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華語幼兒音節縮減研究
A Study of Syllable Deletion in Mandarin Acquisition

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A Study of Syllable Deletion in Mandarin Acquisition

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其實到現在對於「通過口試」還是有種不真實感，連現在要打致謝詞還是很惶恐，因為念研究所的這段期間，我受到的關愛和幫助實在是太多了。

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研究所別：語言學研究所

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論文提要內容（共一冊，25,397 字，分五章）：

本篇論文是針對以台灣華語為母語之幼兒，採長期觀察與收錄自發性語料之方式，研究台灣華語幼兒音節習得與音節縮減(syllable deletion)，並詳加描述單音節、雙音節和多音節之中音節類型出現的頻率、音節縮減模式，以及幼兒與母親的音節比較。本研究同時以 Jakobson (1968)的音節標記理論與頻率使用理論來檢驗幼兒的音節表現。

本研究觀察四位年齡在十個月至兩歲六個月的幼兒，以及四位幼兒的照顧者(母親)的語料。以兩個星期一次的頻率收集幼兒和母親之間的自然對話，並利用錄製回來的影音檔做譯寫分析。

研究結果顯示幼兒的音節習得的表現是有規則可循的，在所有音節產出以及音節縮減的模式中，無標記音節類型CV的頻率最高;在幼兒初階的語言產製中，越是無標記的音節類型，發生頻率則會越高。另一方面，幼兒在早期的音節表現中容易產生音節縮減的模式，常使用韻尾省略(coda-dropping)的方式產出詞彙，以省略韻尾介音[w]和韻尾鼻音為主。此外，為了檢驗每一幼兒與其照顧者的音節類型之間有無影響，透過統計分析，研究結果顯示幼兒與母親的音節類型比較呈現正相關，亦即幼兒的音韻產出或許會受到音韻環境的影響，進而產生與語言環境(母親語言)相似的音節類型與模式。

關鍵詞：音節縮減、音節習得、音節縮減模式、頻率、台灣華語

Abstract

The aim of this study is to discuss the issue concerning syllable deletion of the young children acquiring Taiwan Mandarin. The two main aspects are including in the following: syllable acquisition and syllable deletion pattern. The frequency of overall syllable types, the patterns of syllable deletion, and the syllable relationship between children and caretakers were examined. The findings can be explained by markedness theory proposed by Jakobson (1968) and frequency effects.

The four children, aged between 0;10 to 2;6, and the four caretakers are investigated in this study. The spontaneous speech between the child and the mother every other week was recorded and analyzed. A longitudinal observation study is conducted by the researcher and the research team.

Based on the analyses, the young children show a general syllable tendency; that is, the unmarked syllable type, CV, has the highest frequency in the analyses of overall syllable types and syllable deletion types respectively. The more unmarked syllable types occur more frequently in the children's early production. Since the young children's phonological systems are unstable and immature, they tend to produce the reduced syllable forms, especially the deletion of the postnuclear glide [w] and the deletion of the final nasal. The possible reason may due to the fact that the children use coda-dropping as a simplification strategy in their production. Furthermore, according to statistical findings, the syllable types of the four child-caretaker pairs are positively correlated. Young children's phonological productions may be influenced by the overall productivity and the phonetic content of the ambient language.

Keywords: syllable deletion, syllable acquisition, deletion pattern, frequency, Taiwan Mandarin

Chapter 1

Introduction

1.1 The research background

Although different languages have their own distinct syllable types, all syllables in all languages have the basic form CV based on cross-linguistic reports (Spencer, 1996). In terms of syllable acquisition, numerous studies working on the acquisition of phonology have focused on the order and pattern of syllables. Researchers are curious on whether language-universal syllable types exist in first-language acquisition (e.g., Ingram, 1974, 1978; Lleo & Prinz, 1996; Stoel-Gammon, 1998; Levelt, Schiller & Levelt, 2000). Furthermore, the developmental facts about the syllable acquisition of phonology have been reasonably assessed in many places (e.g., Ingram, 1989; Stoel-Gammon, 1998, 2011). Children acquire CV type first because it is the core syllable, which is the most structurally unmarked (Ingram, 1978; Stark, 1980). The studies of Ingram (1978) and Stark (1980) both proposed that children acquire CV and CVCV syllable forms first, and are then followed by V, VC or CVC forms. Moreover, the children aged around 2;0 are reported to exhibit more consistent patterns, characterized by more simpler words and syllable structures such as CV, CVCV and CVC (Fenson, Marchman, Thal, Dale, Reznick, & Bates, 2007).

The problem stems from the fact that there is inconsistence of acquisition of

syllable order in cross-linguistic studies. Some studies have revealed that syllable-final consonants are mastered earlier than syllable-initial consonants (So & Dodd, 1995; Zhu & Dodd, 2000), and word-final clusters are acquired several months earlier than word-initial clusters (Lleo & Prinz, 1996). However, some children are reported to acquire word-initial clusters (CCVC) earlier than word-final clusters (CVCC) (Levelt et al., 2000). In order to solve this problem, several previous studies aim at the effects of frequency in acquisition syllables. Researchers found that children are sensitive to the high-frequency linguistic structures of the language. Bernhardt and Stemberger (1998) proposed that children have a tendency to produce the less complex and more natural syllable structures in the speech; the simpler structures are acquired earlier. Roark and Demuch (2000) also showed that the earlier acquired structures are much higher in frequency regarding syllable structures and words in a language. H. Y. Wang (2014) described that the ranking of syllable types which are most frequently used is CV, and is followed by CGV, GV or V. Results also showed that syllable types with higher frequency and lower variability rates are unmarked syllable types.

Moreover, researchers in the field of child acquisition also examined the language interaction between the caretaker and the child. They have wondered whether children are sensitive to the ambient language and the input frequency at the

early stage. Ambient effects can be observed from children's final consonant production over the period of 9 to 18 months (de Boysson-Bardies & Vihman, 1991) and children's use of syllabic organization studies (de Boysson-Bardies, 1993). In addition, Albin and Echols (1996) compared the speech performances between children and caretakers in terms of labelling objects; the caretakers produced prosodically highlighted syllables more frequently to the children; children were sensitive to these prosodic input characteristics. Zamuner, Gerken and Hammond (2005) also discussed that high frequency inputs in the ambient language are more likely to be produced by children than are low frequency inputs. Thus, studies have provided persuasive evidence of ambient language influence on children's linguistic development.

