of the rubric design was that mismatch codes assigned for mismatches in word stress, word length and word shape were collectively grouped as *word structure mismatch codes* while codes for segment-structure interactions were separately grouped as *segment-structure interaction mismatch codes*. A descriptive label code as well as a numerical point value was assigned for each type of mismatch, such as 'singleton consonant deletion' (1 point) or 'assimilation' (0.5 points). For example, for the target *guitarra* /giˈta.ra/ 'guitar', a child's production [iˈta.ra] was assigned the code 'CDeltnSingleton 1.0' to describe the deletion of a consonant in a singleton position with the structure mismatch point value of 1.0. See Appendix B for a full listing of the mismatch codes and examples of how the codes were applied to the data.

A second key aspect of the multisyllabic rubric was that mismatches at different tier levels – i.e. word stress versus word length versus syllable shape – were evaluated independently of each other. Therefore mismatch codes compounded across each tier (or level). A common instance of this compounding effect was full syllable deletion, as in the production [ˈta.ɾˡa] for the target *guitarra* /giˈta.ra/ 'guitar'. In this case, the child deleted the first syllable including the consonant and vowel. At the word length level, a 'SyllDeltn 1.0' code was assigned to describe the deletion of the first syllable with a value of 1.0. At the syllable shape level, both the 'CDeltnSingleton 1.0' and 'VDeltnSingleton 1.0' codes were assigned to describe the deletion of the singleton consonant and vowel, with mismatch values of 1.0 each. Collectively, the production had a total of three mismatch points for the deletion of the first syllable and its

consonant and vowel structural units. By compounding mismatch points, the scoring rubric captured the degree of change across tiers quantitatively by assigning a greater total mismatch score to more global patterns such as syllable deletion.

This system therefore provided a quantitative measure of multisyllabic words based on nonlinear phonological principles. It produced a richer analysis of mismatches than possible with PCC or its extensions (Shriberg et al., 1997). For example, if the child's production [ˈta.ɾˡa] for the target *guitarra* /giˈta.ra/ 'guitar' was part of the 100-word conversational speech sample used to calculate PCC, the total number of consonants produced correctly would be divided by the intended number of consonants, i.e. one (for /t/, as /g/ is deleted and /r/ is substituted) divided by three: 33%. Keeping in mind that this single example is not a measure of PCC, since the full metric requires a conversational speech sample, it is still possible to see how the PCC and its extensions obscure information at the CV timing unit, stress and foot levels by evaluating only segmental content. For instance, the child's omission of a consonant is weighted equally to the substituted consonant, conflating consequences of mismatches at the segmental and timing unit tiers. The deletion of a full syllable is not affected by any consequence other than the point for the "incorrect" deleted consonant within it. An analysis with greater depth was necessary for the multisyllabic targets addressed in the current study.

A second analysis measure in current use is the whole word approach (Ingram, 2002). This set of measures, like the PCC metric, proved insufficient for the research questions in the current study. Ingram's whole word approach requires at least 25 word utterances from a speech sample and applies several measures for an analysis of target match. For the sake of demonstration, the single example [ˈta.ɾˡa] for the target *guitarra* /giˈta.ra/ 'guitar' will be discussed. For the proportion of whole word correctness (PWW), each word that matches the

adult target receives a point (for *guitarra*, 0 points for match) and the total number of matches is divided by the minimum 25 total targets. The complexity of the production is analyzed using the phonological mean length of utterance (PMLU): a point is assigned for each segment plus each correct consonant, e.g. for [ˈta.ɾˡa], CVCV = 4 + /t/ = 5. The proximity of the child's production to the target can also be calculated by dividing the child's PMLU over the target PMLU. In this case, for /giˈta.ra/, CVCVCV = 6 + /g t r/ = 9. Therefore the proportion of whole word proximity (PWP) is 5/9, or 55.6%. While the whole word approach does incorporate both timing unit information and segmental information into the analysis, it remains a global approach that, like the PCC, does not provide scores based on the prosodic tiers of interest in the current study. Therefore the rubric design adapted from Mason, Bernhardt and Masterson (2011) was used for this investigation of MSWs.

In the rubric spreadsheet, codes were grouped by column, such that mismatch codes for word stress were listed separately from codes for syllable structure and so on. The rubric was designed to allow the researcher to place tokens on the left hand side of the spreadsheet and move from left to right to assign appropriate codes at specific levels. Codes for word stress and word length were placed in a left-hand column while codes for syllable shape and segment-structure interactions were placed in subsequent columns according to the particular syllable affected. This design created a visual representation of the compounding mismatches across levels. It also provided a fast way to visually evaluate where in the word most mismatches occurred, i.e. in the initial syllable versus the medial syllable and so on. See Appendix C for an example rubric page.

A variety of colours were associated with specific codes as a quick method of determining the overall pattern of mismatches in a given set of productions. For example, warm

colours (red, orange, yellow, pink) were associated with deletion while greens were associated with insertion. Blue colours denoted structure-segment interaction mismatch codes, while purple indicated codes that do not fit well in any of the above categories. See Figure 2.1 for the colour groups and Appendix B for the full list of codes with definitions and examples from the data.

One additional code was included to highlight cases of lexical-semantic error. This 'lexical effects' code was applied to prevent the assignment of multiple phonological mismatch codes for a single semantically-based error. For instance, one child produced [oɹ̝ˈeːhɔ] for the target *conejo* /koˈne{h/x}o/ 'rabbit'. While there are some phonological similarities between this target and the child's production, a fluent non-native speaker of Spanish judged that it was more likely that the child was attempting to produce *oreja* 'ear', particularly since large ears are a salient semantic feature of rabbits. This type of mismatch did not occur among the children with TD and was observed extremely rarely among children with PPD, with just 4 instances in the full 2,458-word sample.

2.4.2 Challenges of the multisyllabic rubric

An area of difficulty when developing the rubric was establishing appropriate point values for each mismatch code. Ideally, perceptual data describing the relative impact of the various mismatches on intelligibility would be the basis for point values: as intelligibility decreased, point values would increase. Unfortunately no perceptual data are available to suggest how these phonological mismatches might reflect changes in listener perception in Granada Spanish. Therefore, point values were assigned based on estimated impact of the degree of change from the target. A basic mismatch value of 1.0 point was assigned to the majority of mismatches involving changes in number of syllables and CV units, such as deletion of a singleton consonant, 'CDeltnSingleton', or insertion of a syllable, 'SyllInsrtn'. Mismatches

Figure 2.1 Mismatch codes and values in categories by colour grouping

Lexical Effects		Global Structure/CV Wordshape					
LexicalEffect	1.0	VDeltnSingleton	1.0	CDeltnSingleton	1.0	VDel&LengthAcrSyll-D	0.5
		VVDeltnRisDiphth	2.0	C1DeltnSeqWinSyll	1.0	VDel&LengthAcrSyll-L	0.5
Stress Patterns		VVDeltnFallDiphth	2.0	C2DeltnSeqWinSyll	1.0	CDel&LengthAcrSyll-D	0.5
SyllDeltn	1.0	V1DeltnRisDiphth	1.0	C1DeltnSeqAcrSyll	1.0	CDel&LengthAcrSyll-L	0.5
SyllInsrtn	1.0	V2DeltnRisDiphth	1.0	C2DeltnSeqAcrSyll	1.0		
StressShift	0.5	V1DeltnFallDiphth	1.0	CCDeltnSeqWinSyll	2.0		
		V2DeltnFallDiphth	1.0				
		VInsrtnSingleton	1.0	CInsrtnSingleton	1.0	C to V	1.0
		VLengthening	1.0	CLengthening	1.0	V to C	1.0
		V1InsrtnRisDiphth	1.0	C1InsrtnSeqWinSyll	1.0	CVMetath	1.0
		V2InsrtnRisDiphth	1.0	C2InsrtnSeqWinSyll	1.0		
		V1InsrtnFallDiphth	1.0	C1InsrtnSeqAcrSyll	1.0		
		V2InsrtnFallDiphth	1.0	C2InsrtnSeqAcrSyll	1.0		

HALF Stress Patterns		HALF Global Structure/CV Wordshape				Segment-Structure Interactions	
HALF-SyllDeltn	0.5	HALF-VDeltnSingleton	0.5	HALF-CDeltnSingleton	0.5	FullSyllRedup	[1.0]
HALF-SyllInsrtn	0.5	HALF-V1DeltnRisDiphth	0.5	HALF-C1DeltnSeqWinSyll	0.5	PartialSyllRedupV	[1.0]
		HALF-V2DeltnRisDiphth	0.5	HALF-C2DeltnSeqWinSyll	0.5	PartialSyllRedupC	[1.0]
		HALF-V1DeltnFallDiphth	0.5	HALF-C1DeltnSeqAcrSyll	0.5	Assimilation	[0.5]
		HALF-V2DeltnFallDiphth	0.5	HALF-C2DeltnSeqAcrSyll	0.5	CompLengthV	[1.0]
		HALF-VInsrtnSingleton	0.5	HALF-CInsrtnSingleton	0.5	CompLengthC	[1.0]
		HALF-V1InsrtnRisDiphth	0.5	HALF-C1InsrtnSeqWinSyll	0.5	SegmentMetath1	[0.5]
		HALF-V2InsrtnRisDiphth	0.5	HALF-C2InsrtnSeqWinSyll	0.5	SegmentMetath2	[0.5]
		HALF-V1InsrtnFallDiphth	0.5	HALF-C1InsrtnSeqAcrSyll	0.5	Migration (Origin)	[1.0]
		HALF-V2InsrtnFallDiphth	0.5	HALF-C2InsrtnSeqAcrSyll	0.5	Liquid to /j/ or /w/	[1.0]

involving partial deletion or insertion of a C or V unit were given 0.5 points, as were several of the segment-structure interaction codes including assimilation. In this case, partial deletion was defined by the deletion of half the timing unit. Mismatches involving the deletion of two C or V units, such as a full diphthong (VV) deletion, were given 2.0 points. See Appendix B for a list of all mismatch codes with point values, definitions and examples.

An important caveat to this approach is that without perceptual data, it is not possible to know whether assigning point values is an effective method of representing the degree of change from the target for a given production compared to simply counting instances of different mismatches. However, counting instances alone instead of using different quantitative levels may be an overrepresentation of the degree of change. For example, for *zapato* /saˈpa.to/ 'shoe', a production such as [saˈta.to] with assimilation of the medial /p/ with labial place to /t/ with coronal place is likely to be closer to the target in terms of intelligibility than a production such as [saˈa.to] with full deletion of the medial /p/, yet both have one instance of a mismatch. Therefore a decision was made to evaluate productions using estimated quantitative mismatch point values to prevent over-representation of mismatches.

Another area of difficulty when using the multisyllabic rubric to code productions was applying the segment-structure interaction mismatch codes. Challenges arose when it was not clear whether segmental mismatches were entirely feature-based or were the result of segment-structure interaction effects. The author evaluated each child's phonological system in order to judge whether changes in segmental content were due to an interaction with the structure of the word or simply a segmental mismatch characteristic of the child's inventory and system. For instance, a child who used the phoneme /t/ consistently across the full 103-word elicitation sample with the exception of the target *tortuga* /tɔɾˈtu.ɣa/ 'turtle', when the child substituted /k/

for /t/ to produce [koɾˈku.ɣa], was likely assimilating the target /t/ to the velar place feature of the target /ɣ/. This assimilation was coded as a segment-structure interaction mismatch. However, a child who consistently substituted a given phoneme with another phoneme would not be given a mismatch code for that pattern. For example, a child who consistently used /l/ for /r/ targets would not receive any mismatch codes for producing *reloj* /reˈlo/ ‘clock’ as [leˈlo]. The author tallied the number of matches and different substitution patterns for segmental mismatches of each child’s full data set to determine consistency and likelihood of purely segmental mismatch versus segment-structure interaction mismatches. While some instances were reasonably clear, as in the cases described above, other instances were less clear due to the inconsistent nature of children’s phonological data. The author was required to make a judgment in these unclear cases.

A third challenge when coding the multisyllabic tokens was resolving ambiguity in children’s productions. In some cases – particularly among the younger children with PPD – there were differences between the target and the child’s production that could be accounted for by several different code assignments. See Table 2.6 for an example of an ambiguous coding situation.

Table 2.6 Example of ambiguous coding for multisyllabic target

Target: *hirviendo* /i{ɾˈβ/β:}jen̪.do/ 'boiling' Child: [ˈme.ɾo]					
Code Option One		(for)	Code Option Two		(for)
SyllDeltn	1.0	/iɾ/	SyllDeltn	1.0	/iɾ/
VDeltnSingleton	1.0	/i/	VDeltnSingleton	1.0	/i/
C1DeltnSeqAcrSyll	1.0	/ɾ/	C1DeltnSeqAcrSyll	1.0	/ɾ/
Migration (Origin)	[1.0]	/ɾ/	Assimilation	[0.5]	β > m
C2DeltnSeqAcrSyll	1.0	/β/	V1DeltnRisDiphth	1.0	/j/
V1DeltnRisDiphth	1.0	/j/	C1DeltnSeqAcrSyll	1.0	/n/
CVMetath	1.0	en > me	PartialSyllRedupC	[1.0]	d > ɾ
Total Points:	7		Total Points:	6.5	

To resolve these ambiguous productions, the first task was to check the list of written code definitions in the manual, provided in Appendix B. If no resolution was found in the coding

manual, the general rule of thumb was first to minimize the total number of mismatch points, i.e. select the option that gives the least number of mismatch points. Secondly, the author attempted to analyze ambiguous tokens within the context of each child's broader system to gain a sense of what codes may be used more frequently by a given child. In particularly complex cases such as in Table 2.6, consultation between the author and a trained graduate student who completed reliability coding led to a consensus decision (in this case, code option one was used: although it had a slightly higher point value overall, re-checking of the coding manual led to a decision that reduplication in code option two was less appropriate than migration to describe the position of the tap segment).

When working with young children's phonological data, some ambiguity is inevitable. The author worked to resolve these challenges with as consistent an approach as possible by developing a written coding manual and consulting with the co-investigators of the original study from which the current data set was taken (See Bernhardt et al., 2011). Following consultation, a total of 25 out of the total 2,458 tokens remained ambiguous for coding, equal to approximately 1% of the analysis set.

2.5 Reliability

Coding of the data set using the multisyllabic rubric was completed by the author. A total of 118 tokens were randomly selected for inter-rater reliability coding including two productions by each participant and at least two productions of each target word. This subset of 5% of the data set was re-coded for reliability by a graduate-level student trained in the use of the rubric and blind to age and gender. Inter-rater reliability per syllable was 95.22%. Overall inter-rater reliability per word was 86.44%.

2.6 Data analyses

All productions were coded using the multisyllabic rubric to produce raw mismatch scores. The distinction between *word structure mismatch codes* and *segment-structure interaction mismatch codes* was a crucial component of the subsequent descriptive and inferential analyses. The word structure mismatch code category included all mismatches in word stress, word length and CV word/syllable shape. The segment-structure interaction mismatch code category included only those mismatches that were realized at the segmental tier due to effects of word position and/or word structure. Each child's mismatch points were summed into three separate total scores: (1) a word structure mismatch score, (2) a segment-structure interaction mismatch score and (3) a combined word structure and segment-structure interaction mismatch score. Inferential analyses were performed on each of these three scores using SPSS 12.0 (SPSS Inc., 2003). Further descriptive analyses were tallied in spreadsheets. The results of these data analyses are outlined below.

Chapter 3: Results

The research questions concerning the effects of (1) participant factors, (2) the frequency of mismatch patterns and (3) the effects of prosodic factors in Spanish-speaking children's MSW productions guided a series of analyses. Descriptive and inferential findings are presented for word structure mismatch scores, segment-structure interaction mismatch scores, and combined word structure and segment-structure interaction mismatch scores.

3.1 Participant factors: Group and age

Research question 1. Participant factors: Among Spanish-speaking children, how do children with PPD versus TD compare on prosodic measures in MSW productions and how does their performance on these measures change with age?