Although the syllable shapes that occur most frequently are acquired first and the ambient language is important in acquisition, children may exhibit individual differences in the learning path when the frequencies of two syllable structures are the same (Levelt et al., 2000). For instance, some children prefer the complexity of the syllable types in the syllable-initial first (i.e. CCVC) while others favor the complexity of the syllable type in the syllable-final first (i.e. CVCC). Data showed that the first earlier acquired and the highest frequency syllable structure is the most unmarked syllable CV, but the last acquired and the least frequent syllable structure is

the most marked syllable CCVCC. Thus, it is suggested that the frequency of these syllable types coincided with markedness. Stites, Demuth and Kirk (2004) claimed that some children may show more frequency-based while others may show more markedness-based according to the investigation of word-final consonant acquisition in the corpus. In addition, the study of Tsay (2006) presented that CVC is the second most frequent syllable types, following the CV type, occurring in children acquiring Taiwan Southern Min. However, the error rate of producing CVC syllable types is up to 98% in the children's production.

Since the relationship between frequency and the acquisition order of syllables has been a subject of debate, many researchers attempted to discuss the acquisition of syllables of different languages. For instance, English allows at most three consonant clusters in the syllable onset but Mandarin permits only two glides. Besides, the second segment in a two-segment onset can be a nasal or liquid, like *snack*, *train*, and *black* in English, whereas the second segment in a onset must be a glide (i.e. [j], [w], or [ɥ]) in Mandarin. Jakobson (1968) has shown that English-speaking children were acquiring open syllables earlier than closed syllables. Although English allows a large number of syllable types, CV syllable types are the most frequent in English words (Zamuner et al., 2005). Moreover, several researchers observed that young children, including English speaking children and French-speaking children, use augmented

(CVC→CVCV) or truncated words (CVC→CV) in their production (Allen & Hawkins, 1980; Demuth & Johnson, 2003).

1.2 Cross-linguistic studies on syllable deletion

This section presents the research background of the types of syllable deletions[1] based on cross-linguistic studies. In order to investigate the area of syllable deletion, the first issue that needs to be considered is to define syllable deletion in children's acquisition. In phonological development, syllable deletion can be regarded as a number of articulatory processes. Young children, aged 18 months to 32 months, frequently omit certain syllables while producing polysyllabic utterances (Carter & Gerken, 2003). The examples of children's syllable omissions are presented in (1a) – (1b).

(1a) [bə'nænə] → ['nænə] *banana*

(1b) [dʒə'ræf] → ['ræf] *giraffe*

In phonetic studies, the articulatory weakening in the production of vowels particularly means "reduction." In the study of Laver (1994), vowel-reduction can be seen as the process of shortening, pitch-lowering, and intensity-lowering. Along with syllable re-organization processes, these processes formed the compression or reduction of syllables in fluent speech (Hilton, Schüppert & Gooskens, 2011).

[1] In this study, I use syllable deletion throughout the whole paper. This term does not involve any specific process in relation to syllable contraction or expansion.

The second issue is the relationship between child acquisition and types of omitted syllables. There have been a number of analyses from cross-linguistic perspectives to examine syllable deletion (e.g., Allen & Hawkins, 1980; Wijnen, Krikhaar & Den-Os, 1994; Tsay, 2006). In terms of stress languages, studies showed that the children's syllable deletion is strongly related to the stress assignment. For example, English-speaking children frequently produce the stressed portion of bisyllabic words (e.g., *nana* rather than *banana*) while omitting or producing with reduction of unstressed syllables. A similar pattern also occurs in children's early productions of Dutch and Spanish. They frequently omit the first syllable of words with a weak-strong stress structure and words with a weak-strong-weak structure (Macken, 1992; Wijnen et al., 1994).

Other than stress languages, several linguists are interested in young children's omission of tone languages and they observe that stress is far less important. Tse (1991) proposed that Cantonese-speaking children in the phonological processes show structural simplification, such as syllable-final consonant deletion and cluster reduction. Furthermore, Zhu and Dodd (2000) explicitly put forward a study of phonological acquisition of 134 children, aged 1;6 to 4;6 in Beijing Mandarin. Based on speech error patterns, children on the one hand are likely to omit syllable-initial consonants before the vowels [i], [u], and [y] all the time; on the other hand, they are

inclined to delete syllable-final nasals (i.e. /n/ deletion and /ŋ/ deletion). Tsay (2006) explored the relationship between prosodic models and syllable deletion produced by children acquiring Taiwan Southern Min. Results showed that word-initial syllables are omitted more frequently than word-final syllables in the corpus. It was suggested that children use simplification strategies, such as syllable omission, to shorten long and complex utterances. Consequently, by reviewing the studies of syllable acquisition, there are many different syllable development and types of syllable deletion from other languages. This study aims to investigate this issue by looking at the patterns of syllable deletion in Taiwan Mandarin-speaking children.

There are only a few studies concerning the issue of acquisition of syllable in Mandarin and less is known about children's types of syllable deletion in Mandarin. It is still an issue how Mandarin children use the syllable deletion in the acquisitional process, and whether or not such a process has a cross-linguistic tendency. This present study hopes to examine the syllable types and syllable deletion patterns from young children's natural production.

1.3 Research questions

This study examines syllable acquisition and syllable deletion patterns produced by the four children acquiring Taiwan Mandarin, aged between 0;10 and 2;6, in a longitudinal observation method. The children's pre-meaningful speech and

meaningless production are excluded in the thesis. The frequency of each deleted syllable patterns will also be the focus in the study. The three main research questions to be addressed are described as follows:

(1) Regarding overall syllable patterns: what is the general syllable type used by the four children? What is the most frequent syllable type used by the children? What is the least frequent syllable type used by the children? What is the rank-order of frequency in different syllable types? Is there obvious individual variation between four children's overall syllable types?

(2) Regarding syllable deletion: What are those types of syllable deletion produced by young children during their early phonological stage? What are the rates of different syllable deletion types? What is the most frequent syllable deletion type? What is the least frequent syllable deletion pattern? Are there obvious individual differences between two children's syllable deletion patterns? What kind of strategy do the children use to produce syllable deletion in lexicon?

(3) Regarding caretaker-child language interaction: what is the general syllable type used by the four caretakers? What is the most frequent syllable type used by the caretakers? What is the least frequent syllable type? Is there relationship between caretaker's frequent used syllable types and the child's syllable types? Is the child's syllable pattern influenced by the caretaker's overall productivity?

1.4 Organization of the thesis

The study is organized as follows. In chapter 1, I have set out the introduction to the research background of this study and research questions concerning data analysis. In chapter 2, firstly I will review the literature of Mandarin consonants, vowels, glides and syllable types in 2.1, and I will introduce the issue of syllable acquisition in cross-language studies and syllable deletion in 2.2. Theories on syllable deletion will be thoroughly shown in 2.3. The deletion in Mandarin and Taiwan Southern Min will be discussed in 2.4. Chapter 3 includes the methodology of this study. Section 3.1 presents the data collection methods. Section 3.2 is the data analysis explaining how the data were arranged and analyzed. Chapter 4 will present the results in tables and figures. Section 4.1 will reveal the overview of the overall data. Section 4.2 will demonstrate the results of syllable analysis, including the frequent syllable types that children tend to produce and the frequency of syllable deletion in the production. Section 4.3 will laid out the different patterns of syllable deletion of the four children's productions. Section 4.4 will show the results of four child-caretaker's syllable relationship. The discussion and explanation will be provided in chapter 5. Section 5.1 summarizes the findings in chapter 4. Section 5.2 presents the discussion on syllable analysis. The conclusion for the finding is provided in section 5.3.

Chapter 2

Literature Review

In this section, a review of literature of Mandarin phonology regarding Mandarin consonants, vowels and glides will be presented in 2.1. Secondly, I will introduce the issue of syllable acquisition in cross-linguistic studies in 2.2. I will illustrate the relationship between acquisition and syllable omission in 2.3. Theories on syllable omission will be thoroughly shown in 2.4. Finally, I will summarize the omissions in Mandarin and Taiwan Southern Min in section 2.5.

2.1 Introduction to Mandarin phonology

There are two parts in this section. The possible syllable types and the syllable structures in Mandarin will be introduced.

2.1.1 Syllable types in Mandarin

According to Lin (2007), consonants are articulated with obstruction of the airstream in the vocal tract to different degrees based on the manner of articulation. Consonants can also form constrictions in different locations by the place of articulation. The inventories of Mandarin consonants including glides and nasals are presented in IPA symbols in the following Table 2.1. Throughout this study, the Mandarin phones are transcribed by IPA forms.

Table 2.1 Mandarin consonants (Lin, 2007)

	Bilabial		Labio-dental	Dental		Post-alveolar		Alveolo-palatal		Palatal	Velar	
Stop	p	p^h		t	t^h						k	k^h
Fricative			f	s		ʂ		ɕ			x	
Affricate				ts	ts^h	tʂ	$tʂ^h$	tɕ	$tɕ^h$			
Nasal	m			n							ŋ	
Central approximant	w ɥ					ɹ				j ɥ	w	
Lateral (Approximant)				l								

As shown in Table 2.1, symbols are arranged by the place of articulation and the manner of articulation. Symbols that are under the same manner of articulation share the every feature while symbols that are under the same place of articulation share every feature other than aspiration. The shaded one on the left is voiceless unaspirated while the unshaded one on the right is voiceless aspirated. Nasals and approximants are all voiced.

Based on the studies of Duanmu (2000, 2007) and Lin (2007), the followings are some phonetic properties regarding Mandarin consonants. Firstly, aspiration is a distinctive feature. That is, aspirated and unaspirated stops are separate phonemes in Mandarin. The change of aspiration can change the meaning of the word; for example, the meaning of the word [pa]51 *father* differs from the word [p^ha]51 *to fear*. Secondly, the lateral and the nasal [m] can appear only in syllable initial position; all consonants

except for the nasal [ŋ] in Mandarin can occur in the syllable-onset position, and only nasals [n] and [ŋ] can occur in the syllable-final positions. Finally, alveolo-palatals are not independent phonemes but allophones. They occur only before high front vowels or glides; that is, [ɕ], [tɕ] and [tɕʰ] appear only before [i]/ [j] and [y]/[ɥ].

Regarding the vowels of Taiwan Mandarin, they are classified according to degree of openness (vowel high), location of the active part of the tongue (vowel backness), and lip position (vowel rounding). There are twelve surface vowels in Mandarin, as shown in Table 2.2.

Table 2.2 Vowel phones in Taiwan Mandarin (Wan & Jaeger, 2003)

	Front		Central	Back	
	Unrounded	Rounded	Unrounded	Unrounded	Rounded
High	i	y	ɨ		u
Mid	e		ə	ɤ	o
Lower-mid	ɛ				ɔ
Low			a	ɑ	

Among the inventory of Taiwan Mandarin vowels, only the five vowels [i], [y], [u], [ɤ] and [a] can occur alone as complete syllables. The vowels [i], [ɨ], [y], [u], [ɛ], [ɔ], [ɤ] and [a] can appear in the open syllables. The vowels [i], [ɨ], [y], [ɛ], [ə] and [a] can occur in syllables closed with the nasal [n]; the vowels [i], [o] and [ɑ] can appear in syllable closed with the nasal [ŋ]. In addition, the vowels of [o] and [ɑ] can occur in syllables closed with the glide [w] while the vowels [a] and [e] can occur in syllables closed with the glide [j].

Glides can be treated as phonetic variants of high front vowels rather than phonemes in Mandarin because prenuclear glides do not contrast with corresponding high vowels (e.g., Wan, 1999, 2002; Duanmu, 2007; Lin, 2007). When a high vocalic segment alternating with a glide is adjacent to a nonhigh nucleus vowel, there is an alternation of [i] with [j], [u] with [w], or [y] with [ɥ]; however, there is no glide alternation of the high central phone [ɨ] in Mandarin (Wan & Jaeger, 2003).

Finally, since we have introduced consonants and vowels, we then look at the possible syllable types of Taiwan Mandarin, as in Table 2.3, based on the study of Wan (1999).

Table 2.3 Possible Mandarin in Mandarin (Wan, 1999)

Syllable Type	Phonetic Transcription	Gloss
V	i55	dependent
CV	ma55	mother
GV	ja55	push
VG	aj51	love
VN	an55	safe
CVG	maj21	buy
CVN	tjŋ214	top
CGV	ɕjɛ35	shoes
GVG	jɑw35	shake
GVN	wan51	ten thousand
CGVG	tjɑw51	drop
CGVN	tʰjan55	sky

As can be seen from Table 2.3, Taiwan Mandarin allows at most four segments in a raw for a syllable and it is analyzed as having twelve syllable types: V, CV, VG, GV,

VN, CVG, CVN, CGV, GVG, GVN, CGVG, and CGVN. A syllable that has no coda is called an open syllable, such as a CV, GV or CGV syllable, whereas a syllable that has a coda is called a closed syllable, like CVN, CGVG or CGVN.