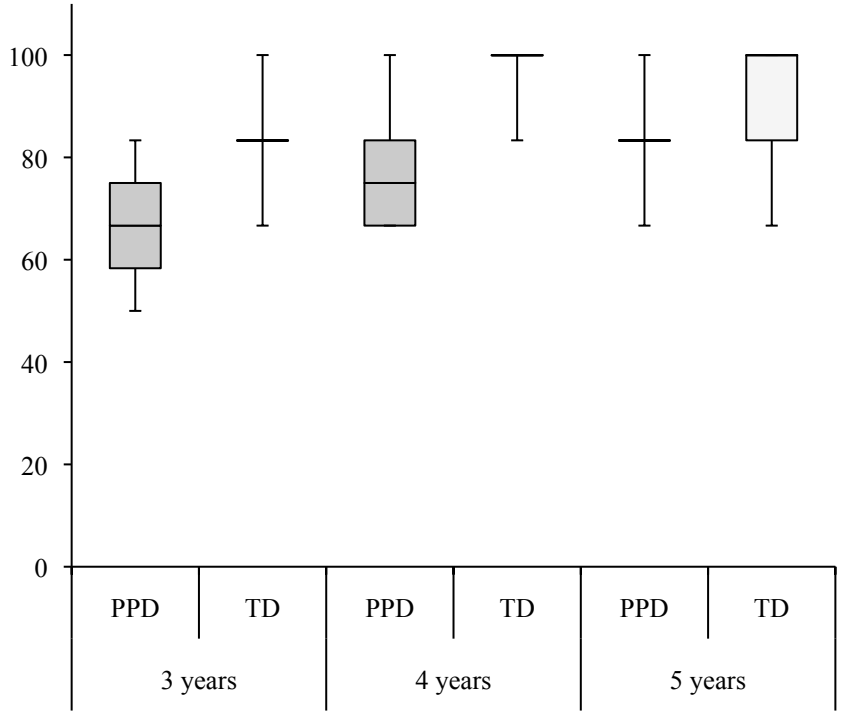
Method for analysis: This research question was addressed with both descriptive and inferential analyses. A descriptive analysis was carried out for the first dependent variable (DV) 'percent structure match' with the predicted result of greater percent match among older children and those with TD compared to children with PPD. A second analysis was used to examine each group's performance on the prosodic mismatch scores (DV) derived from total counts of mismatches per child and a third analysis determined whether a relationship existed between age and prosodic mismatch scores. Based on previous studies, the research hypothesis predicted a significant difference in mismatch pattern use between children with TD and PPD plus a correlation between age and mismatch scores.

3.1.1 Descriptive analysis of group and age

To perform the descriptive analysis for research question 1, the percentage of each child's productions that fully matched the adult target on word stress, word length and word shape – i.e.

had a structure mismatch code score of zero – was calculated to determine the percent structure match per participant (DV). Results are presented in Figure 3.1, Figure 3.2 and Figure 3.3.

Figure 3.1 % match on word stress, word length and word shape in 2-syllable targets



The box plots in Figure 3.1 suggest that there was minimal difference of group or age in the overall percent structure match for the 2-syllable targets in the MSW analysis set. The 3-year-old children with PPD had the lowest overall % match with a median and mean of 66.67%, with the 4-year-old children with PPD showing the second lowest median of 75.00% match (with a mean of 76.19%). The 5-year-old children with PPD and all of the children in the TD group had a similar range of percent scores: all medians and means were between 83.33% and 100%. These results suggest that similarity to target word structure in iambic disyllable words was high among the typically developing preschoolers and somewhat lower among their younger peers with PPD. Thus, a slight effect of age appeared only among the PPD group.

The descriptive percent word structure match analysis for MSWs revealed a larger discrepancy in group and age than the simpler disyllabic targets. In Figure 3.2, the box plots suggest the presence of both group and age effects for targets with three syllables. The range of percent match was consistently lower among the children with PPD compared with their age-matched TD peers and also those in the preceding TD age division. Overall percent match was higher among older children in the PPD and TD groups. Three-year-olds with PPD had the lowest median, at 41.67% match, with a mean of 35.36%. The four-year-old group with PPD had a median of 57.69% and mean of 58.80% match, lower than both the 3-year-old TD group (median 63.46% and mean 63.17% match) and the 4-year-old TD group (median 88.46% and mean 86.65% match). The 5-year-old children with PPD had a median 75.00% and mean 73.56% match, lower than both the 4-year-old TD group and the 5-year-old TD group (median 92.31% and mean 91.52% match). A similar set of effects is shown in Figure 3.3 for 4- and 5-syllable targets, with median and mean percent match for the PPD group (3-year-olds at median 20.00% and mean 22.14% match; 4-year-olds at median 50.00% and mean 48.10% match; and 5-year-olds at median 80.00% and mean 77.22% match) consistently lower than the TD group (3-year-olds at median 55.00% and mean 52.00% match; 4-year-olds at median 80.00% match and mean 83.33% match; and 5-year-olds at median 90.00% and mean 91.82% match).

Therefore, in this sample, 3-year-old children with TD had difficulty matching word structure of multisyllabic targets at age 3 years. However, the 4-year-old children with TD were more accurate, with a minimum 70% structure match, and all of the 5-year-old children with TD had a minimum of 80% structure match for all word lengths. In contrast, the children with PPD had lower match scores than their TD peers not only in the same age division but also in the preceding age division. These findings suggest the greatest discrepancy between children

Figure 3.2 % match on word stress, word length and word shape in 3-syllable targets

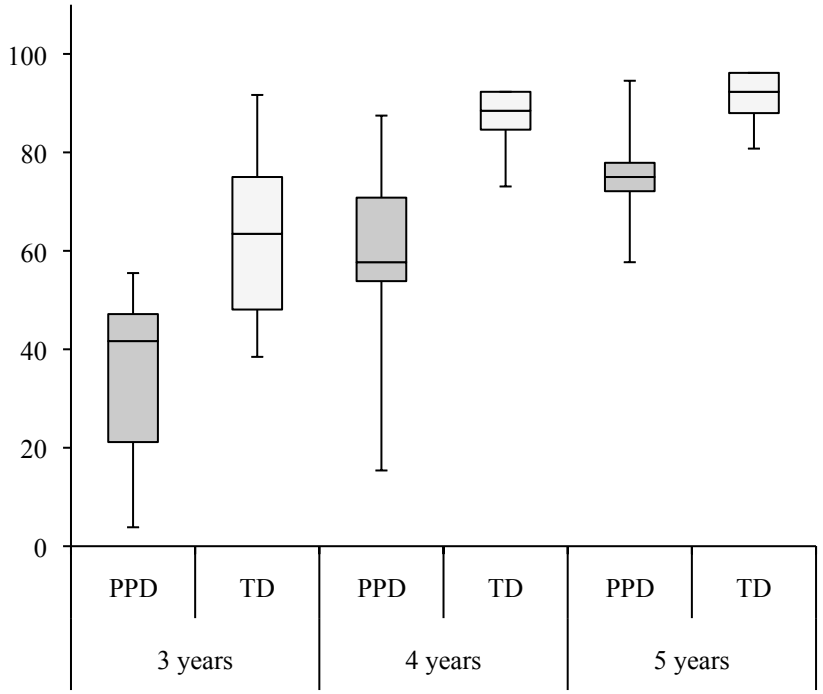
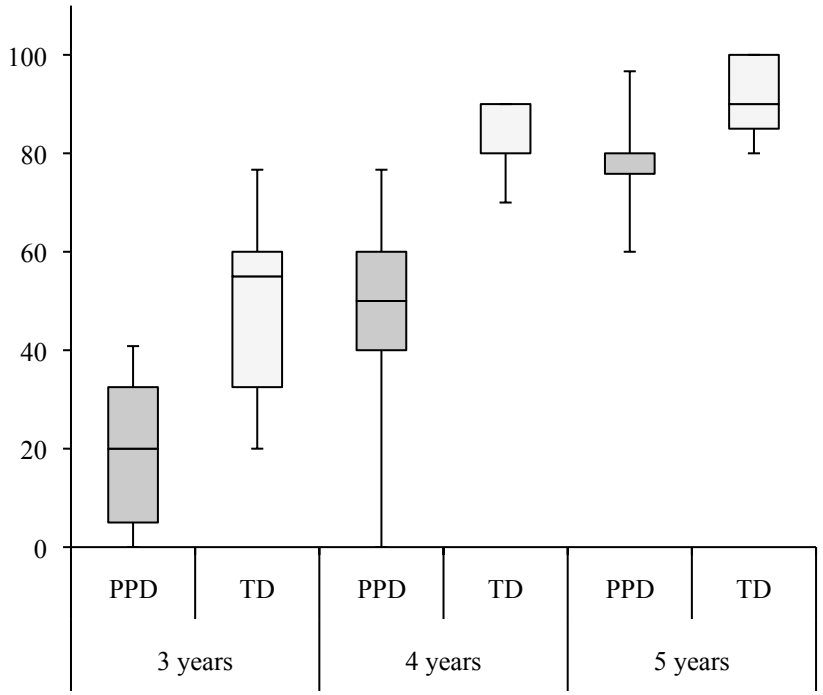


Figure 3.3 % match on word stress, word length and word shape in 4- and 5-syllable targets



with PPD versus TD in this sample was at age 4 years. In this age division, the children with TD had nearly reached the mastery levels achieved by 5-year-olds with TD. However the 4-year-old children with PPD had lower percent match than the 3-year-old children with TD. This trend was noted in targets with three and four or more syllables. Overall, percent structure match seemed to increase with age and was higher among participants in the TD group compared with participants in the PPD group, as predicted.

3.1.2 Inferential analysis of group and age

A series of inferential analyses were carried out to examine the role of participant factors of group and age. Independent sub-analyses were performed to capture effects of group and age relevant to the different types of mismatch scores as described in section 2.3 above: (1) word structure mismatch scores, (2) segment-structure interaction scores and (3) combined structure and interaction mismatch scores.

The effect of group on mismatch scores was evaluated first. A set of three two-way independent ANOVAs was used to assess the effects of the categorical independent variables "group" (0 = TD, 1 = PPD) and "gender" (0 = male, 1 = female) on the continuous dependent variable "mismatch score". One ANOVA was run for each mismatch score type. The variable "gender" was included in the analyses to rule out the possibility of gender accounting for variability in the data. Each of the participants' mismatch scores were tallied across the 42 elicited tokens in three categories, resulting in 59 raw word structure mismatch scores, 59 raw segment-structure interaction mismatch scores and 59 raw combined structure and interaction mismatch scores. The three categories of mismatch scores were then converted into z-scores to allow comparison across the mismatch score types. To create z-scores, the mean of each category distribution was first subtracted from each raw score and the difference divided by the standard

deviation of the distribution. See Table 3.1 for the mean and standard deviation of the raw scores for each mismatch score type. Each participant's standardized mismatch scores are provided in Appendix D and Appendix E. Two-way ANOVAS were then run with the resulting z-scores.

Table 3.1 Raw total mismatch score means and standard deviations

Type of Mismatch Score	Raw Total Mean		Raw Standard Deviation	
	PPD	TD	PPD	TD
Word structure mismatch score	33.0	13.0	35.9	12.6
Segment-structure interaction mismatch score	11.0	4.0	7.7	3.7
Combined structure and interaction mismatch score	44.0	16.0	40.2	15.8

3.1.2.1 Effect of group on word structure mismatch scores

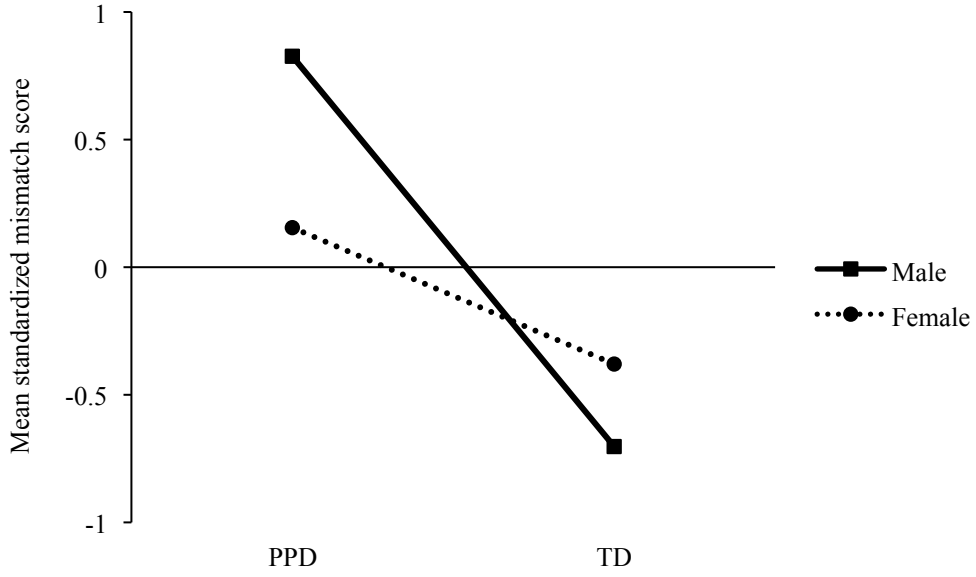
A two-way ANOVA was used to examine the effects of group (IV) and gender (IV) on the number of word structure mismatches (DV) in multisyllabic (MSW) productions. There was a significant main effect of group (PPD versus TD) on the number of word structure mismatches, F (1, 55) = 8.34, p = .006, η^2 = .13, but not of gender, (F (1, 55) = 0.08, p = .78, η^2 = .001) or the interaction between group and gender (F (1, 55) = 0.10, p = .75, η^2 = .002). The assumption of homogeneity of variances was met, as assessed by Levene's Test (p = .066). The results indicate a significant difference between PPD and TD groups in word structure mismatch scores for MSW productions but no significant difference between genders. The number of word structure mismatches in the TD and PPD groups did not vary by gender.

3.1.2.2 Effect of group on segment-structure interaction mismatch scores

The number of segment-structure interaction mismatches (DV) was evaluated with a two-way ANOVA again examining group (IV) and gender (IV). There was a highly significant main

effect of group on the number of segment-structure interaction mismatches in MSW productions, F (1, 55) = 23.01, $p < .001$, $\eta^2 = .30$, but not of gender, F (1, 55) = 0.66, $p = .42$, $\eta^2 = .012$. However, there was also a significant interaction effect between group and gender on the number of segment-structure interaction mismatches, F (1, 55) = 5.35, $p = .03$, $\eta^2 = .089$. Figure 3.4 illustrates the group and gender interaction for mean segment-structure interaction mismatch scores. There was a greater difference in mean group scores for males compared with females in this sample, suggesting that the significant group effect found for segment-structure interaction mismatch scores varied by gender. The assumption of homogeneity of variances was not met, as assessed by Levene's Test ($p = .007$).

Figure 3.4 Interaction of group and gender for segment-structure interaction mismatch scores



3.1.2.3 Effect of group on combined mismatch scores

A two-way ANOVA was used to determine the effects of group (IV) and gender (IV) on the participants' combined word structure and segment-structure interaction mismatch scores for MSW productions. Similar to word structure mismatch findings, there was a significant main effect of group on the number of combined mismatches, F (1, 55) = 11.94, $p = .001$, $\eta^2 = .18$.

There was no significant effect of gender (F (1, 55) = 0.01, p = .92 η^2 < .001), nor was the interaction between group and gender significant, F (1, 55) = 0.52, p = .48, η^2 = .009. The assumption of homogeneity of variances was not met, as assessed by Levene's Test (p = .042). Note that the combined mismatch scores are composed of approximately 60-70% word structure mismatches and 30-40% segment-structure interaction mismatches: thus, it is unsurprising that the results for this ANOVA closely followed the patterns of the word structure and segment-structure interaction mismatches described above.

These findings suggest there was a significant difference in combined mismatch scores between PPD and TD groups but no other significant effects or interactions. Across the three types of mismatch scores, the research hypothesis that there would be a significant effect of group was supported by the inferential analyses.

3.1.2.4 Relationship between age and word mismatch scores

A second inferential analysis was conducted to determine whether there was a significant relationship between age (in months) and each type of mismatch score, using the z-scores described above (see Table 3.1). A Pearson correlation was performed to compare age in months with standardized mismatch scores. Significant correlations were found for each type of mismatch score: for word structure mismatch scores and age, r = -.55 (p < .001); for segment-structure interaction mismatch scores and age, r = -.57 (p < .001); and for combined structure and segment-structure interaction mismatch scores, r = -.59 (p < .001). These highly significant correlations indicate that across this sample, increasing age of the participants was associated with decreasing overall mismatch scores of all types. Thus, the participant factors of group and age, but not gender, impacted the participants' mismatch scores on MSW productions.