2.1.2 Syllable structures

In terms of traditional analysis, the syllable can be divided into two main parts: the “initial” and the “final”. The initial means the syllable initial non-glide consonant, which can be the consonant or the nasal, while the rest of the syllable following the initial consonant is the final, which could be separated into the “medial” and the “rime.” The medial is the glide before the nuclear vowel, and the rime consists of the nucleus and the ending. The nucleus is obligatory in every syllable whereas the initial, the medial and the ending are all optional in Mandarin. The maximal syllable is CGVX, where C is a consonant, G is a glide, V is a vowel, and X can be a glide or a nasal (cf. Lin, 1989, 2007).

Although the traditional analysis of Mandarin has been adopted for several researchers, the increasing studies reanalyze the syllable structure of Chinese with contemporary view (Duanmu, 1990, 2000; 2007; Bao, 1990, 1996; Lin, 2007). Regarding the status of prenuclear glide, the traditional analysis considers prenuclear glide to be structurally part of the rime, whereas the contemporary view shows that the prenuclear glide can serve as either the onset of the syllable, or the secondary

articulation of the onset position (cf. Bao, 1990; Duanmu, 1990; Z. Wang, 1996). Bao (1990) proposed that the prenuclear glide formed a cluster with an initial consonant. The prenuclear glide was argued to be part of the onset rather than the rime segment. Based on the acoustic evidence, dialectal evidence, historical evidence and poetry rhyming patterns, Duanmu (1990) further elucidated that the prenuclear glide is the part of the onset and acts as the secondary articulations.

Since the structural status of prenuclear glides in Mandarin has been a subject of debate, more researchers attempted to resolve this problem by experimental evidence (H. S. Wang & Chang, 2001), or psycholinguistic evidence (Wan, 2002). H. S. Wang and Chang (2001) asked participants to blend two syllables into one in the first experiment, and then choose from two alternatives (i.e. prenuclear glides clustering with the onset or the rime) to break up a syllable in the second experiment. The results showed that the participants preferred to classify the glide with the rime. Therefore, H. S. Wang and Chang (2001) treated prenuclear glides as part of the final in support of traditional analysis.

However, Wan (2002) proposed that prenuclear glides are part of initial or final depending on the place of articulation of the preceding consonant. Wan (2002) used psycholinguistic and acoustic evidence to reexamine the status of prenuclear glides from speech errors. She claimed that the glide could be syllabified in two ways in

surface phonological representation. As the glide shared the same place of articulation with the onset, the glide formed a unit with the onset as the consonant cluster. Nevertheless, while the onset and the glide were not the same place of articulation, the glide stayed away from the onset. Wan (2002) thus concluded that whether the prenuclear formed with an onset or a rhyme largely depended on Mandarin phonotactic constrains and articulatory gestures.

The syllable-structure status of glides in the postvocalic position is faced with different analyses owing to treatments of postnuclear glides and coda nasals. As previously noted, the traditional analysis divides the syllable structure into the initial, which is the onset consonant, and the final, which consists of prenuclear glides, nuclear vowels, and either postnuclear glides or nasals. It is suggested that the postnuclear glide and the final nasal not only were in the same structure position, but were treated as codas (Cheng, 1973).

However, investigators (Lin, 1989; Bao, 1990; Chiang, 1992) described that the postnuclear glides should be considered part of the nucleus instead of the coda based on linguistic data from Taiwanese language games. Lin (1989) proposed that the vowel and ending nasal were treated as different phonetic units in the rhyme position, whereas the vowel and the postnuclear glides were treated as the same unit (i.e. a diphthong) in the nucleus position. Chung (1989) used Hakka data to claim that

postnuclear glides and postnuclear nasal consonants did not have an equal syllable-structure status. Therefore, Lin (1989) and Chung (1989) both suggested that a structure of postnuclear glides and ending nasals showed an asymmetrical behavior because the postnuclear glides were seen as part of the nucleus instead of the coda.

Furthermore, Wan (2006) attempted to examine the status of postnuclear glides and coda nasals based on a corpus of speech errors in Taiwan Mandarin. She validated speech-error data as external evidence by psycholinguistic studies, which have been used for decades in English (Fromkin, 1973; Stemberger, 1983). Wan (2006) proposed an asymmetry in the syllable structure between glides and nasals in the postvocalic position. Because postnuclear glides were derived from vowels and associated with the nuclear vowel, postvocalic glides were not as firmly affiliated with the coda structure as nasals. Besides, Chien (2011) also claimed that postnuclear glides should be treated differently from final nasals. Based on experimental elicitation of speech errors, results showed that the error frequency of the interaction between postnuclear glides and final nasals was fewer than that between final nasals and final nasals. Consequently, these studies generally addressed that syllable structure of postnuclear glides and coda nasals did not behave in a parallel fashion.

2.2 Syllable acquisition and syllable deletion in cross-linguistic studies

In this section, I will review studies on syllable acquisition and types of syllable

omission on different languages, including English, Spanish and French. Linguists are interested in whether there are language universal in first language acquisition and children's preferred types in syllable omission.

2.2.1 English

The early study of Ingram (1974) found that there were general phonological processes operating in the child's acquisition, including the deletion of consonant clusters and the deletion of unstressed syllables. He proposed that identifying general rules could account for the children's simplification strategies. Ingram (1978) then focused on his English-speaking daughter's first-word stage in order to carefully examine the acquisition of syllable types. Data showed that the child acquired CV and CVCV first, and were followed by CVC form. By the age of two, the child produced most words containing closed syllables in the following Table 2.4.

Table 2.4 Acquisition of syllable (Ingram, 1978)

	Monosyllabic Words	**Disyllabic Words**
1;3	89% CV	87% CVCV
1;6	Mostly CVC	47% CVCV
2;3	Most of the words contained closed syllable	

Ingram (1978) analyzed the monosyllabic and disyllabic token separately. When the child was at 1;3, 89% of words were CV form in monosyllabic words; however, when she was aged 1;6, most forms in monosyllabic words was CVC. The child was

acquiring open CV syllables earlier than closed CVC forms.

Moreover, before infants begin to produce their first words, specific and orderly changes that occur in the vocalizations can be observed. Stark (1980) found that in the "canonical babbling" stage, English-speaking infants in the 6-month-old age started to produce sequences of identical CV syllables (e.g. [mama]). At around 12 or 13 months, syllable strings, with varying consonants and vowels, emerged as the more frequent type in this stage. In terms of syllable patterns, when infants were 10-month-old, syllables like V, VC, and CVC started to appear at the babbling stage. Ingram (1978) and Stark (1980) put forward an ordering of syllable development: children acquired CV and CVCV forms first, and then V, VC, and CVC forms are the next steps. Both studies showed that children mastered syllable onset consonants earlier than coda consonants.

Stoel-Gammon (1998) however found that some English-speaking children's most common target syllable forms were CVC, far more exceeding the frequency of CV and CVCV forms. Kehoe and Stoel-Gammon (2001) therefore claimed that codas were produced early by some English-speaking children because of lexical frequency. Onsets and codas were therefore presented in some English-speaking children's first words. Hence, syllable patterns observed in child language offer a main source of evidence for investigating and understanding of phonology. Rose and Inkelas (2011)

proposed that every study on child phonology should be carefully examined, including all properties of the child's language that occurred in the development.

Although some studies focused on children's general syllable types and occurrences of onsets or codas in syllables, other studies were related to the issue where young children acquiring English tended to truncate forms and delete syllables in production (e.g., Ingram, 1974; Allen & Hawkins, 1980; Gerken, 1994; Kehoe & Stoel-Gammon, 1997; Carter & Gerken, 2003, 2004). Young English-speaking children frequently omitted the initial weak syllables when producing polysyllabic utterances. For example, when producing a weak-strong[2] (iambic) syllable structure word *giRAFFE*, children tended to produce *RAFFE*, but rarely omitted the weak syllable of a strong-weak (trochaic) word such as *MOKkey*, producing *MON* (Allen & Hawkins, 1980). The study of Gerken (1994) documented that the 2-year-old English-speaking children showed a preference for words with the primary stress on the first syllable or for trochaic word structure, especially strong-weak syllables.

Recent studies have been concerned with the frequency of use of unstressed syllable omission by age (e.g., Dodd, Holm, Hua, & Crosbie, 2003; James, van Doorn, & McLeod, 2007). James et al. (2007) focused on 283 English-speaking children's

[2] Throughout the study, S will refer to a strong or stressed syllable, and W will refer to a weak or unstressed syllable. Target lexical items will appear in italics with primary and secondary stressed syllables denoted by uppercase letters.

weak syllable deletion in terms of different age groups. Results showed that about two thirds of the participants used nonfinal weak syllable deletion, whereas final weak syllable deletion and deletion of stressed syllables could be negligible. Researchers explained that children did not acquire the final weak syllables and stressed syllables until the age of three, whereas they did not master the nonfinal weak syllable in polysyllabic words until the age of seven. Consequently, based on observation of different age groups, it is clearly noted that English-speaking young children's omitted syllables largely depend on the stress factors.

2.2.2 Spanish

The early study of Macken (1978, 1992) focused on the phonological development of syllable structures and co-occurring consonants by analyzing a Spanish-speaking child, aged between 1;9 and 2;6. This child showed a gradual increase in complexity in terms of the syllable numbers, syllable types and ordering when producing final-nasal words and fricative words. For numbers, monosyllable productions (i.e. CV forms) and the simplest of two-syllable productions (i.e. VCV forms) preceded disyllable productions of the CVCV forms. In terms of syllable types and ordering, CV was the most common, followed by CVC in this child's production; no other syllable types were produced until this child was at the age of 2;6 when the first rudimentary CCV syllables were produced. In general, the child's preferred

syllable structure was CV form. Macken (1978) explained that this simple structure CV can be seen in the production processes, adapting adult's CVCV and VCV both to the CV form.

In addition to the phonological relationship between syllable types and consonants, Lleo and Prinz (1996) investigated the early stage of acquisition of consonant clusters of four Spanish-speaking children, aged from 0;9 to 2;1. Data revealed the following acquisition order: CV > CVC > CVCC > CCVCC. Based on the syllable ordering, they found that word-final clusters were mastered several months earlier than word-initial clusters in the children's production. Furthermore, they tended to reduce target clusters to a single consonantal position, which could be explained by strategies of different syllabification.

Studies of Macken (1978, 1992) and Lleo and Prinz (1996) showed that children acquiring Spanish tended to omit the target syllables during phonological acquisition. Macken (1978) proposed three major processes which combined to achieve the optimal CV syllable type: (1) syllable deletion (2) final-consonant deletion (3) consonant cluster reduction. Specifically, Macken (1992) in the following study revealed that the reason why Spanish-speaking children tended to omit the syllable structures because of trochees. That is, the first syllable of words with WSW structure would be omitted, such as *manZAna* [mən'zanə] "apple" omitted as *ZAna* ['zanə].

In order to account for the omission of initial unstressed syllables, the empirical basis for a longitudinal corpus in CHILDES (MacWhinney, 2000) has been used by a number of researchers (e.g., Prieto, Bosch-Baliarda, & Saceda-Ulloa, 2005; Saceda-Ulloa, 2005; Prieto, 2006). Saceda-Ulloa (2005) compared the initial unstressed syllable deletion in WS and WSW words of two Spanish children from the corpus CHILDES. Two children produced the initial unstressed syllables of bisyllabic WS words from the start, but there were almost no iambic (i.e. WS structure) truncation. However, at the age of 1;2 to 1;8, children would omit the initial unstressed syllable of trisyllabic WSW words. This omission of WSW syllable structures of young Spanish-speaking children was consistent with previous studies (e.g., Prieto et al., 2005). Besides, the findings of Prieto (2006) accorded with previous studies, showing that the omitted patterns were closely associated with trochee model in children acquiring Spanish.

2.2.3 French

Other than English and Spanish, researchers found that children acquiring French presented a slightly different pattern of syllable acquisition. The early proposal by Fee and Ingram (1982) has noted that 24 French-speaking children, aged between 1;1 and 2;8, who frequently used reduplication would use multiysllables and show limited ability at final consonant production. Findings suggested that reduplication was

regarded as a general pattern during the earlier stages of phonological development, and final consonant in CVC form seemed to be difficult for French-speaking children.