3.2 Mismatch patterns in multisyllabic words

Research question 2. Mismatch patterns in MSWs: What types of mismatch patterns occur most frequently in MSW productions among Spanish-speaking children and how frequently do these mismatch patterns occur across group and age?

Method for analysis: A descriptive analysis was used to investigate common mismatch patterns at the word stress, word length and word shape levels. Targets with and without consonant sequences were analyzed independently. The sample was divided into words without consonant sequences and words with at least one consonant sequence (i.e. CC in word shape, within or across syllable boundaries). The purpose of this division was twofold: (1) if a difference was found in mismatch patterns between words with and without consonant sequences it would provide important insight into the children's ability to produce structurally complex MSWs, and (2) the detailed mismatch codes limited the value of including targets with and without consonant sequences in the same frequency count. For instance, while deletion of consonants was common across the sample, singleton consonant deletion was coded independently of sequence consonant deletion. Therefore using a count of singleton consonant deletion to measure the general pattern of deletion across the full sample would be an incomplete description of consonant deletion because of the separate coding for deletion of consonants in sequences.

To perform this analysis, the total number of codes used by children in each group (TD and PPD) and age set was calculated for each word length (2, 3 and 4+ syllables). This process was carried out twice: once for target words without consonant sequences and again for targets with consonant sequences. These frequency counts yielded the most common mismatch codes in three separate categories: (1) word stress and word length, (2) word shape and (3) segment-

structure interactions. The three targets with word-initial stress, including *triángulo* ‘triangle’, *pájaro* ‘bird’, and *lámpara* ‘lamp’, were excluded from this analysis due to dissimilarity of prosodic stress pattern relative to other targets in the analysis set. The results for each code category are outlined below with a summary of information about trends in use for the most commonly used mismatch patterns.

3.2.1 Mismatch patterns for word stress and word length

Of the possible word stress and word length mismatch patterns, ‘syllable deletion’ was the most frequently assigned code for the targets with and without consonant sequences. The average use of syllable deletion per subject, based on number of possible targets, is shown in Figure 3.5 and Figure 3.6.

Across the analysis set, there appeared to be a strong tendency for weak syllable deletion rather than deletion of strong syllables. Similar trends were noticeable in the samples with and without consonant sequences:

1. There was little to no use of syllable deletion by children in the TD group, with one exception: typically-developing 3-year-olds used syllable deletion in words with 4 and 5 syllables, most commonly in words with initial ‘V’ syllables, such as: *elefante* /e.leˈfan̪.te/ ‘elephant’ produced as [leˈfan̪te] with the initial weak syllable deleted.
2. When syllable deletion occurred, children in the PPD group consistently used this mismatch pattern more frequently than their age-matched TD peers. The difference in frequency was particularly notable among 3-year-olds and 4-year-olds for targets with 4 and 5 syllables.
3. In general, as age increased the use of syllable deletion decreased. No child in the PPD or TD groups used syllable deletion by age 5 years.

Figure 3.5 Frequency of syllable deletion in targets without consonant sequences

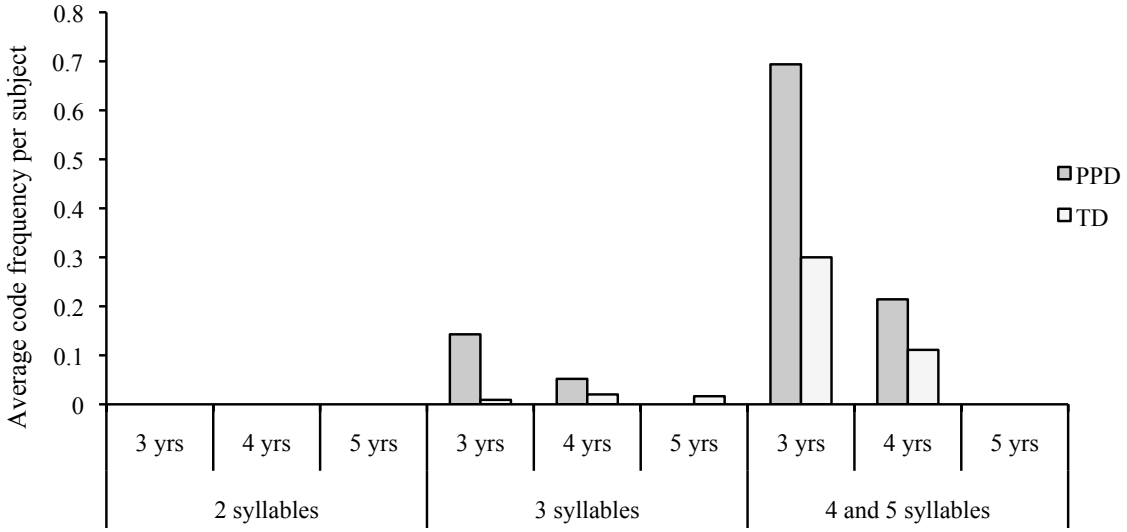
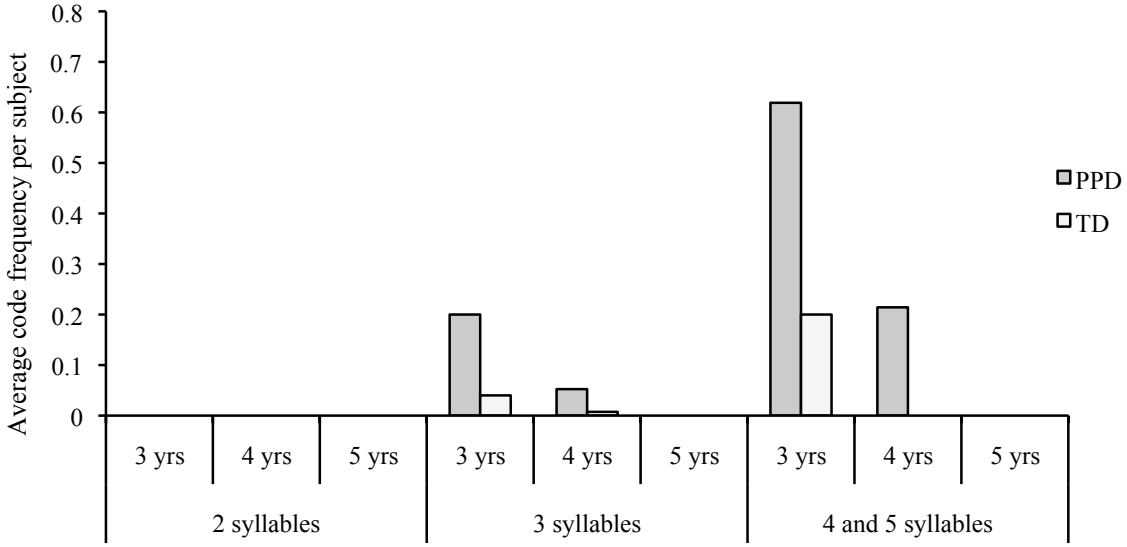


Figure 3.6 Frequency of syllable deletion in targets with consonant sequences



The similarity across the samples with and without consonant sequences suggests that presence of these sequences did not impact the use of syllable deletion by children in the current study.

3.2.2 Mismatch patterns for word shape

Much like the use of syllable deletion in the word length and stress category, the most common type of code assigned for word shape mismatches was deletion. Due to differences in syllable structure between the target words with and without consonant sequences, the analysis

revealed distinct mismatch patterns for these two sample sets. In the target words without consonant sequences, the ‘singleton consonant deletion’ and ‘singleton vowel deletion’ mismatch codes were most common. As shown in Figure 3.7 and Figure 3.8, the overall frequency trends were similar to those of syllable deletion mismatches described above.

Figure 3.7 Frequency of single consonant deletion in targets without consonant sequences

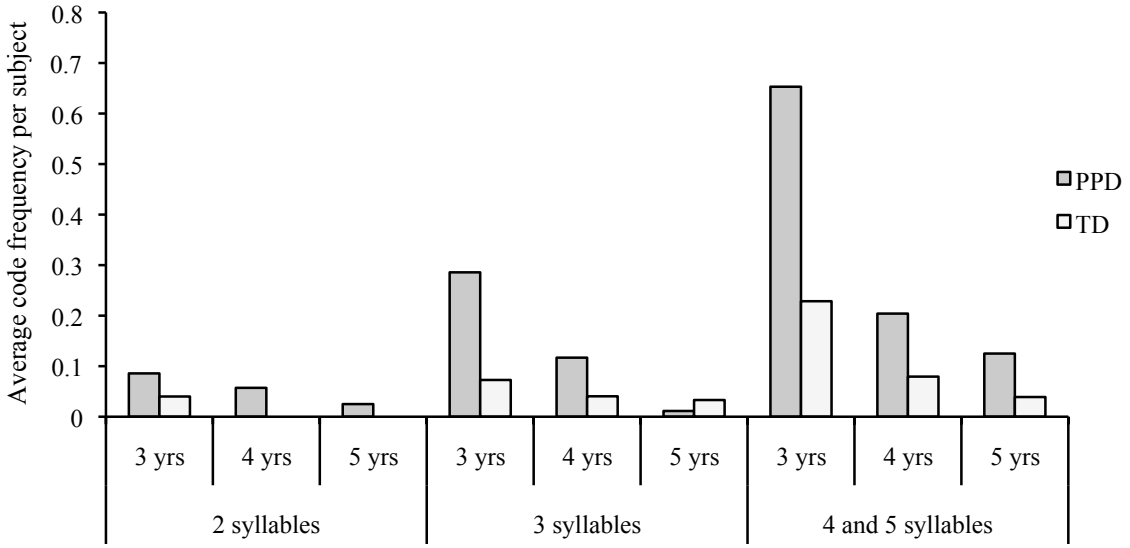
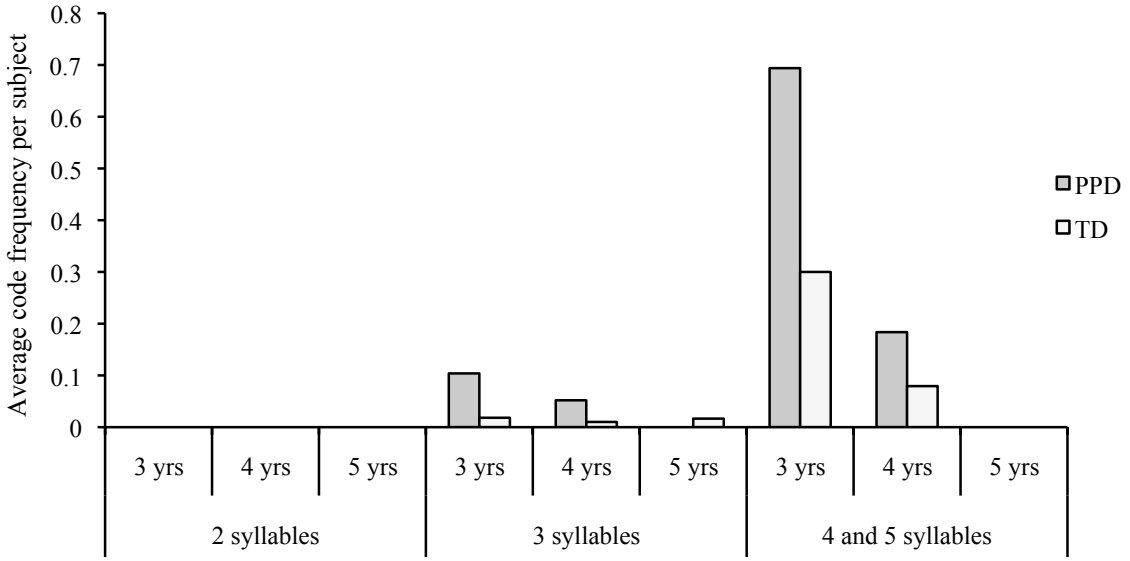


Figure 3.8 Frequency of single vowel deletion in targets without consonant sequences



This pattern is not surprising given that the rubric was designed to compound mismatches across word stress, word length and word shape levels. By definition, the deletion of a syllable requires the deletion of a vowel, in the case of 'V' syllables, and the deletion of a consonant and vowel in the more common 'CV' syllables. Thus it is reasonable to expect the patterns of singleton consonant and vowel deletion to closely follow the pattern of syllable deletion. Figure 3.7 and Figure 3.8 show that this was the case. Indeed the frequency of singleton vowel deletion followed the trends for syllable deletion in a near-identical pattern for the targets with no consonant sequences. These trends included:

1. Zero singleton vowel deletions in 2-syllable words.
2. Zero singleton vowel deletions among 5-year olds.
3. There was greater use of vowel deletion by participants in the PPD group overall.
4. As age increased, vowel deletion decreased.

Singleton vowel deletion always coincided with syllable deletion. For example, a 3-year-old in the PPD group produced *tortuga* / tɔɾˈtuɣa / 'turtle' as [ˈtuɣa], with the singleton vowel in the initial weak consonant deleted, as was the full initial syllable.

The singleton consonant deletion patterns were similar with slightly higher frequency across words with 2, 3 and 4+ syllables, as expected when taking into account instances where the vowel (and syllable) were preserved while the consonant was deleted. Again trends in group and age emerged for targets without consonant sequences:

1. Participants in the PPD group used singleton consonant deletion more frequently than their age-matched peers.
2. As age increased, singleton consonant deletion decreased.

In target words with consonant sequences, deletion within these sequences was more common than deletion of singleton consonants. Separate codes were used to denote the position of a deleted consonant within the sequence and whether the sequence occurred within or across syllable boundaries. The three most common mismatch codes in this sample set were 'C1DeltnSeqWinSyll' and 'C2DeltnSeqWinSyll' for deletion of the first or second consonant of a sequence within a syllable, respectively, and 'C1DeltnSeqAcrSyll' for deletion of the first consonant in a sequence that crossed syllable boundaries.

Due to the limited number of target words with consonant sequences in the analysis set, no summary figures could be produced to compare these mismatch code frequencies across ages and word lengths. Consequently, a more detailed frequency count of consonant deletion within each of the five targets containing sequences within a syllable (tautosyllabic sequences) was carried out to gain more information about consonant deletion patterns. Tallies of C1 and C2 deletion of sequences within syllables for each target are listed in Table 3.2.

Table 3.2 Frequency of deletion in consonant sequences within syllables

Target	Transcription	Sequence position	Stress	C1 Deletion Tally (use/total targets)		C2 Deletion Tally (use/total targets)	
				PPD	TD	PPD	TD
dragón	/dɾaˈɣo{ŋ/n/ø}/	word-initial	unstressed	9/29	9/30	11/29	3/30
princesa	/pɾiɲ{ˈθ/s}e{θ/s}a/	word-initial	unstressed	0/29	0/30	20/29	9/30
primavera	/pɾimaˈβeɾa/	word-initial	unstressed	0/29	0/30	21/29	8/30
sombrero	/{s/θ}omˈbɾeɾo/	word-medial	stressed	1/29	1/30	11/29	4/30
cocodrilo	/kokoˈðɾilo/	word-medial	stressed	18/29	12/30	9/29	4/30

Clear patterns emerged for the unstressed word initial consonant sequence /pɾ/: for both targets, the second consonant /ɾ/ was deleted and the less sonorant voiceless stop was preserved.

This mismatch pattern occurred in approximately two thirds of the PPD group and one third of the TD group. A more mixed trend occurred for the unstressed word initial consonant sequence /dɾ/, with approximately one third of children with PPD deleting the initial stop and another third deleting the /ɾ/ for the TD group, deletion of the initial /d/ was more common than deleting the /ɾ/. Further mixed trends were noted for the medial stressed consonant sequences, with a preference for /ɾ/ deletion in *sombrero* among both PPD and TD groups – at a lower rate than in unstressed initial contexts – and an apparent preference for initial /ð/ deletion in *cocodrilo*. These trends are consistent with previous research indicating that Spanish-speaking children may reduce consonant sequences to the least sonorant segment, but that variation may exist in cluster reductions across children with TD and PPD (Barlow, 2005; 2006). A preference for preserving labial obstruents compared with dental obstruents in consonant sequences could also account for this pattern. However, an in-depth analysis of segmental features such as sonority and articulatory place is beyond the scope of the current study.