In addition, Levitt and Aydelott Utman (1992) worked on cross-linguistical studies in order to explore the general and language-specific effects on child acquisition. They focused on the relationship between sound systems and syllable types of one French-speaking child and one English-speaking child. The utterances of both infants at 0;5, 0;8, 0;11 and 1;2 were acoustically analyzed for syllable types. In terms of syllable characteristics, the French-speaking infant less frequently produced closed syllables than the English-speaking infant. Besides, results showed that the occurrences of closed syllables for the French-speaking infant remained stable during observations, whereas the English-speaking infant showed a dramatic increase over time because English has more closed syllables than French.

It is reported that French, with an iambic prosodic word structure that differs from English and Spanish, shows another interesting perspective for examining young children's syllable omission. According to the acquisition studies, young children were likely to omit disyllabic or trisyllabic targets to monosyllabic CV and CVC forms observed in the study of three French-speaking children, aged between 1;3 and 1;10 (Archibald & Carson, 2000). Moreover, Rose (2000) investigated many predicted syllable forms (e.g., CV, CVC and CVCV reduplicated form) in the

longitudinal study of two children learning Quebec French. Data showed that not only the child would truncate CVC targets to CV forms, but also the trisyllabic targets were frequently reduced to disyllables. It is suggested that a binary foot was the maximal form for early prosodic words. Consequently, Rose (2000) claimed that syllable omission in French is expected to occur frequently.

Demuth and Johnson (2003) further re-examined a longitudinal data collected by Deville (1891) of his daughter, acquiring Parisian French. The data gathered from the onset of the child's first words until the age of two. The finding revealed that in the beginning this child was faithful to the target form, correctly producing CV and disyllabic reduplicated words. Then she went through a short period during which she produced CVC targets as CVCV reduplicated forms. During this period, she also truncated trisyllabic words to disyllabic words, showing that her prosodic words were maximally a binary foot. Thereafter she began to drop word-final consonants, producing CVC targets as subminimal CV words, and truncated more disyllabic and trisyllabic targets.

2.3 General theories on syllable deletion

Researchers have been particularly interested in explaining why children omit certain syllables in certain word positions more than others. Some researchers have proposed that children's syllable deletion can be accounted by markedness theory

(e.g., McCarthy & Prince, 1994; Pater, 1997; Roark & Demuth, 2000); other studies showed that frequency effect can explain the patterns of syllable deletion produced by the young children (e.g., Demuth & Johnson, 2003; Ota, 2003, 2006); other investigators have claimed that children' syllable deletion are closely related to perceptual biases (e.g., Echols & Newport, 1992; Echols, 1993); still other researchers have observed the production account on young children's truncations (e.g., Menn, 1983; MacNeilage & Davis, 1990, 1993). In order to investigate young children's syllable deletion, four approaches, including markedness theory, frequency effect, perceptual account and production account will be laid out in this section.

2.3.1 Markedness theory

Jakobson's early work (1968) proposed a universal order of acquisition of syllable structure based on markedness theory. He proposed that young children's utterances would exhibit "unmarked" linguistic structure. Children acquired CV unmarked syllable, and gradually followed by marked syllable types. That is, they began the processes of phonological acquisition with CV or CV reduplicated syllable forms, and then followed by complex syllables, such as CVC and CVCV.

In order to account for young children's phonological development, the claim of optimality theory (McCarthy and Prince, 1994) posited of constraints on children's outputs of the syllable acquisition in terms of markedness, where "unmarked"

structures play an important role. Children appeared to start with “unmarked” structures in their early grammars (i.e. the syllable CV as the only possible output of the grammar), and gradually moved to more “marked” types of structures during the course of development. Gnanadesikan (1996) noted that young children’s first syllables would be the unmarked form of core syllables, or CV, showing a preference for the least marked onsets. Levelt et al. (2000) conducted a longitudinal study of twelve Dutch-speaking children, aged from 1;0 to 1;11. Results showed that there was a shared developmental order: children were acquired the order CV, CVC, V, and VC subsequently. Tsay (2007) also examined the issue of the interactions between markedness and syllables types of children acquiring Taiwan Southern Min, showing that CV was the most frequently used syllable, and was followed by CVC, CVV, and V. According to above studies, CV syllable is considered as the most unmarked syllable across languages.

While discussing young children output data, Ingram (1986) proposed an active role for the children acquiring their phonological system. He viewed phonological processes as “a universal set of hierarchically ordered procedures used by children to simplify speech” (Ingram, 1986). Besides, Matthei (1989) found that the children learning English and Dutch initially omitted the use of coda consonants, producing early words with unmarked “core” CV syllables. They frequently omitted the pretonic

syllable, such as [nænə] in *baNAna*, which conforming to trochaic foot. Pater (1997) further examined the truncation patterns in children's productions. Although some children were likely to truncate *banana* to [nænə], he found that the children truncated early words containing an initial unstressed syllable, selecting the word-initial stop to fill the onset of the truncated form, such as [bænə] *banana*. As a result, Pater (1997) explained that young children had a tendency to preserve the consonant that was unmarked in the onset position.

With the development of OT theory, children's early prosodic structures also can be understood in terms of a series of hierarchically linguistic constraints, which involve structural constraints and faithfulness constraints (cf. Pater, 1997; Roark & Demuth, 2000). Among these constraints, the lack of early codas indicates the relative higher ranking of a constraint "No-Coda", which is the prime key of the study. CVC target forms are realized as CV, depending on the relative ranking of faithfulness constraints on the realization of segments. The early syllable deletion is closely related to the re-ranking of markedness constraints. On the other hand, in order to examine the learnability preferences in terms of markedness and frequency, Stites et al. (2004) proposed that children exhibited the different learning strategies in coda consonants owing to different input frequency. Results showed that one child acquired the more marked but more frequent stop codas first, while the other child acquired

less marked but less frequent nasal and fricative codas first. Thus, although children's early stages of development could be determined by markedness constraint and frequency effect, the researchers suggested that the unmarked structures might be also the most frequent, resulting in early and stable acquisition patterns cross-linguistically (e.g., Demuth, 1996; Stites et al., 2004).

2.3.2 Frequency effect

A number of studies have discussed the frequency effects in the course of child language development, including the input frequency of phonemes, phoneme sequences and syllable structures (e.g., Ingram, 1988; Demuth & Johnson, 2003; Zamuner et al, 2005; Ota, 2003, 2006). The likelihood that a young child produced a target phonological structure was closely related to the input frequency (Ota, 2006). For instance, Ingram (1988) found that the interaction between the accuracy and acquisition timing of phonemes could show the frequency in the language. Chen and Kent (2005) analyzed 24 Mandarin-speaking children's CV affiliation patterns in early spontaneous vocalizations and examined the caretakers' CV combinations as well. The findings showed the positive correlation between number of CV productions of children and their caretakers. That is, the young children's phonological productions may influenced by the overall productivity and the phonetic content of the ambient language. Besides, in a cross-linguistic study, Roark and

Demuth (2000) found that English-speaking children and Spanish-speaking children would acquire structures that were much higher in frequency relative to syllable structures and word shapes in each language.