Interestingly, for consonant sequences spanning syllable boundaries, deletion of the first consonant (i.e. 'C1DeltnSeqAcrSyll') was a common mismatch processes yet deletion of the second consonant was not, likely due in part to the low frequency of syllable codas versus syllable onsets in Granada Spanish. For instance, in *princesa* /pɾin̪ˈsesa/ the coda /n̪/ was deleted and the child said [pi̪ˈsesa], therefore deleting the coda in the initial syllable. Overall, there was an effect of group in the frequency of initial consonant deletion in heterosyllabic consonant sequences, with more deletions by the PPD group. This finding combined with the results observed in the tautosyllabic sequences together suggest that in this sample, mismatch pattern use varied by group.

3.2.3 Mismatch patterns for segment-structure interactions

While deletion of syllables, consonants and vowels at the word length and shape levels tended to show group and age effects, the findings for segment-structure interaction codes did not. As predicted, in this code category *assimilation* was the most frequent mismatch pattern for target words without and with consonant sequences (see Figure 3.9 and Figure 3.10).

Figure 3.9 Frequency of assimilation in targets without consonant sequences

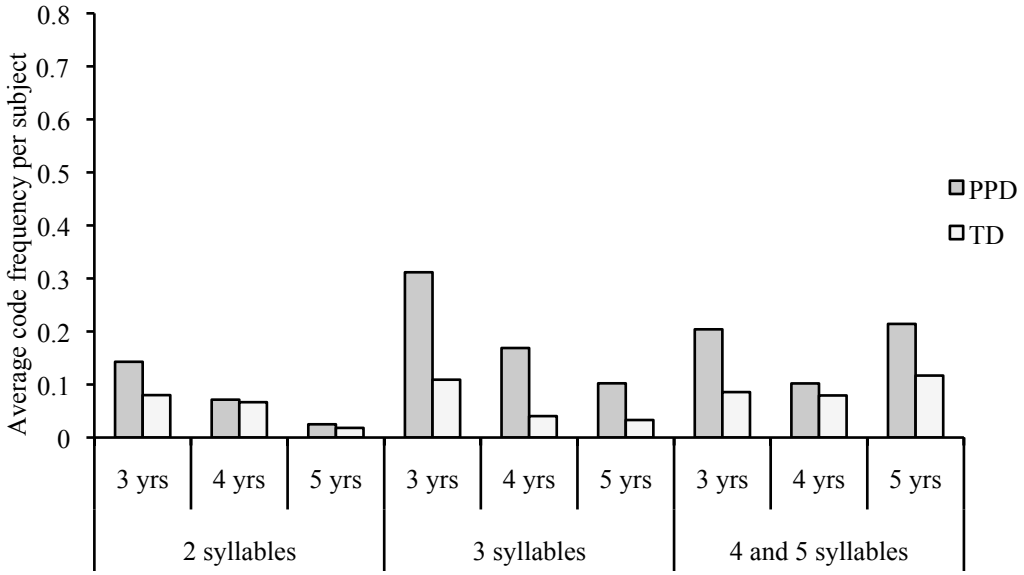
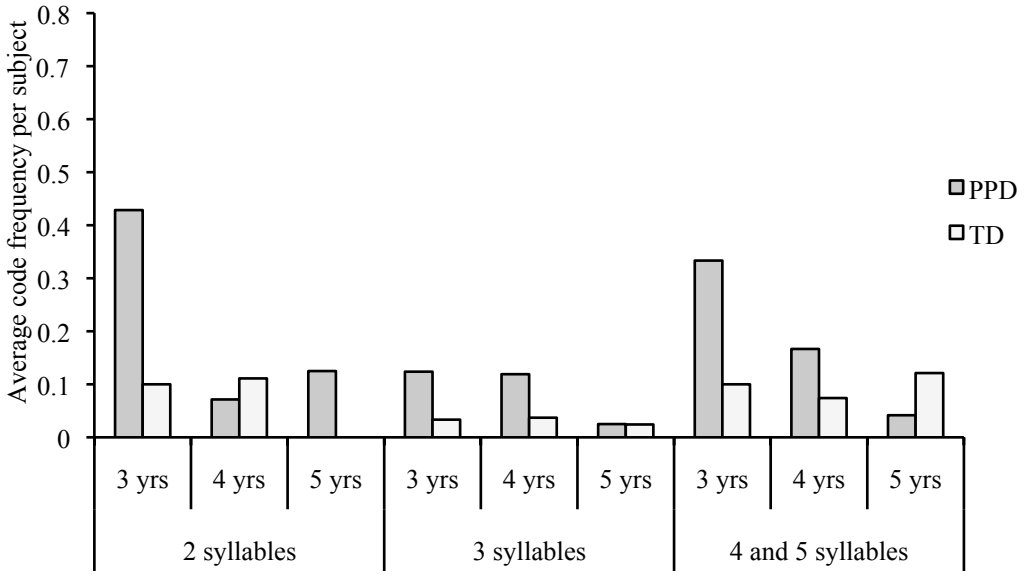


Figure 3.10 Frequency of assimilation in targets with consonant sequences



However, unlike the deletion-related codes, there were no strong trends in assimilation mismatches across the sample. A possible age effect occurred in some sub-sets, such as for the 2-syllable and 3-syllable targets without consonant sequences; however, this trend did not extend across all ages and word lengths. A slight group effect was observed because the frequency of assimilation was generally higher for children with PPD, but the difference between the PPD and TD groups was neither large nor consistent. These descriptive data suggest that, unlike deletion, assimilation was used similarly by the two groups of participants. The null hypothesis that there would be no difference in group and age for assimilation was retained.

In sum, the descriptive analysis showed that deletion was a common mismatch pattern. Across word stress, length and shape, deletion of various prosodic elements was the most frequent type of mismatch and followed trends consistent with group and age effects. Assimilation was also a common mismatch pattern. However there was no consistent evidence of a group or age effect in assimilation mismatches.

3.3 Prosodic factors: Stress and word length effects

Research question 3.A: Is there a difference in number of mismatch patterns used in initial unstressed syllables relative to non-initial stressed syllables in Spanish-speaking children with PPD versus children with TD?

Research question 3.B: Is there a difference in frequency of prosodic mismatch patterns across targets with 2-, 3- and 4+-syllables?

Method of analysis: Several strategies were used to evaluate the role of prosodic factors stress and word length. For research question 3.A, inferential analyses first determined the effect of group in each participant's mismatch difference scores for initial unstressed and stressed syllables in uS and uSu targets and, secondly, evaluated the relationship between age and

mismatch difference scores. Research question 3.B was addressed using the results of descriptive analyses described above for exploring the role of word length in overall percent structure match as well as mismatch pattern frequency.

3.3.1 Inferential analysis of unstressed versus stressed syllables

An inferential analysis was performed to assess group effects in the difference between mismatch scores of initial unstressed syllables relative to neighbouring medial (in "uSu" 3-syllable targets) or final (in "uS" 2-syllable targets) stressed syllables. This line of analysis was driven by the prediction that word-initial unstressed syllables would be more vulnerable to mismatches than non-initial stressed syllables in MSW productions (Bernhardt & Stemberger, 1998). A series of two-way ANOVAs were performed using SPSS 12.0 (2003).

Each child's mismatch scores were summed for initial unstressed syllables and medial or final stressed syllables in 6 uS targets and 22 uSu targets. The difference between these two scores was entered as the dependent variable in each of three indepdendent two-way ANOVAs in order to examine word structure, segment-structure interaction and combined mismatch difference scores for these uS and uSu productions. The raw mismatch difference scores were converted to *z*-scores using a process identical to that described above (Section 3.1.2) for total mismatch scores. See Table 3.3 for raw means and standard deviations.

Table 3.3 Raw mismatch difference score means and standard deviations

Type of Mismatch Difference Score	Raw Total Mean		Raw Standard Deviation	
	PPD	TD	PPD	TD
Word structure mismatch difference score	-7.0	-3.0	7.3	2.8
Segment-structure interaction mismatch difference score	0.0	0.0	2.0	1.0
Combined structure and interaction mismatch difference score	-7.0	-3.0	7.0	3.3

Note that a negative raw mean difference score implies a greater number of mismatches in the initial unstressed syllable compared to the non-initial stressed syllable, whereas a mean of "0" implies no difference, on average, in number of mismatches in the unstressed and stressed syllables. (Appendices F and G contain tables of the standardized mismatch difference scores for each participant in the TD and PPD groups, respectively.) The "uSuu" target *teléfono* 'telephone' was excluded from this analysis as it was the only 4-syllable target with this less common stress pattern. The independent variables "group" and "gender" were coded in the same manner as describe above, with gender again included to rule out possible gender effects within the sample.

3.3.1.1 Word structure mismatches in unstressed versus stressed syllables

A two-way ANOVA examining the effect of group (IV) and gender (IV) on the difference in word structure mismatch scores (DV) of initial unstressed and non-initial stressed syllables was performed. There was a significant main effect of group for word structure mismatch difference scores, F (1, 55) = 5.51, p = .02, η^2 = .09, but not of gender, F (1, 55) = 0.33, p = .57, η^2 = .006. The interaction between group and gender was not significant, F (1, 55) = 0.02, p = .88, η^2 < .001. The assumption of homogeneity of variances was met, as assessed by Levene's Test (p = .117).

3.3.1.2 Segment-structure interaction mismatches in unstressed versus stressed syllables

A two-way ANOVA was also used to analyze the effect of group (IV) and gender (IV) on segment-structure interaction mismatches (DV) in unstressed initial versus stressed medial/final syllables. There were no significant results for group (F (1, 55) = .22, p = .64, η^2 = .004), gender (F (1, 55) = 0.93, p = .34, η^2 = .017) or the interaction between group and gender (F (1, 55) = .01, p = .92, η^2 < .001). The assumption of homogeneity of variances was not met, as assessed by Levene's Test (p = .019). Therefore, there were no significant effects or interactions of group or

gender on the difference between segment-structure interaction mismatch scores for initial unstressed syllables non-initial stressed syllables.

3.3.1.3 Combined mismatches in unstressed versus stressed syllables

A final two-way ANOVA was performed with group and gender as independent variables. The dependent variable was the difference of combined word structure and segment-structure interaction mismatches in unstressed and stressed syllables for uS and uSu targets. There was a significant main effect of group, F (1, 55) = 5.04, p = .03, η^2 = .08, but not of gender (F (1, 55) = 0.09, p = .76 η^2 < .002). The interaction between group and gender was not significant, F (1, 55) = 0.02, p = .90, η^2 < .001. The assumption of homogeneity of variances was met, as assessed by Levene's Test (p = .196).

Similar to the findings for the word structure mismatch difference scores, these results indicate a significant difference between the PPD and TD groups for combined word structure and segment-structure interaction mismatch difference scores. No other significant results were found.

Overall, the research hypothesis that there would be greater mismatch difference scores among children with PPD versus TD was supported only for word structure mismatch difference scores and combined word structure and interaction mismatch scores.

3.3.1.4 Relationship between age and mismatch difference scores

A second set of inferential analyses were conducted to determine the relationship between the participants' age and each type of mismatch difference score. Pearson's correlation was used to compare age in months with the standardized mismatch difference scores for unstressed initial versus stressed non-initial syllables (note that z-scores are listed in Appendix F and Appendix G). The results of these analyses were consistent with the findings for group

described above. A highly significant correlation was found between age and word structure mismatch difference scores ($r = .52$, $p < .001$) and between age and combined word structure and segment-structure interaction mismatch difference scores ($r = .57$, $p < .001$). However, no significant correlation was found between age and segment-structure interaction mismatch difference scores ($r = .13$, $p > .05$). In this sample, therefore, increasing age was related to decreasing difference in word structure mismatch scores – but not segment-structure interaction scores – between initial unstressed and non-initial stressed syllables for uS and uSu targets. The participant group showed a similar pattern of significance, while gender had no effect on the mismatch difference scores.

3.3.2 Descriptive analysis of word length

To assess the impact of target word length, data from several of the descriptive analyses were compiled, including the participants' overall percentage structure match (Section 3.1.1) and the patterns of use for common mismatch patterns (Section 3.2).

In section 3.1.1, boxplot analyses described the percent of structure match for targets with 2, 3 and 4+ syllables across groups and ages. The data revealed an effect of word length: percent structure match was greatest in uS disyllabic targets and least in targets with 4+ syllables (see Figures 3.1, 3.2 and 3.3). This trend was strongest among children in the 3-year-old range. For example, participants in the typically developing 3-year-old group had a median percent structure match of 83.33% for 2-syllable words, 63.46% for 3-syllable words and 55.00% for 4+-syllable words. In contrast, the participants in the typically developing 5-year-old group had a median percent structure match of 100.00% for 2-syllable words, 92.31% for 3-syllable words and 90.00% for 4+-syllable words.

The frequency analysis of common mismatch patterns described in Section 3.2 also showed a tendency for the use of mismatch patterns to increase as word length increased. In the word stress and word length category of analysis for words, Figures 3.5 and 3.6 show the frequency of syllable deletion in words without and with consonant sequences, respectively. The data indicated that as word length – and therefore the number of opportunities to delete syllables – increased, the use of syllable deletion increased. For instance in the 4-syllable *primavera* 'spring', a 3-year-old child in the PPD group deleted the first two unstressed syllables in the word: /pɾimaˈβeɾa/ was produced as [ˈeɾa]. This effect was limited to children in the 3-year-old and 4-year-old age divisions in this sample because there was no use of syllable deletion by participants aged 5;0 to 5;11.

At the word shape level, a word length effect was observed for vowel and consonant deletion in words without consonant sequences. Figure 3.7 shows how increased vowel deletion was associated with increased word length while Figure 3.8 depicts a similar trend in the frequency of singleton consonant deletion. Due to the limited distribution of words with consonant sequences within the analysis set, no comparison could be made across word lengths for words with consonant sequences.

In the segment-structure interaction category, only a slight effect of word length was noted for frequency of assimilation in words without consonant sequences (Fig. 3.9). No effect was found for frequency of assimilation in words with consonant sequences (Fig 3.10). Rates of use were similar across word lengths for this mismatch pattern. However, while the predicted word length effect was not found for assimilation, all other descriptive analyses produced results consistent with the research hypothesis that increased word length would co-occur with increased use of mismatch patterns.

In sum, data analyses revealed several trends that were consistent with the research hypotheses for participant factors, including significantly greater use of mismatch patterns among children with PPD compared to their TD peers and a significant decrease in mismatch pattern use as age increased across the sample. As predicted, the most common types of mismatch patterns included syllable deletion at the word length level and various types of consonant deletions at the word shape level. For prosodic factors, the research hypothesis predicting differences in group mismatch scores between unstressed and stressed syllables was supported for structure mismatch scores but not for segment-structure interaction mismatch scores. For word length, mismatch frequency increased as word length increased. Therefore participant and prosodic factors were observed to impact the productions of MSWs in this sample of Spanish-speaking children ages 3;0 to 5;11.

Chapter 4: Discussion

The main purpose of the current study was to determine whether Granada Spanish-speaking preschoolers with protracted phonological development (PPD) perform differently than their typically-developing (TD) peers on measures of word stress, length and shape in multisyllabic word productions (MSWs). A scoring rubric designed for nonlinear phonological evaluation of MSWs was used to calculate mismatch scores for a group of 29 children with PPD and 30 age-matched peers with TD. Three types of mismatch scores were calculated for each token, including: (1) a word structure mismatch score; (2) a segment-structure interaction mismatch score; and (3) a combined structure and interaction mismatch score. Several descriptive and inferential analyses were used to evaluate the data.

To summarize, results indicated a greater number of mismatches on MSWs for participants with PPD than TD with the most notable group difference occurring among 3-year-olds and 4-year-olds. An age effect was also noted. No significant effect of gender was found. Across group and age, syllable deletion, consonant deletion and assimilation were common mismatch patterns. For the prosodic factors of stress and word length, more structural mismatches – but not segment-structure interaction mismatches – were noted in initial unstressed versus non-initial stressed syllables among children with PPD and among younger participants, while a word length effect was noted across group and age. The outcomes of the analyses are discussed below and followed by a description of limitations of the study and clinical implications. The current study provides evidence of the value of using MSWs for phonological analysis within this sample of Spanish-speaking children.

4.1 Evaluation of participant factors: Effects of group and age

A number of descriptive and inferential analyses were performed to evaluate the effects of the independent participant variables of group and age. Descriptive analyses were carried out when inferential analyses were not possible due to sample size and characteristics of the distribution.

4.1.1 Percent structure match on multisyllabic productions

The descriptive analysis concerning percent target match was designed to provide an overview of the children's performance on MSW productions. Boxplot figures depicted the overall percent structural match (i.e. a word structure mismatch score of zero per token based on word stress, word length, and word shape) for 2-, 3- and 4+-syllable targets by group (PPD versus TD) and age. Unlike the PCC metric or the whole word approach, this analysis did not require match at the segmental level (Shriberg et al., 1997; Ingram & Ingram, 2001). An age effect was noted for both PPD and TD participants' productions of 3-syllable and 4+-syllable targets: in older children, percent match was greater. In the 3- and 4+-syllable targets, the PPD group consistently had lower percent match scores than their TD peers, revealing a group effect. These global findings are consistent with previous research showing group and age effects in MSW productions among English-speaking children (Flipsen, 2006; James, van Doorn, & McLeod, 2008).

The boxplots for 3-syllable and 4+-syllable targets suggested a trend such that the children with PPD had, on average, lower percent match scores not only than their same-age TD peers but also the TD children in the age bracket below. This difference was particularly notable in the 4-year-old age range, where the PPD group medians were 57.69% match for 3-syllable targets and 50.00% match for 4+-syllable targets while the corresponding TD group medians

were 88.46% and 80.00% match, respectively. Therefore, there was an approximate 30% median difference between PPD and TD groups in the 4-year-old age range for both 3-syllable and 4+-syllable targets. However, in the 5-year-old cohort, median differences were approximately 17% for 3-syllable targets (PPD = 75.00%, TD = 92.31%) and 10% for 4+-syllable targets (PPD = 80.00%, TD = 90.00%). Within this sample, there appeared to be a larger group effect for percent structure match among 4-year-olds compared with 5-year-olds on MSW productions.

4.1.2 Total mismatch scores

A series of inferential analyses were completed to determine independent participant variable effects, i.e. gender (IV) and group (IV), on the number of mismatches (DV) in Spanish-speaking children's productions of MSWs. Two-way independent ANOVAs were used to assess effects for each of the three mismatch score categories, including the structure mismatch score, segment-structure interaction mismatch score and the combined structure and interaction score. The ANOVA results indicated that overall, children in the PPD group had significantly greater mismatch scores than their TD peers for all three mismatch scores. There were no significant main effects of gender. A significant interaction between group and gender was noted only for segment-structure interaction mismatch scores. A third independent variable, age, was significantly negatively correlated with all types of mismatch scores: the youngest children had the highest mismatch scores, while the oldest children had the lowest mismatch scores.

The participant factors group and age showed effects in both the descriptive and inferential analyses, as predicted based on English and Spanish-speaking MSW acquisition (James, 2006; Flipsen, 2006; Goldstein, Fabiano & Iglesias, 2004; Astruc et al., 2010; Chávez-Peón et al., 2012). The overall trends included a decrease in mismatches as age increased plus a

significantly greater use of mismatches among children with PPD compared to children with TD in this sample.

4.2 Evaluation of most frequent mismatch patterns

A second descriptive analysis determined common word structure and segment-structure interaction mismatch patterns across group, age and word length. A frequency count yielded the most common mismatches for words with and without consonant sequences. On average, mismatches involving deletion and or assimilation were most frequent.

At the word stress and word length level, syllable deletion was the most common mismatch pattern for words with and without consonant sequences. It occurred more commonly than syllable insertion and stress shift across the groups and age ranges. Increasing syllable deletion was associated with increasing word length and with decreasing age. More syllable deletion was also noted in the PPD group compared with the TD group, who used minimal to no syllable deletion across word lengths and ages. Syllable deletion occurred predominantly in unstressed syllables. These group and age effects are consistent with previous research findings in English- and Spanish-speaking monolinguals (James, 2006; Goldstein & Iglesias, 1996; Goldstein, Fabiano, & Iglesias, 2004; Astruc et al., 2010). Moreover, the trend that initial unstressed syllable deletion was the most common type of syllable deletion corresponds to expectations regarding the vulnerable prosodic environment of initial unstressed syllables (Bernhardt & Stemberger, 1998). Typically-developing English-speaking children have been noted to use weak syllable deletion in multisyllabic words up to the age of 7;11 (Demuth, 2001; Gerken, 1994; James, van Doorn, & McLeod, 2008). Moreover, the vulnerability of initial unstressed syllables has also been noted in Spanish-speaking children with TD and PPD (Goldstein & Iglesias, 1996; Astruc et al., 2010; Chávez-Peón et al., 2012).

However, while syllable deletion was used more commonly than other mismatch patterns in the word stress and length category, it was not used in 2-syllable targets and used only infrequently in 3-syllable targets. Syllable deletion was used predominantly by 3-year-olds in 4-syllable targets. Therefore the children's MSW productions appeared, overall, to match the target word length relatively frequently among younger participants. Older participants nearly always matched the target word length. Existing evidence of the relatively early acquisition of multisyllabic stress patterns – particularly uSu – by Spanish-speaking children with typical development is consistent with these results (Piñeiro & Manzano, 2000; Prieto, 2006). This suggests that frequency of prosodic patterns in the input language plays an important role in phonological acquisition. The high proportion of multisyllabic words in general Spanish (3- and 4- syllable words account for 30%) and in child-directed speech (uSu pattern accounts for 17% of structures) supports the early development of prosodic words with greater syllabic complexity in Spanish-speaking children compared with children who speak English or Catalan (Quilis, 1983; Prieto, 2006; Astruc et al., 2010).

At the word shape level, deletion continued to be the dominant mismatch trend. However, different types of deletion were noted in targets without and with consonant sequences. Singleton consonant deletion and singleton vowel deletion were most common in words without consonant sequences, with group, age and word length effects similar to those observed for syllable deletion. In words with consonant sequences within a syllable – i.e. tautosyllabic sequences – deletion of the first (C1) or second (C2) consonant occurred. While the primary focus of this paper was a suprasegmental and not segmental analysis, investigation of the segments within tokens was used to clarify the structural patterns observed in these consonant sequences. A more detailed frequency count revealed a strong pattern of C2 (/ɾ/) deletion in unstressed word-initial

consonant sequences (e.g. *princesa* /pɾinˈ{s/θ}e.{s/θ}a/ ‘princess’ produced as [pinˈθeθa]). This deletion pattern preserved the less sonorant C1 segment, as noted in previous research (Barlow, 2006).

Tautosyllabic sequences in stressed word-medial positions showed less deletion overall and a less consistent tendency for deletion of the second consonant, C2, suggesting that the weaker prosodic environment of the initial unstressed syllable was more vulnerable to mismatch (Gerken, 1994). Consonant deletion in stressed tautosyllabic sequences was particularly mixed between C1 and C2 deletion for the target *cocodrilo* /ko.koˈðɾi.lo/ ‘crocodile’, indicating possible segment-structure interactions between the /l/, /ɾ/ and /ð/ in this complex syllable sequence. In this case, preserving the /ɾ/ rather than the /ð/ may have been a preference for some children as a strategy to decrease the difficulty of sequencing multiple syllables. The patterns of C1 and C2 deletion in tautosyllabic and heterosyllabic sequences were similar across the PPD and TD groups, suggesting a similar developmental course for complex syllable structures within this sample. However the frequency of consonant deletion was far higher among the PPD participants than their TD peers. This finding is consistent with evidence of phonological process use in Puerto Rican Spanish-speaking children (Goldstein, Fabiano, & Iglesias, 2004). It implies that the majority of children in the PPD sample were following the same developmental patterns as children in the TD sample, yet at a protracted rate of acquisition.

In words with consonant sequences crossing syllable boundaries (heterosyllabic sequences), deletion of the first consonant (coda) was more common than deletion of the second consonant (onset) and overall frequency was higher in the PPD group than in the TD group. This trend follows expectations based on the low frequency of syllable codas in Granada Spanish: in this dialect, word-final codas are often optional and many unstressed word-medial codas may be

weakened such that the second consonant segment in the heterosyllabic sequence becomes geminated. For example, *escalera* /e{s/θ/ʰ/ø}kaˈle{ɾ/r}a/ ‘staircase’ may be produced with or without a coda in the initial syllable. (Note that in cases of optional gemination, such as tortuga /to{ɾˈt/ˈtː}uɣa/ ‘turtle’, the timing unit of the coda consonant must be preserved. See Bernhardt et al. (unpublished) for more details on the use of syllable codas in this dialect.)

For overall segment-structure interaction mismatch patterns, assimilation was the most frequent mismatch pattern in targets with and without consonant sequences. This mismatch code was assigned for the partial migration of segmental content – i.e. one or more phonological features – that did not result in full segmental reduplication and was not consistent with the child’s typical segmental match/mismatch patterns. Unlike deletion patterns, however, there was no clear word length effect and only a slight age effect for assimilation. A slight group effect was noted but with less consistency than for deletion mismatch patterns. Overall, these findings suggest that assimilation was a mismatch pattern used roughly equally by both the TD and PPD children. This finding is inconsistent with the expectation of group and age effects based on previous comparisons between Spanish-speaking children with typical and atypical phonological development (Goldstein & Iglesias, 1996; Goldstein, Fabiano, & Iglesias, 2004).

The MSW rubric design may account for the unexpected lack of group and age effects in the use of assimilation. The children who have lowest overall rates of percent structure match – i.e. those who are younger and in the PPD group – might be expected to use mismatch patterns such as deletion and assimilation with greater frequency than other children. Considering that the rubric assesses multiple levels of the prosodic hierarchy simultaneously, these unexpected findings for assimilation frequency could have been the result of participants using mismatch patterns such as syllable deletion. If children used syllable deletion, or even singleton vowel or

consonant deletion in a production, they would reduce the overall number of opportunities (i.e. CV units) to use assimilation within that token, therefore possibly equalizing the use of the assimilation mismatch pattern between groups.

Overall, the most frequent mismatch patterns were, as predicted, syllable and consonant deletion as well as assimilation. While group and age effects were observed for the structurally-based deletion mismatches, corresponding to the literature, no effects were found for assimilation mismatch. This finding could be accounted for by a greater use of structure codes among younger participants in this sample and those with PPD.

4.3 Evaluation of prosodic factors: stress and word length

Several inferential and descriptive analyses were performed to evaluate the effects of stress and word length on the participants' MSW productions. Similar restrictions for use of the inferential analyses applied to the evaluation of prosodic factors as described above for examining participant factors. Consequently descriptive analyses were carried out when inferential approaches were not possible due to sample characteristics of the data.

4.3.1 Mismatch scores in unstressed versus stressed syllables

The first analysis for prosodic factors concerned the mismatch proportions in stressed versus unstressed syllables (the latter being a weak prosodic environment, and considered potentially more vulnerable). An inferential approach very similar to that described in the previous section was employed, with the same two IVs (group and gender) included. In this analysis, each participant's raw mismatch scores in initial unstressed syllables were subtracted from their raw mismatch scores in medial or final stressed syllables in productions of uS and uSu targets. The results of two-way ANOVA tests revealed that participants with PPD had

significantly larger word structure mismatch difference scores and combined structure and interaction mismatch difference scores relative to the participants with TD.

No other significant effects were found for group, gender or for interactions between group and gender. There was no significant group difference for segment-structure interaction mismatch difference scores: in fact the raw mean was for both groups was zero, indicating an average of no difference in interaction mismatch points in unstressed versus stressed syllables. These data suggest that there was no significant difference in the use of segment-structure interaction codes in initial unstressed syllables and non-initial stressed syllables in uS and uSu targets. This result was unexpected based on the prediction that more segment-structure interaction patterns would occur in the initial unstressed syllable for children with PPD. According to previous research, initial unstressed syllables are vulnerable to changes in typically-developing children (Gerken, 1994; Kehoe, 2001). Moreover, evidence of Spanish-speaking children has suggested that children with PPD use substitution patterns with greater frequency than children with TD (Goldstein, 2005). This finding was not consistent with previous research but did not examine segmental accuracy per se, because analysis of segmental match was performed only when structure-segment interaction was involved.

On the other hand, the significant group effect for word structure and combined structure and interaction mismatch difference scores indicated that children with PPD did use a greater number of structure mismatches – i.e. syllable deletion or consonant deletion – in the unstressed initial syllable, as predicted by the literature (Chávez-Peón et al., 2012; Kehoe, 2001). A possible explanation for the discrepancy between structural mismatch difference scores and segment-structure interaction mismatch difference scores was the greater use of deletion in initial unstressed syllables noted above in the discussion of mismatch pattern frequencies. Because

mismatch points compound across word stress and word shape levels, initial syllable deletion results in at least two structural points and simultaneously removes the possibility of assigning segment-structure interaction points.[7] Thus, children in the PPD group used segment-structure interaction codes in unstressed and stressed syllables in uSu targets with approximately the same pattern as the children in the TD group in addition to using a greater number of word structure mismatch codes in unstressed syllables compared with their TD peers. It is possible that if the data were adjusted to exclude productions with syllable, consonant and/or vowel deletion in this analysis, the children with PPD may have used more segment-structure interaction mismatch patterns in initial unstressed syllables than the children with TD.

A second possible explanation of these non-significant results could stem from the method of analysis. The mismatch difference scores were created by subtracting the number of mismatch points in the unstressed syllable from those in the stressed syllable. Therefore a child in the PPD group could, in theory, have numerous segment-structure interaction mismatch points in the initial unstressed syllables of uS and uSu targets and have equally as many in the non-initial stressed syllables. This pattern would result in a mismatch difference score of zero. In contrast, a child in the TD group could match all the targets in both the unstressed and stressed syllables and therefore have no mismatch points. Like the first child, the second child would have a mismatch difference score of zero. In this scenario, the two children would have different overall mismatch scores but for this measure they would have identical mismatch difference scores resulting in no significant difference for this measure.

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[7] Segment-structure interaction mismatch codes could not be assigned to syllables simultaneously with structural (i.e. deletion) mismatch codes with one exception: migration. See the definition of mismatch codes in Appendix B for further details. The migration code was used infrequently.

These potential explanations of the non-significant findings highlight a weakness in this inferential measure. Since the unstressed-stressed mismatch difference score analysis was designed to find the difference in scores and not overall frequency of use, non-significant findings cannot be fully interpreted without further analysis of the data beyond the scope of this study.

An analysis of the correlation between age and mismatch different scores was significant for word structure and combined structure and interaction mismatch difference scores, but as with the findings for group, there was no significant correlation between age and segment-structure interaction mismatch difference scores. Again, the possibility that syllable and/or consonant deletion in initial unstressed syllables precluded the opportunities for segment-structure interaction mismatches across the age range could account for this non-significant finding.

Therefore, the general findings of this investigation of mismatch difference scores suggested the children in the PPD group had greater use of mismatch patterns than their TD peers within the more vulnerable prosodic environment of initial unstressed syllables. Younger children also had greater mismatch difference scores than older children. However, these patterns only emerged for structurally-based mismatches, such as deletion. For segment-structure interaction mismatches there were no significant findings for group or age and the null hypothesis was not rejected.

4.3.2 Trends in descriptive analyses of word length

The final area of investigation was the role of word length in children's productions of MSWs. This prosodic factor was evaluated using the descriptive analyses outlined above for percent structure match mismatch code frequency. As predicted based on previous studies in

Spanish acquisition, word length effects were found for both descriptive analyses (Astruc et al., 2010).

In the percent structure match analysis, there was very little difference among participants for 2-syllable targets, with the exception of a lower percent match median for 3-year-old participants with PPD. For 3-syllable targets, the participants' median percent match was lower than for 2-syllable targets. Percent structure match was lower still for 4-syllable targets than for 3-syllable targets. Thus, a word length effect was noted: as word length increased, percent match decreased.

A similar trend of word length was found in the frequency of common mismatch codes. At the word stress and word length level, the use of syllable deletion decreased in both groups as word length increased for words with and without consonant sequences. However, since no 5-year-old participants used this mismatch pattern, the effect was only observed among 3- and 4-year-olds. The same trend occurred at the word shape level without consonant sequences: vowel deletion and consonant deletion both increased in frequency as word length increased for participants in the 3- and 4-year-old age range. The most common word shape mismatch patterns in words with consonant sequences could not be analyzed by word length because the distribution of tautosyllabic and heterosyllabic sequences was not balanced across the data set.