It is reported that syllable deletion also appeared in French-speaking children's production. Many disyllabic and trisyllabic words frequently truncated to monosyllabic words (Demuth & Johnson, 2003); however, this deletion pattern occurred less frequently in the production of Japanese-speaking children (Ota, 2003). Demuth and Johnson (2003) therefore attributed these cross-language differences to the high frequency of CV syllable words by French-speaking children. In addition, Ota (2006) further examined whether the frequency effects of prosodic word structures and lexical item impacted on Japanese-speaking children's patterns of early word truncation based on CHILDES database. The findings revealed that young children's target words were less likely to truncate when they were lexical items that were more frequent in the inputs. Ota (2006) explained that perhaps mothers knew some words that their children enable to produce in a target-like fashion, so they would repeat those words more frequently. Accordingly, it was concluded that the importance of taking input frequency account when discussing about young children's phonological systems.

2.3.3 Perceptual account

The perceptual salience proposes that stressed syllables are acoustically more prominent than unstressed syllables. Moreover, word-final syllables are more prominent than nonfinal syllables because they may receive acoustic cues related phrase boundaries such as lengthening and accent effects.

The recent articulation of a perceptual model has been provided by Echols and colleagues (Echols & Newport, 1992; Echols, 1993). They gathered data from English-speaking children during the one-word stage of language development. They observed that stressed and final syllables with more salient acoustic information were retained, whereas others were omitted. Results therefore showed that stressed syllables or final syllables were frequently preserved and more accurately produced than syllables that were unstressed and nonfinal.

In addition, Echols (1993) further discussed the relationship between saliency and stressed/unstressed syllables. Because unstressed nonfinal syllables were acoustically less salient than stressed syllables, they were less specified in underlying representations and they were vulnerable to omission. Moreover, Kehoe and Stoel-Gammon (1997) also indicated the importance of the phonetic content of syllables, which caused them to be less salient and less represented than other syllables. Because of under such salience proposals, weak syllables were omitted and

they were less likely to be fully encoded in the first place. As a result, *banana* would be encoded as [nænə] because [bə] is a weak syllable and stress is the salience in English.

Although a mechanism focusing on the perceptual properties of syllables is consistent with the pattern of syllable deletions observed, this account still faces problems. On the one hand, it is unclear how to explain the truncations such as [bænə] *banana* in terms of perceptual account. The children must have perceived the onset to the unstressed syllable if it is mapped into the word form. On the other hand, individual variation is frequently attested. For example, children frequently alternate between truncated and non-truncated forms in their production. That is, *banana* [bənænə] and *banana* [nænə] occur at similar point, suggesting that their lexical representations are not constrained (Kehoe & Stoel-Gammon, 1997). Thus, the perceptual account still leaves unanswered questions regarding why children delete certain syllables from their early words.

2.3.4 Production account

Other studies attempt to discuss syllable deletion on the basis of articulatory framework mainly proposed by Davis and MacNeilage (1990). This articulatory-base account is the frame-content theory (Menn, 1983; MacNeilage & Davis, 1993). In the beginning, investigators introduced the concept of articulatory modulation in terms of

the basic consonant-vowel (CV) syllable type from the closing and the opening mandibular movements. The closing is for consonant production, and the opening is for vowel. They argued that young children's syllable production process is restricted by cycles of mandibular oscillation. Besides, mastication bears a motor resemblance to the opening and closing phases of articulatory cycle, associated with syllabic elements of spoken language. Hence, this account notes that articulatory regularities in the sound patterns of babbling and early speech could be attributed to properties of basic mandibular cycle (MacNeilage & Davis, 1993).

However, this articulatory account runs into similar problems with perceptual account. If the young children are articulatorily restricted in either syllable complexity or the number of syllables per word, researchers expected these maturational limitations to be found cross-linguistically. However, according to acquisition studies, it is reported that children acquiring Spanish produced WSW words like *manZAna* [mən'zanə] several months before their English-speaking children peer group produced WSW trisyllablic words like *baNAna* [bə'nænə] (Demuth, 2001). Spanish-speaking children also produced trisyllabic words with an initial unstressed syllable also earlier than German-speaking children (Lleo, 2001). Therefore, it seemed that English- and German-speaking children's syllable omission of initial unstressed syllables must be due to non-articulatory factors (Roark & Demuth, 2000).

On the whole, most of the cross-linguistic studies showed a strong relationship between stress and syllable in children's phonological acquisition. However, in Mandarin, the salient status of stress is lower. Duanmu (2000) suggested that it is difficult to detect stress in Mandarin since the most important phonetic cue for stress is F0, but F0 is already for tone use in order to differentiate word meanings, and thus cannot be used freely for stress. Moreover, Zhu and Dodd (2000) showed that weak stressed syllables have a very short duration and a much reduced pitch range. The pitch of a weak syllable is primarily determined by the preceding tone. Compared with the saliency of tones, consonants and vowels, the saliency of weak stress is far less important because of the low value in differentiating word meaning (Zhu & Dodd, 2000). Consequently, because this study attempts to investigate the syllable acquisition in Mandarin and types of syllable deletion, the following section will be laid out the relative phonological elements in Mandarin.

2.4 Syllable deletion in Mandarin, Cantonese and Taiwan Southern Min

As previously stated, studies have indicated that young children's types of syllable omission will be easily influenced by the factor of stress because stress is salient in stress languages. However, children's syllable deletion in tonal languages may not be related to stress. According to Zhu and Dodd (2000), they worked on the phonological acquisition of Beijing Mandarin, and they found that children acquiring

Beijing Mandarin acquired syllable elements in the following order: tone was acquired first; and followed by syllable-final consonants and vowels; syllable-initial consonants were mastered last. Results showed that tone errors were rare, even in the youngest group of children. Tone has the highest saliency in Mandarin: it is compulsory for every syllable structure; change of tone will change the lexical meaning (Zhu & Dodd, 2000; Yip, 2002). It is suggested that the saliency of the components in a language system determines the order of acquisition. Consequently, based on the comparison of phonological processes used by children acquiring different languages, phonological patterns showed both universal tendencies and language-specific constraints on acquisition.