The single descriptive analysis that did not reveal a clear word length effect was the frequency of assimilation in words with and without consonant sequences, although a slight effect of word length may be observed in words without consonant sequences. This finding was not consistent with predictions based on mismatch pattern use in MSWs by English-speaking children (James, van Doorn, & McLeod, 2008). This pattern may have emerged for several reasons, including the possibilities that: (1) there was truly no difference in assimilation use for

words of different lengths; that (2) the limited data set, particularly for words with consonant sequences, was too small to provide accurate results; or that (3) segmental variation in the data set accounted for more variability in assimilation mismatch codes than word length and therefore obscured any word length effect that might have been present.

In sum, stress and word length each impacted mismatch scores in this sample of Spanish-speaking children's productions of MSWs. Effects of the prosodic factors stress and word length were found for structural mismatches and combined structure and interaction mismatches, but not for segment-structure interaction mismatches. These findings are similar to the analyses of the participant factors, group and age. For both group and age, effects were found for both structural and combined structure and segment-structure interaction mismatches. A significant group effect was found for overall segment-structure interaction mismatches, but group and age effects were not observed in the analysis of the most common segment-structure mismatch pattern, assimilation. This result could be due in part to the relatively infrequent use of assimilation across the full data set. With the exception of these results for segment-structure interaction, all of the predicted group, age, stress and word length trends were supported by the research findings and are consistent with previous studies on MSW productions in Spanish- and English-speaking children (Goldstein, Fabiano, & Iglesias, 2004; Flipsen, 2006; Astruc et al., 2010; Prieto, 2006; James, 2006).

4.4 Limitations of the current study

In the field of child speech acquisition it is common to use convenience sampling. Children's participation requires parental consent and there are often limited settings within which children who fit the specific study criteria may be recruited. Moreover, limitations in resource availability – such as the time frame for data collection and financial support – can

impact sampling procedures. Given these challenges, the use of a convenience sample is commonplace in the literature. Limitations in the current inferential analysis methods have stemmed from the necessary use of this sampling approach in the current study. Although the current sample size is larger than is often the case for acquisition studies, each age and gender group remains small.

A second limitation, as described in the rubric design process, was the challenge of applying a detailed scoring rubric to the children's speech data. Judgments of whether mismatches were purely segmental or the result of segment-structure interactions were at times ambiguous, as were a small proportion of child productions that included multiple mismatches and therefore permitted several different coding options to fit the data, each with a slightly different result. A coding manual was used to constrain ambiguity. However some children's idiosyncratic productions were very creative and prevented the implementation of a fully systematic coding procedure. Nevertheless, the inter-rater reliability score (95.22%) indicated that ambiguities were likely present in only a small proportion of the data. Further refinements of the coding manual would be beneficial for future use of the MSW rubric.

Another challenge with the MSW scoring rubric was the absence of perceptual data in the literature to use for anchoring mismatch point values. As with Shriberg's (1993; 1997) PCC measures and Ingram's (2002) whole word approach to evaluating child speech productions, this scoring tool lacks concrete connections to listeners' experiences of child speech productions. It is not possible to know without further research whether the quantitative point value approach – rather than simply a frequency count of instances – is an accurate representation of the impact of mismatches on intelligibility and listeners' perception. Further research into perceptual norms in

Granada Spanish are necessary to strengthen the application of this MSW scoring rubric to children's MSW productions.

Regarding the sample data set, a large number of productions were collected per participant (approximately 100 words per participant in the full data set; see Bernhardt et al. [unpublished]). While in itself this large data set is a strength, a consequence of this decision was the restriction of elicitations to one production per token per child. Estimates of within-word variability or the effect of imitation on production could not be performed within the existing data set. Thus, the decision to include both spontaneous and imitated tokens in the current analysis set had to be made based on previous research on a different group of Spanish-speaking children rather than an analysis within the sample set (Goldstein, Fabiano, & Iglesias, 2004).

4.5 Conclusion

Despite the limitations discussed above, the current research findings have indicated that participant and prosodic factors impacted MSW productions by Granada Spanish-speaking preschoolers. Within this sample of children aged 3;0 to 5;11, effects of group and age were noted on measures of word stress, length and shape in MSW words. The participants with PPD had significantly more mismatches overall than the TD participants. This trend was strongest among 3-year-olds and 4-year-olds for structurally-based mismatches at the word stress, word length and word shape levels. Descriptive analyses revealed that mismatch patterns decreased as age increased across both PPD and TD groups: of all the 5-year-old children in this sample, a large majority used few, if any, structural mismatch patterns in their MSW productions. An analysis of stress revealed group differences in structural mismatches between unstressed word-initial and stressed word-medial/final syllables. A word length effect was also noted, with very few mismatches occurring in 2-syllable uS targets and the greatest number of mismatches in 4-

syllable targets. These patterns were consistent with the predictions made based on the existing evidence of MSW and Spanish acquisition (James, 2006; Prieto, 2006; Astruc et al., 2010; Chávez-Peón et al., 2012). The implications of these findings are discussed below.

4.5.1 Research implications

The similarity of the current findings to previous research suggests that the multisyllabic scoring rubric is able to accurately quantify and describe mismatch patterns for MSWs. This analysis approach provided a richer depth of information than would have been possible from a PCC or whole word analysis (Shriberg, 1993; Ingram & Ingram, 2001). The multisyllabic rubric successfully carried out simultaneous evaluation of multiple levels of the prosodic hierarchy in a single scoring process. This analysis approach yielded global quantitative mismatch scores and detailed qualitative information on participants' use of word stress, word length, word shape and segment-structure interactions. The colour-coding for mismatch scores also provided quick visual information about general mismatch trends in the data and enabled the author to easily gain a gist of the data for shaping in-depth analyses. Moreover, the rubric design could be easily adapted for research use in different languages by adjusting the list of mismatch codes (see Mason, Bernhardt, & Masterson, 2011). For all of these reasons, the MSW scoring rubric is a valuable new tool for researching children's phonological abilities at the prosodic word level.

In addition to providing evidence supporting the use of this rubric approach in analyzing MSWs, the data illustrated specific trends within this Spanish-speaking sample that have not previously been reported. A direct comparison between children with PPD and TD revealed a difference in MSW production across group and age ranges. This difference was particularly noticeable in this sample among the 4-year-old children. In this age range, the majority of the TD Granada Spanish-speaking children used few mismatch patterns, even in the complex 4+-syllable

targets. In contrast, the 4-year-old children with PPD used mismatch patterns with a higher overall frequency than the 4-year-old with TD and the 3-year-old children with TD. However among the 5-year-old participants, the particular children in the PPD group had mismatch scores closer to those of their TD peers with similar (non)use of mismatch patterns such as syllable deletion and singleton consonant deletion. While it is possible that due to small sample size, these participants may not be representative of the population, there appeared to be a large developmental difference in the children with PPD when comparing the 4-year-old children with those in the 5-year-old group.

James (2006) reported that TD English-speaking children producing MSWs continued to use several mismatch patterns, such as weak syllable deletion, cluster reduction and metathesis, until age 7;11. The 5-year-old TD Spanish-speaking children in this study used very few mismatch patterns. This finding was consistent with evidence that Spanish-speaking children acquire MSWs earlier than children learning English, Catalan or German due to frequency of MSWs in the input (Astruc et al., 2010; Prieto, 2006; Lleó, 2006). The low frequency of coda consonants and complex consonant sequences in Granada Spanish could also impact the children's MSW productions: because Spanish word structures are less complex than those of English (i.e. a maximum of two consonants in the onset and infrequent use of codas, especially in Granada), Spanish-speaking children who perform at an apparently higher level than their English-speaking peers may not be challenged to the same degree.

In sum, this study indicates independent participant and prosodic trends in MSW productions in Spanish-speaking children, a new contribution to the literature on Spanish acquisition.

4.5.2 Clinical implications

Although the current research findings may not be generalizable to decision-making for clients in clinical populations due to the limitations described above, the concepts underlying the use and design of the rubric are particularly valuable for clinicians who need to assess children with PPD. The nonlinear framework of the MSW scoring rubric provides a rich quantitative and qualitative method of understanding a child's phonological abilities. The theoretical foundation, ease of incorporating analysis at multiple levels of the prosodic hierarchy and the visual colour coding for quick scanning of mismatch patterns together make the rubric a potentially powerful measure for phonological analysis. In its current design, the MSW rubric itself is likely too time-consuming to be used in the clinic, yet future research to shorten the procedure and potentially automate the system would make it a useful clinical tool. Mason, Bernhardt and Masterson (2011) have demonstrated the value of a preliminary MSW rubric for English-speaking school-aged children, indicating that the rubric may be adapted for different languages. Note that the MSW rubric is not currently a technique that evaluates segmental match/mismatch (although it could), and cannot be used in isolation: rather, it could be used as part of a battery of tools for phonological analysis.

Ultimately the findings in this study show that MSWs are an area of phonological difficulty for Spanish-speaking children despite their relatively early acquisition of prosodic structures. The group, age, stress and word length trends in the sample demonstrate that MSWs are an important component of phonological evaluation. As noted by James (2006) in English-speaking populations, these Spanish-speaking children's difficulty with various tiers of the prosodic hierarchy, which may be obscured in sorter mono- and disyllabic words, can be revealed in MSW productions. This effect is particularly clear among 3-year-old and 4-year-old

children with PPD. For instance, within this sample, participants in the TD group had a minimum of 80% structure match on uS iambic targets by age 3 years but did not have 80% structure match on 4+-syllable targets until age 5 years. Moreover, there was very little difference between the TD and PPD groups for either percent match or mismatch pattern use for disyllabic uS targets at age 4, yet there was a noticeable different between these two groups for targets with 3- and 4+-syllables at this age. Therefore, analyzing MSW productions is a crucial component of understanding a child's phonological abilities at each level of the prosodic hierarchy and would be useful to include in assessment and treatment for all children with suspected or confirmed PPD.

4.6 Areas for further research

Future investigations of MSWs in Spanish-speaking children with larger sample sizes are necessary to establish data that may be generalized across populations. Furthermore, prosodic measures of word stress, length and shape could be investigated not only at the word level but also at the phrase level to gain a better understanding of Spanish-speaking children's prosodic abilities. Data from 2-year-old TD English-speaking children indicated greater frequency of weak syllable deletion in MSWs than in equivalently stressed phrases of monosyllabic words (Gerken, 1994). Further research on this topic among Spanish-speaking children with TD and PPD, including direct a comparison of prosodic match in MSWs and phrases, would provide a broader understanding of Spanish-speaking children's prosodic development especially taking into account the impact of multiple unstressed clitics. This future research would also provide greater insight on prosodic stress patterns in this syllable-timed (rather than stress-timed) language, particularly considering the application of phonological stress at the phrase level in Spanish (Gennari & Demuth, 1997).

Another future line of investigation would be to gather further information on the role of input frequency at the phonological and lexical level for Granada Spanish-speaking children. An extensive search for lexical frequency norms of child-directed speech in the Granada region of Spain yielded no results. Several Spanish databases were found, including a database of oral frequency for adult language in Spain (Alonso, Fernandez, & Díez, 2011), a database of phonologically transcribed surface forms taken from the writings of children ages 6 to 10 years in southern Spain (Santiago, Justicia, Palma, Huertas, & Gutiérrez, 1996) and a database of lexical acquisition among young children in Cuba (Piñeiro & Manzano, 2000). However none of these could provide information specific to the current sample. Further research into frequency of the target MSWs in child-directed Granada Spanish would enable evaluation of the role of lexical familiarity – and potentially complex phonological familiarity – on children's MSW productions.

Two key aspects of the MSW scoring rubric merit further research. First, quantitative outputs of the rubric should be empirically compared with outputs of the PCC and whole word measures for the same sample data in order to validate the rubric design. Note that whole word match – an adapted version of Ingram's (2001) proportion of whole word proximity used for single word elicitation sample rather than a conversational speech sample – was calculated for each of the participants in the original study from which the current data were drawn (See Bernhardt et al., unpublished). A highly significant correlation existed between age (in months) and whole word match ($r = .56$, $p < .001$). It is likely, therefore, that a whole word analysis of multisyllabic targets in this data set would also show a significant effect of age, as found for the current data. However, it is necessary to repeat the whole word match analyses (and to perform PCC) on this specific subset of the original data for validation of the rubric.

Finally, the MSW rubric will need improvements in design for it to become an efficient clinical tool. Investigations into potential computer automatization, such as in the program PHON, would be beneficial (Rose & Hedlund, 2011). The end goal of this line of research would be to establish the MSW rubric as an efficient, accessible phonological tool for quantitatively and qualitatively analyzing multisyllabic words in both clinical and research populations.

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Appendices

Appendix A List of analyzed targets by word length, stress, and word shape pattern

Syllables	Stress	Word Shape	Freq.	Targets
Two	uS	V'CV(C)	1	azul /aˈ{s/θ}u{l/ɾ/ø}/
	uS	CV'CV(C)	4	jamón /{x/h}aˈmõ{ŋ/n/ø}/, nariz /naˈɾi{s/ʰ/θ/ø}/, ratón /raˈto{ŋ/n/ø}/, reloj /reˈl{o/ɔ}{x/ʰ/ø}/
	uS	CCV'CV(C)	1	dragón /dɾaˈɣo{ŋ/n/ø}/
Three	Suu	'CVC.CV.CV	1	lámpara /ˈlampaɾa/
	Suu	'CV.CV.CV	1	pájaro /ˈpa{x/h}aɾo/
	Suu	'CCVVC.CV.CV	1	triángulo /ˈtɾjaŋɣulo/
	uSu	VV'CV.CV	1	Europa /euˈɾopa/
	uSu	VC'CVVC.CV	1	hirviendo /i{ɾˈβ/ˈβː}{je/ie}n̪do/
	uSu	VC'CV.CV	1	hermano /e{ɾˈm/ˈmː}ãno/
	uSu	V'CVVC.CV	1	abierta /aˈβ{je/ie}{ɾt/tː}a/
	uSu	V(C)'CVC.CV	1	estanque /e{s/θ/ʰ/ø}ˈtaŋke/
	uSu	CVV'CVC.CV	1	bailando /baiˈlan̪do/
	uSu	CVC'CVC.CV	1	saltando /{s/θ}a{l/ɾ}ˈtan̪do/
	uSu	CVC'CV.CV	1	tortuga /to{ɾˈt/ˈtː}uɣa/
	uSu	CVC'CV.{C/V}V	1	martillo /ma{ɾˈt/ˈtː}i{d͡ʒ/ʝ/j}o/
	uSu	CVC'CCV.CV	1	sombrero /{s/θ}omˈbɾeɾo/
	uSu	CV'CVC.CV	1	chocando /t͡ʃoˈkan̪do/
	uSu	CV'CV.CV	7	conejo /koˈne{x/h}o/, guitarra /giˈtaɾa/, jirafa /{x/h}iˈɾafa/, juguete /{x/h}uˈɣete/, muñeca /mũˈɲeka/, regalo /reˈɣalo/, zapato /{s/θ}aˈpato/
	uSu	CV'CV.{C/V}V	1	caballo /kaˈβa{d͡ʒ/ʝ/j}o/
	uSu	CV(C)'CV.(C)V	1	pescado /pe{s/θ/ʰ/ø}ˈka{ð/ø}o/
	uSu	CCVC'CV.CV	1	princesa /pɾin̪{ˈθ/s}e{θ/s}a/
	uSu	{C/V}V'CVC.CV	1	llorando /{d͡ʒ/ʝ/j}oˈɾan̪do/
	uuS	CVC.CV'CV(C)	1	pantalón /pan̪taˈlo{n/ŋ/ø}/
Four and Five	uSuu	CV'CV.CV.CV	1	teléfono /teˈlefono/
	uuSu	V(C).CV'CV.CV	1	escalera /e{s/θ/ʰ/ø}kaˈle{ɾ/r}a/
	uuSu	V.CV'CVC.CV	1	elefante /eleˈfan̪te/
	uuSu	CV.CV'V.CVV	1	zanahoria /{s/θ}anaˈoɾja/
	uuSu	CV.CV'CVV.CVV	1	dinosaurio /dinoˈ{s/θ}auɾjo/
	uuSu	CV.CV'CV.V	1	chimenea /{t͡ʃ/ʃ}imẽˈne.a/
	uuSu	CV.CV'CV.CV	1	chocolate /t͡ʃokoˈlate/
	uuSu	CV.CV'CCV.CV	1	cocodrilo /kokoˈðɾilo/
	uuSu	CCV.CV'CV.CV	1	primavera /pɾimaˈβeɾa/
	uuSuu	V.CV'CV.CV.CV	1	hipopótamo /ipoˈpotamo/

Appendix B List of codes with definitions and example of use in data

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Lexical Effects	LexicalEffect	1.0	The child's production is influenced by, or is a full realization of, a separate semantic target. No further code points given because child is not attempting the intended target.	conejo	/koˈneho/	[oɣ̞ˈeːhɔ]	Child appears to be attempting "oreja" (ear) rather than "conejo" (rabbit)
Word Length	SyllDeltn	1.0	One syllable is deleted.	guitarra	/giˈtara/	[ˈtala]	First syllable deleted.
Word Length	SyllInsrtn	1.0	One syllable is inserted.	sombrero	/somˈbrɛro/	[soˈbɔrɛro]	Additional syllable inserted into 2nd syllable.
Stress Pattern	StressShift	0.5	The child uses a non-target stress pattern. (Not simply the result of deleted syllables, i.e. child moves stress within word.)	primavera	/pɾi.maˈβe.ɾa/	[ˈtjaβera]	Child produces Suu rather than uuSu.
Word Length	HALF-SyllDeltn	0.5	Half of the nucleus (V) of one syllable is deleted. Does not apply to deletion of one V in a VV nucleus sequence. Child's nucleus must be short single vowel to use this code.	elefante	/eleˈfan̪te/	[eðˈfan̪te]	Child partially deletes nucleus (vowel) of second syllable.
Word Length	HALF-SyllInsrtn	0.5	Half of the nucleus (V) of one syllable is inserted. Does not apply to insertion of one V to create VV nucleus sequence. Child's inserted nucleus must be short single vowel to receive this code.	teléfono	/teˈlefono/	[peðˈbeɸono]	Additional half-syllable (short schwa) inserted between first and second syllable.
Structure/CV Word Shape	VDeltnSingleton	1.0	One singleton (V) vowel is deleted.	hermano	/eɾˈmãno/	[ˈmãno]	Initial singleton V vowel /e/ is deleted.
Structure/CV Word Shape	VVDeltnRisDiphth	2.0	One rising diphthong (jV or wV) is fully deleted (both VV segments deleted).	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	VVDeltnFallDiphth	2.0	One falling diphthong (Vi or Vu) is fully deleted (both VV segments deleted).	bailando	/baiˈlan̪.do/	[banˈdo]	Falling diphthong /ai/ in initial syllable deleted.

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Structure/CV Word Shape	V1DeltnRisDiphth	1.0	The first segment (j or w) of a rising diphthong (jV or wV) is deleted, preserving the second segment (V2).	hirviendo	/ɪrˈβ{je/ie}n̪.do	[iˈβen̪to]	First vowel segment (V1, /j/) deleted in medial syllable, preserving /e/ (V2).
Structure/CV Word Shape	V2DeltnRisDiphth	1.0	The second segment (V) of a rising diphthong (jV or wV) is deleted, preserving the first segment (j or w).	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	V1DeltnFallDiphth	1.0	The first segment (V) of a falling diphthong (Vi or Vu) is deleted, preserving the second segment (i or u).	Europa	/euˈɾopa/	[uˈɾopa]	First vowel /e/ is deleted in initial syllable, leaving /u/ (V2).
Structure/CV Word Shape	V2DeltnFallDiphth	1.0	The second segment (i or u) of a falling diphthong (Vi or Vu) is deleted, preserving the first segment (V1).	bailando	/baiˈlan̪.do/	[baˈlan̪do]	Second vowel (V2, /i/) deleted, preserving /a/ (V1).
Structure/CV Word Shape	HALF-VDeltnSingleton	0.5	One singleton (V) vowel is partially deleted. Preserves a half-length (superscript or short) vowel.	chocolate	/t͡ʃokoˈlate/	[t͡ʃo.ŏˈlate]	Second vowel segment /o/ is partially deleted.
Structure/CV Word Shape	HALF-V1DeltnRisDiphth	0.5	The first segment (j or w) of a rising diphthong (jV or wV) is partially deleted, preserving a short V1 (j or w) and the full second segment (V2).	dinosaurio	/di.noˈsau.ɾjo/	[ˈs̪oðjo]	First vowel segment of rising diphthong /jo/ is partially deleted.
Structure/CV Word Shape	HALF-V2DeltnRisDiphth	0.5	The second segment (V) of a rising diphthong (jV or wV) is partially deleted, preserving the full first segment (j or w) and a short V2.	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	HALF-V1DeltnFallDiphth	0.5	The first segment (V) of a falling diphthong (Vi or Vu) is partially deleted, preserving a short V1 and a full second segment (i or u).	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	HALF-V2DeltnFallDiphth	0.5	The second segment (i or u) of a falling diphthong (Vi or Vu) is partially deleted, preserving the full first segment (V) and a short V2 (i or u).	dinosaurio	/di.noˈsau.ɾjo/	[dinoˈθaŭɾo]	Second vowel segment of falling diphthong /au/ is partially deleted.

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Structure/CV Word Shape	VInsrtnSingleton	1.0	One singleton (V) vowel is inserted. Note that no additional codes are given to the inserted segmented even if it appears to be reduplication/ assimilation/etc.	lámpara	/ˈlampaɾa/	[ˈpaɾampala]	Child inserts full /a/ in added syllable.
Structure/CV Word Shape	VLengthening	1.0	Any vowel segment (V) is lengthened, i.e. given an extra timing unit, independently of other deletions in the word.	jamón	/xaˈmõn/	[maˈmõːn]	Child lengthens /o/ vowel without deleting any other timing units.
Structure/CV Word Shape	V1InsrtnRisDiphth	1.0	The first segment (j or w) of a rising diphthong (jV or wV) is inserted to create a VV sequence.	abierta	/aˈβjeɾta/	[wiˈjeta]	Child inserts full /w/ as V1 of rising diphthong in initial syllable.
Structure/CV Word Shape	V2InsrtnRisDiphth	1.0	The second segment (V) of a rising diphthong (jV or wV) is inserted to create a VV sequence.	juguete	/xuˈɣete/	[puβuˈwute]	Few instances. In this case the child inserts a full extra diphthong syllable /wu/, including the V2 vowel /u/.
Structure/CV Word Shape	V1InsrtnFallDiphth	1.0	The first segment (V) of a falling diphthong (Vi or Vu) is inserted to create a VV sequence.	hipopótamo	/ipoˈpotamo/	[ˈpamɐ̃u]	Few instances. Here the child creates /ɐ̃u/ VV sequence word finally with steady /u/ (falling).
Structure/CV Word Shape	V2InsrtnFallDiphth	1.0	The second segment (i or u) of a falling diphthong (Vi or Vu) is inserted to create a VV sequence.	conejo	/koˈneho/	[koˈnehou]	Child inserts full /u/ as V2 of falling diphthong in final syllable.
Structure/CV Word Shape	HALF-VInsrtnSingleton	0.5	One partial/half singleton (V) vowel is inserted.	teléfono	/teˈlefono/	[peðˈbeɸono]	Half-vowel segment (short schwa) inserted between first and second syllable.
Structure/CV Word Shape	HALF-V1InsrtnRisDiphth	0.5	The first half/partial segment (j or w) of a rising diphthong (jV or wV) is inserted before a full V segement creating a partial VV sequence.	regalo	/reˈɣa.lo/	[gɣ̆eˈɣaɣʷo]	Child inserts partial /w/ in 3rd syllable to create partial rising diphthong.

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Structure/CV Word Shape	HALF-V2InsrtnRisDiphth	0.5	The half/partial second segment (V) of a rising diphthong (jV or wV) is inserted after a full /j/ or /w/ segment creating a partial VV sequence.	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	HALF-V1InsrtnFallDiphth	0.5	The half/partial first segment (V) of a falling diphthong (Vi or Vu) is inserted before a full /j/ or /w/ segment creating a partial VV sequence.	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	HALF-V2InsrtnFallDiphth	0.5	The half/partial second segment (i or u) of a falling diphthong (Vi or Vu) is inserted after a full V creating a VV sequence.	guitarra	/giˈtara/	[tiˈtaŭla]	The child inserts partial /u/ as V2 second segment of newly created diphthong.
Structure/CV Word Shape	CDeltnSingleton	1.0	One singleton (C) consonant is deleted.	teléfono	/teˈlefono/	[teˈefono]	Child deletes consonant /l/ segment.
Structure/CV Word Shape	C1DeltnSeqWinSyll	1.0	The first segment (C1) of a CC sequence WITHIN a syllable is deleted, preserving C2.	cocodrilo	/ko.koˈðɾi.lo/	[kokoˈɾilo]	In medial CC sequence within syllable 3, child deletes C1 /ð/ and preserves C2 /ɾ/.
Structure/CV Word Shape	C2DeltnSeqWinSyll	1.0	The second segment (C2) of a CC sequence WITHIN a syllable is deleted, preserving C1.	cocodrilo	/ko.koˈðɾi.lo/	[kokoˈðilo]	Second consonant segment /ɾ/ in medial CC sequence is deleted, leaving C1 /ð/.
Structure/CV Word Shape	C1DeltnSeqAcrSyll	1.0	The first segment (C1) of a CC sequence ACROSS a syllable boundary is deleted, preserving C2.	abierta	/aˈβjeɾta/	[aˈβjeta]	Consonant segment /ɾ/ in C1 position of CC sequence is deleted.
Structure/CV Word Shape	C2DeltnSeqAcrSyll	1.0	The second segment (C2) of a CC sequence ACROSS a syllable boundary is deleted, preserving C1.	hirviendo	/iɾˈβ{je/ie}n̪.do	[iˈβjeno]	Second consonant /d/ (C2) in medial CC sequence is deleted, leaving C1 /n/.

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Structure/CV Word Shape	CCDeltnSeqWinSyll	2.0	Both C1 and C2 segments of a CC sequence WITHIN a syllable are deleted, preserving no C segments.	princesa	/pɾin̪ˈsesa/	[ˈs̪es̪a]	Entire first syllable is deleted, including both consonants of initial CC sequence.
Structure/CV Word Shape	HALF-CDeltnSingleton	0.5	One singleton (C) consonant is partially deleted leaving a half-consonant (C).	guitarra	/giˈtara/	[ˣiˈtara]	Initial consonant segment /ɣ/ is partially deleted.
Structure/CV Word Shape	HALF-C1DeltnSeqWinSyl	0.5	The first segment (C1) of a CC sequence WITHIN a syllable is partially deleted, preserving half C1 plus C2.	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	HALF-C2DeltnSeqWinSyl	0.5	The second segment (C2) of a CC sequence WITHIN a syllable is partially deleted, preserving C1 and half C2.	sombrero	/somˈbɾe.ɾo/	[s̪om̆ˈbʷeo]	Child partially deletes segment in C2 position of sequence within syllable. In the target this is /ɾ/ but note that child subs /ɾ/ > /w/ also.
Structure/CV Word Shape	HALF-C1DeltnSeqAcrSyll	0.5	The first segment (C1) of a CC sequence ACROSS a syllable boundary is partially deleted, preserving half C1 and C2.	abierta	/aˈβjeɾta/	[aˈβjeɾ̆ta]	Consonant /ɾ/ in C1 position of CC sequence is partially deleted.
Structure/CV Word Shape	HALF-C2DeltnSeqAcrSyll	0.5	The second segment (C2) of a CC sequence ACROSS a syllable boundary is partially deleted, preserving C1 and half C2.	chocando	/t͡ʃoˈkan̪do/	[t͡ʃoˈkan̪d̆o]	Consonant segment /d/ in C2 position of CC sequence is partially deleted.
Structure/CV Word Shape	CInsrtnSingleton	1.0	One singleton (C) consonant is inserted and does not create a CC sequence within or across syllable boundaries.	chimenea	/t͡ʃimẽˈnea/	[t͡ʃimẽˈmeɾa]	Consonant segment /ɾ/ inserted into fourth syllable.
Structure/CV Word Shape	CLengthening	1.0	Any consonant segment (C) is lengthened, i.e. given an extra timing unit, independently of other deletions in the word.	chocando	/t͡ʃoˈkan̪do/	[toˈtan̪ːto]	Consonant segment /n/ is lengthened, adding a timing unit to the word.

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Structure/CV Word Shape	C1InsrtnSeqWinSyll	1.0	One (C) consonant segment is inserted next to another existing (C) consonant segment resulting in a CC sequence WITHIN a syllable. The inserted C takes the C1 position.	regalo	/reˈɣa.lo/	[dleˈɣalo]	Consonant segment /d/ inserted in C1 position in first syllable, creating CC sequence within syllable.
Structure/CV Word Shape	C2InsrtnSeqWinSyll	1.0	One (C) consonant segment is inserted next to another existing (C) consonant segment resulting in a CC sequence WITHIN a syllable. The inserted C takes the C2 position.	chocolate	/t͡ʃokoˈlate/	[t͡ʃkot͡ʃoˈlate]	Child inserts additional C /k/ to create word-initial CC sequence: C1 /t͡ʃ/ and C2 /k/.
Structure/CV Word Shape	C1InsrtnSeqAcrSyll	1.0	One (C) consonant segment is inserted next to another existing (C) consonant segment resulting in a CC sequence ACROSS a syllable boundary. The inserted C takes the C1 position.	guitarra	/giˈtara/	[tirˈtaɣla]	Consonant segment /ɾ/ in C1 position of new CC sequence across syllables 1 and 2.
Structure/CV Word Shape	C2InsrtnSeqAcrSyll	1.0	One (C) consonant segment is inserted next to another existing (C) consonant segment resulting in a CC sequence ACROSS a syllable boundary. The inserted C takes the C2 position.	guitarra	/giˈtara/	[giˈtalda]	Consonant segment /d/ is inserted word medially, creating consonant sequence across syllables. C1/l/ (sub for /r/) and C2 /d/.
Structure/CV Word Shape	HALF-CInsrtnSingleton	0.5	One partial/half singleton (C) consonant is inserted.	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	HALF-C1InsrtnSeqWinSyl	0.5	One partial/half (C) consonant segment is inserted next to another existing full (C) consonant segment resulting in a CC sequence WITHIN a syllable. The inserted C takes the C1 position.	(No instances)	(No instances)	(No instances)	(No instances)

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Structure/CV Word Shape	HALF-C2InsrtnSeqWinSyl	0.5	One partial/half (C) consonant segment is inserted next to another existing full (C) consonant segment resulting in a CC sequence WITHIN a syllable. The inserted C takes the C2 position.	regalo	/reˈɣa.lo/	[gɣ̆eˈɣaɣʷo]	Partial consonant segment /ɣ/ inserted to create initial CC sequence.
Structure/CV Word Shape	HALF-C1InsrtnSeqAcrSyl	0.5	One partial/half (C) consonant segment is inserted next to another existing full (C) consonant segment resulting in a CC sequence ACROSS a syllable boundary. The inserted C takes the C1 position.	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	HALF-C2InsrtnSeqAcrSyl	0.5	One partial/half (C) consonant segment is inserted next to another existing full (C) consonant segment resulting in a CC sequence ACROSS a syllable boundary. The inserted C takes the C2 position.	(No instances)	(No instances)	(No instances)	(No instances)
Structure/CV Word Shape	VDel&LengthAcrSyll-D	0.5	PAIRED CODES. Use when a (V) vowel segment is deleted from one syllable and a separate (V) vowel segment is lengthed in a different syllable (i.e. the child preserves timing units within the word). The "-D" code refers to segment deleted and "-V" code refers to segment lengthened. Always assigned in a pair to create a sum point value of [1.0]: each pair placed in the appropriate syllable column for deletion and lengthening.	estanque	/eˈtaŋke/	[ˈtan̪teː]	Child deletes vowel /e/ in first syllable and lengthens vowel /e/ in final syllable (with preserved timing units).
Structure/CV Word Shape	VDel&LengthAcrSyll-L	0.5					

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Structure/CV Word Shape	CDel&LengthAcrSyll-D	0.5	PAIRED CODES. Used when a (C) consonant segment is deleted from one syllable and a separate (C) vowel segment is lengthed in a different syllable (i.e. the child preserves timing units within the word). The "-D" code refers to segment deleted and "-V" code refers to segment lengthened. Always assigned in a pair to create a sum point value of [1.0]. Note: In some cases this applies within the syllable between the onset and coda.	cocodrilo	/ko.koˈðɾi.lo/	[tokːoˈlilo]	Child lengthens /k/ in 2nd syllable with deletion of /ð/ in stressed syllable (with preserved timing units).
Structure/CV Word Shape	CDel&LengthAcrSyll-L	0.5					
Structure/CV Word Shape	C to V	1.0	A consonant segment target (C) is produced as vowel (V) segment (including j and w EXCEPT for when liquids > /l/ or /w/).	juguete	/huˈɣete/	[huˈwete]	Consonant segment /ɣ/ produced as vowel /w/.
Structure/CV Word Shape	V to C	1.0	A vowel segment target (V) is produced as a consonant (C) segment.	dinosaurio	/dinoˈsaurjo/	[dinoˈsaβljo]	V2 segment /u/ of medial falling diphthong becomes C segment /β/.
Structure/CV Word Shape	CVMetath	1.0	A consonant segment target (C) and a neighbouring vowel (V) segment reverse position in word, ie: CV > VC, or VC > CV.	sombrero	/somˈbɾero/	[dɾoˈβero]	The CVC.CCV.CV shape becomes CCV.CV.CV (word shape of the initial syllable, C**VC** becomes C**CV**).

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Segment-Structure Interactions	CompLengthC	[1.0]	Used when the child deletes one (C) consonant segment and lengthens a neighbouring (C) segment in a CC sequence, preserving timing units (but losing segmental information). Note: this code is assigned in the destination syllable, not the syllable of origin. NB: V to C code also applies when consonant lengthens with vowel deleted, or when a neighbouring C segment is only half deleted but the neighbour is lengthened.	elefante	/eleˈfan̪te/	[eleˈfatːe]	The /n/ segment is deleted; /t/ segment is lengthened, preserving timing units (Compensatory Length).
Segment-Structure Interactions	SegmentMetath1	[0.5]	PAIRED CODES. When one segment and another segment reverse places. Applies to segmental content specifically not to structual level (eg: /k/ <> /l/). SegmentMetath1 and SegmentMetath2 assigned separately to affected segments for a total sum [1.0].	cocodrilo	/ko.koˈðri.lo/	[kokoˈliðo]	The segmental content of consonants in third and fourth syllables has reversed: /l/ and /ð/ have reversed positions.
Segment-Structure Interactions	SegmentMetath2	[0.5]					
Segment-Structure Interactions	Migration (Origin)	[1.0]	Migration/transposition of full segmental content of one segment (can be C or V) from one position in word to another. This does not code the STRUCTURAL content but only the SEGMENTAL content. NB: this code is assigned in the original syllable of the segment that migrates, not in the destination syllable. It applies when segments move across syllable boundaries due to deletions as well.	zanahoria	/θanaˈoɾja/	[taɾ̃aˈoja]	The /ɾ/ consonant segment from target 4th syllable migrates to take /n/ position in second syllable.
Segment-Structure Interactions	Liquid to /j/ or /w/	[1.0]	When the child substitutes /l/, /r/ or /ɾ/ with /j/ or /w/, vocalic elements in Spanish (not glides).	regalo	/reˈɣa.lo/	[leˈlajo]	Child substitutes /l/ > /j/ in 3rd syllable.

Category	Mismatch Code	Pts	Definition	Example	Target	Child	Explanation
Segment-Structure Interactions	CompLengthC	[1.0]	Used when the child deletes one (C) consonant segment and lengthens a neighbouring (C) segment in a CC sequence, preserving timing units (but losing segmental information). Note: this code is assigned in the destination syllable, not the syllable of origin. NB: V to C code also applies when consonant lengthens with vowel deleted, or when a neighbouring C segment is only half deleted but the neighbour is lengthened.	elefante	/eleˈfan̪te/	[eleˈfatːe]	The /n/ segment is deleted; /t/ segment is lengthened, preserving timing units (Compensatory Length).
Segment-Structure Interactions	SegmentMetath1	[0.5]	PAIRED CODES. When one segment and another segment reverse places. Applies to segmental content specifically not to structual level (eg: /k/ <> /l/). SegmentMetath1 and SegmentMetath2 assigned separately to affected segments for a total sum [1.0].	cocodrilo	/ko.koˈðɾi.lo/	[kokoˈliðo]	The segmental content of consonants in third and fourth syllables has reversed: /l/ and /ð/ have reversed positions.
Segment-Structure Interactions	SegmentMetath2	[0.5]					
Segment-Structure Interactions	Migration (Origin)	[1.0]	Migration/transposition of full segmental content of one segment (can be C or V) from one position in word to another. This does not code the STRUCTURAL content but only the SEGMENTAL content. NB: this code is assigned in the original syllable of the segment that migrates, not in the destination syllable. It applies when segments move across syllable boundaries due to deletions as well.	zanahoria	/θanaˈoɾja/	[taɾ̃aˈoja]	The /ɾ/ consonant segment from target 4th syllable migrates to take /n/ position in second syllable.
Segment-Structure Interactions	Liquid to /j/ or /w/	[1.0]	When the child substitutes /l/, /r/ or /ɾ/ with /j/ or /w/, vocalic elements in Spanish (not glides).	regalo	/reˈɣa.lo/	[leˈlajo]	Child substitutes /l/ > /j/ in 3rd syllable.

Appendix C Condensed sample multisyllabic coding rubric for target *princesa* 'princess' in PPD group

Orthography **princesa** Word shape: **CCVCˈCV.CV**

Adult Target: prin̪ˈ{θ/s}e{θ/s}a					LexEff	Word Stress	Syll1	Syll2	Syll3	Structure Points
Age	Gend	Ptcpt	Target	Child		uSu	prin̪	ˈ{θ/s}e	{θ/s}a	
3;01	0	31	prin̪ˈθesa	aˈfes̪a			CCDeltnSeqWinSyll 2.0 C1DeltnSeqAcrSyll 1.0	Assimilation [0.5]		3.0
4;07	0	33	prin̪ˈθeθa	piˈθeθa			C2DeltnSeqWinSyll 1.0 C1DeltnSeqAcrSyll 1.0			2.0
3;01	1	35	prin̪ˈsesa	ˈs̪es̪a [_ˈs̪e.s̪a]		SyllDeltn 1.0	CCDeltnSeqWinSyll 2.0 VDeltnSingleton 1.0 C1DeltnSeqAcrSyll 1.0			5.0
3;02	1	37	prin̪ˈsesa	pinˈses̪a			C2DeltnSeqWinSyll 1.0			1.0
4;03	1	38	prin̪ˈsesa	tiɾˈsesa			Assimilation [0.5] C2DeltnSeqWinSyll 1.0 Migration (Origin) [1.0]			1.0
4;09	1	39	prin̪ˈsesa	prin̪ˈs̪es̪a						0.0
5;10	1	40	prin̪ˈθesa	pin̪ˈθesa			C2DeltnSeqWinSyll 1.0			1.0
4;09	0	45	prin̪ˈθesa	priˈθesa			C1DeltnSeqAcrSyll 1.0			1.0
4;08	0	46	prin̪ˈθeθa	tin̪̩ˈθeθa			Assimilation [0.5] C2DeltnSeqWinSyll 1.0			1.0
5;11	0	47	prin̪ˈsesa	piňˈsesa			C2DeltnSeqWinSyll 1.0 HALF-C1DeltnSeqAcrSyll 0.5			1.5
5;03	0	57	prin̪ˈθeθa	prin̪̩ˈθeθa						0.0
4;00	0	58	prin̪ˈsesa	ˈtet͡ʃa [_ˈte.t͡ʃa]		SyllDeltn 1.0	CCDeltnSeqWinSyll 2.0 VDeltnSingleton 1.0 C1DeltnSeqAcrSyll 1.0	Assimilation [0.5]		5.0
3;03	0	59	prin̪ˈθeθa	pin̪̩ˈθeθa			C2DeltnSeqWinSyll 1.0			1.0
				SUMS:	0.0	2.0	20.5	0.0	0.0	22.5 22.5

Total Sum Points

Structure	**22.5**
Interaction	3.0
Combined	**25.5**

SUMS:	**STR**	**0.0**	**STR Stress**	**2.0**	**STR POINTS Syll1**	**20.5**	**STR Syll2**	**0.0**	**Syll3**	**0.0**	**22.5**
SUMS:	Intrct	0.0	Intrct Stress	0.0	Intrct Pnts Syll1	2.0	Intrct Syll2	1.0	Syll3	0.0	3.0
SUMS:	**ALL**	**0.0**	**ALL Stress**	**0.0**	**ALL POINTS Syll1**	**22.5**	**ALL Syll2**	**1.0**	**Syll3**	**0.0**	**25.5**

Appendix D Standardized total mismatch scores for TD group

Participant	Group	Age (Months)	Gender	Word Structure Mismatch *z*-scores	Segment-Structure Interaction Mismatch *z*-scores	Combined Structure and Interaction *z*-scores
3001	TD	71	male	-0.59	-0.75	-0.66
3021	TD	62	female	-0.66	-1.03	-0.78
3031	TD	69	male	-0.55	-0.61	-0.60
3041	TD	65	male	-0.73	-0.40	-0.71
3011	TD	71	male	-0.80	-1.03	-0.90
3061	TD	60	male	-0.73	-0.96	-0.83
3071	TD	61	male	-0.37	-0.96	-0.53
3081	TD	67	female	-0.80	-0.89	-0.87
3091	TD	65	female	-0.59	-0.75	-0.66
3101	TD	69	male	-0.73	-0.96	-0.83
3111	TD	55	male	-0.57	-0.89	-0.68
3141	TD	51	female	-0.69	-0.82	-0.77
3131	TD	52	male	-0.52	-0.89	-0.63
3121	TD	51	male	-0.37	-0.54	-0.44
3151	TD	53	female	-0.55	-0.75	-0.63
3161	TD	59	female	-0.80	-0.89	-0.87
3171	TD	53	female	-0.59	-0.61	-0.63
3181	TD	48	female	-0.37	-0.68	-0.47
3191	TD	47	female	-0.69	-1.03	-0.81
3201	TD	56	male	-0.23	-0.68	-0.35
3211	TD	47	female	-0.13	-0.26	-0.17
3221	TD	45	male	-0.41	-0.54	-0.47
3231	TD	43	female	0.26	0.86	0.41
3241	TD	41	female	-0.16	-0.61	-0.27
3281	TD	44	female	0.26	0.51	0.33
3261	TD	37	female	0.01	-0.19	-0.03
3251	TD	44	male	0.87	-0.05	0.74
3291	TD	41	female	0.21	0.65	0.32
3301	TD	40	female	0.75	0.44	0.74
3051	TD	71	male	-0.37	-0.54	-0.44

(Standardized mean = 0, SD = 1)

Appendix E Standardized total mismatch scores for PPD group

Participant	Group	Age (Months)	Gender	Word Structure Mismatch *z*-scores	Segment-Structure Interaction Mismatch *z*-scores	Combined Structure and Interaction *z*-scores
301	PPD	37	male	3.20	2.34	3.23
302	PPD	48	male	-0.11	0.86	0.09
303	PPD	55	male	0.10	0.65	0.23
304	PPD	57	male	0.03	0.16	0.06
305	PPD	37	female	4.90	0.23	4.24
306	PPD	41	female	1.02	3.04	1.52
307	PPD	38	female	0.59	0.51	0.62
308	PPD	51	female	-0.20	0.02	-0.17
315	PPD	57	female	-0.30	0.37	-0.18
326	PPD	70	female	-0.52	-0.68	-0.59
311	PPD	69	female	-0.43	-0.40	-0.45
312	PPD	62	female	-0.34	-0.54	-0.41
313	PPD	52	male	0.51	1.22	0.69
314	PPD	58	female	0.05	0.09	0.06
309	PPD	57	male	-0.01	0.30	0.06
316	PPD	56	male	0.22	1.57	0.53
318	PPD	71	male	-0.46	-0.61	-0.53
319	PPD	39	male	0.22	1.57	0.53
320	PPD	60	male	-0.37	0.23	-0.27
321	PPD	53	male	0.19	1.29	0.44
322	PPD	52	female	-0.37	-0.54	-0.44
323	PPD	57	female	0.24	0.30	0.27
324	PPD	60	male	-0.44	0.09	-0.36
325	PPD	39	male	1.00	2.69	1.43
310	PPD	70	male	-0.44	-0.82	-0.56
327	PPD	51	female	-0.30	-0.54	-0.38
328	PPD	63	male	-0.25	-0.89	-0.41
329	PPD	48	male	3.11	2.20	3.12
330	PPD	39	male	-0.20	1.22	0.09

(Standardized mean = 0, SD = 1)

Appendix F Standardized unstressed-stressed mismatch difference scores for TD group

Participant	Group	Age (Months)	Gender	Word Structure Mismatch Difference *z*-scores	Segment-Structure Interaction Mismatch Difference *z*-scores	Combined Structure and Interaction Difference *z*-scores
3001	TD	71	male	0.34	-0.60	0.18
3021	TD	62	female	0.69	0.66	0.89
3031	TD	69	male	0.87	0.03	0.89
3041	TD	65	male	0.87	0.03	0.89
3011	TD	71	male	0.87	0.34	0.98
3061	TD	60	male	0.69	0.03	0.72
3071	TD	61	male	0.87	0.34	0.98
3081	TD	67	female	0.34	0.66	0.54
3091	TD	65	female	0.34	0.03	0.36
3101	TD	69	male	-0.01	-1.24	-0.36
3111	TD	55	male	-0.18	-1.24	-0.53
3141	TD	51	female	-0.18	0.03	-0.18
3131	TD	52	male	-0.18	-0.92	-0.44
3121	TD	51	male	0.08	-0.92	-0.18
3151	TD	53	female	0.69	0.03	0.72
3161	TD	59	female	0.87	0.66	1.07
3171	TD	53	female	0.34	0.34	0.45
3181	TD	48	female	0.34	0.34	0.45
3191	TD	47	female	0.69	0.34	0.80
3201	TD	56	male	0.87	0.66	1.07
3211	TD	47	female	0.87	0.03	0.89
3221	TD	45	male	0.17	-0.29	0.09
3231	TD	43	female	0.52	0.03	0.54
3241	TD	41	female	-0.71	-0.60	-0.89
3281	TD	44	female	-0.44	-0.60	-0.62
3261	TD	37	female	-0.62	1.29	-0.27
3251	TD	44	male	-0.01	-0.60	-0.18
3291	TD	41	female	-0.36	0.34	-0.27
3301	TD	40	female	-0.36	0.34	-0.27
3051	TD	71	male	0.34	-0.92	0.09

(Standardized mean = 0, SD = 1)

Appendix G Standardized unstressed-stressed mismatch difference scores for PPD group

Participant	Group	Age (Months)	Gender	Word Structure Mismatch Difference *z*-scores	Segment-Structure Interaction Mismatch Difference *z*-scores	Combined Structure and Interaction Difference *z*-scores
301	PPD	37	male	-3.77	0.97	-3.57
302	PPD	48	male	0.43	-0.29	0.36
303	PPD	55	male	-0.36	2.24	0.27
304	PPD	57	male	0.61	0.03	0.63
305	PPD	37	female	0.34	-0.60	0.18
306	PPD	41	female	0.43	0.97	0.72
307	PPD	38	female	-0.44	-2.18	-1.07
308	PPD	51	female	0.69	-0.92	0.45
315	PPD	57	female	-0.36	-2.18	-0.98
326	PPD	70	female	-0.01	0.03	0.00
311	PPD	69	female	-0.18	1.29	0.18
312	PPD	62	female	0.17	1.92	0.72
313	PPD	52	male	-0.18	-0.92	-0.44
314	PPD	58	female	0.52	-0.29	0.45
309	PPD	57	male	0.08	0.66	0.27
316	PPD	56	male	-1.76	-0.92	-2.05
318	PPD	71	male	-0.53	-0.60	-0.71
319	PPD	39	male	-4.91	2.24	-4.37
320	PPD	60	male	-0.79	0.34	-0.71
321	PPD	53	male	0.52	-2.18	-0.09
322	PPD	52	female	0.78	-0.60	0.63
323	PPD	57	female	0.43	0.66	0.63
324	PPD	60	male	0.69	0.34	0.80
325	PPD	39	male	0.69	0.97	0.98
310	PPD	70	male	-0.18	-0.60	-0.36
327	PPD	51	female	-1.23	2.24	-0.62
328	PPD	63	male	-0.01	0.03	0.00
329	PPD	48	male	-0.53	-1.87	-1.07
330	PPD	39	male	0.17	0.66	0.36

(Standardized mean = 0, SD = 1)