In terms of Cantonese acquisition, Tse (1991) investigated the process of the acquisition of the phonological system based on a longitudinal study of one Cantonese-speaking child. According to the analysis of child's speech data, the most used structure in the order of frequency was CV, and was then followed by CVG and CVC. However, CVG syllable remained a relatively unstable structure with omission of the final glide. Furthermore, while analyzing the structural simplification, Tse (1991) observed that the child was likely to delete the consonant cluster [kw] to be either [k] or [w]. In addition to initial consonant, final consonant deletion was seen as a fairly active process, with 17.6% of the final consonant deletion. The most

frequently affected type was postnuclear glides with 24.6%, followed by nasal finals with 10.6% and stop finals with 1.4%. Hence, Tse (1991) found the evidence for universal trends in the sequence of phonological acquisition, and concluded that these phonological patterns, simplification strategies and salient phonological distributions were accounted for Cantonese children. In order to further attest phonological patterns, So and Dodd (1995) enrolled 268 Cantonese-speaking children to analyze their speech errors in a picture-naming test. Based on the comparison of phonological structures of different languages, the younger Cantonese-speaking children made more errors in the syllable-initial position than in the syllable-final position. Results revealed that only a relatively small proportion (10.7%) of the total number errors were made on final syllable positions, including fronting, backing and final consonant deletion. However, for syllable-initial consonants, So and Dodd (1995) indicated that the acquisition patterns of children acquiring Cantonese exhibited a interaction of linguistic universal tendency with language-specific effects.

On the other hand, Tsay (2006) found that the patterns of syllable deletion occurred differently in terms of the word-position and the number of the syllables. Tsay (2006) explored the relationship between prosodic model and the syllable omission patterns produced by children acquiring Taiwan Southern Min, aged from 1;6 to 3;0. The children used syllable omission as simplification strategies to shorten

long utterances. There were two patterns of the children's syllable deletion: (1) word-initial syllables were omitted more frequently than word-final syllables and (2) omission occurred in multisyllabic words more frequently than in monosyllabic word. Thus, on the basis of different factors and elements in syllable omissions, we may deduce that stress is irrelevant with syllable deletion in tonal language, Mandarin.

To sum up, previous studies have focused on a shared developmental order of syllables and examined the universal syllable types at children's early phonological stage in terms of different theoretical approaches. Most of cross-language studies have highlighted the strong relationship between stress and syllable deletion; however, stress is not the most salient in Mandarin. Based on the observation of syllable patterns in Mandarin, the patterns may reveal both universal tendencies and language-specific constraints on syllable acquisition and syllable deletion. Consequently, this thesis aims at types and patterns of syllable acquisition and syllable deletion of the four young children acquiring Taiwan Mandarin in a longitudinal observation method.

Chapter 3

Methodology

There are two parts in this section. The first part consists of the data collection, and the second part involves the data analysis. The data have been collected by the researcher and the research team. There are in total 84 hours; 39 hours have been collected and transcribed by the researcher and 45 hours have been collected and transcribed by the research team in Phonetics and Psycholinguistics Lab at National Chengchi University. The study has been sponsored by MOST research projects, “Consonant acquisition in Taiwan Mandarin (MOST 100-2410-H-004-187-)”, “Consonant acquisition in Taiwan Mandarin: Evidence from longitudinal and experimental studies (MOST 101-2410-H-004-182-)” and “Consonant acquisition in Taiwan Mandarin: Evidence from observational and experimental studies (MOST 102-2410-H-004-107-).”

Section 3.1 presents the way in which the participants have been recruited and their background information. The procedure and the recording equipment used during the data collection will also be introduced in this section. For data analysis in section 3.2, I will present the methods of data transcription, the criteria for choosing target words, the formulas used in obtaining syllable type frequency and how the syllable deletion patterns have been organized.

3.1 Data collection

This section presents how the researcher and the research team collected the speech data from the children and their families' background information. The families participating in the research projects were recruited from an advertisement posted on a non-profit parent forum – Babyhome (http://www.babyhome.com.tw/). On the forum, the research team posted the recruiting page, which listed the background of the research information and the age of recruiting children. Parents who would like to join in the research were supposed to fill a registration form out. Sixteen children were enrolled under the projects.

According to children's speech data and family backgrounds, some of the children in the MOST research projects lived with their grandparents who spoke Taiwanese Southern Min, so the children would produce Taiwanese Southern Min words during the observation. Besides, because some parents used to speak English to the children, the children might also produce English in the data. In order to rule out the influence of the languages (i.e. Taiwan Southern Min and English), this study excludes these children and focuses on the children acquiring Taiwan Mandarin. This study therefore collected four children and their caretakers. There were in a total number of 16515 tokens produced by four children and 4586 tokens produced by four caretakers, among which 8132 tokens were transcribed by the assistants in the

research team and 12692 tokens were transcribed by the researcher.

3.1.1 Participants

The background of the four children, two girls and two boys, were selected and enrolled in this study. They were from middle class family in Taipei, Taiwan. The four children lived with their parents and their mothers took care of them in the day time. They were the only child in their families during the observation. Their mothers used Taiwan Mandarin to communicate with them, so the children's first languages were Taiwan Mandarin. The participants' background information is presented in the following Table 3.1 and Table 3.2.

Table 3.1 Participants' age range and recording duration

Participant	Gender	Age Range	Recording Duration
Child #1	Female	1;0 – 2;5	18 months
Child #2	Female	0;10 – 2;3	18 months
Child #3	Male	1;1 – 2;6	18 months
Child #4	Male	0;11 – 2;4	18 months

The children's ages were 0;10 to 1;1 at the beginning of the observation. The data in the boys' and girls' babbling stages were excluded in this study. The age when they were in non-reduplicated babbling stages and they had produced first meaningful words was selected. At the end of the observation, the their ages were 2;3 to 2;6. Besides, they were reported to have no speech, hearing or visual impairments.

Table 3.2 Participants' gender and relation with children

Participant	Gender	Relation	Language
Caretaker #1	Female	Mother of child #1	Taiwan Mandarin
Caretaker #2	Female	Mother of child #2	Taiwan Mandarin
Caretaker #3	Female	Mother of child #3	Taiwan Mandarin
Caretaker #4	Female	Mother of child #4	Taiwan Mandarin

Four adult participants were four children's caretakers respectively. They were mothers and their native languages were Taiwan Mandarin. Each mother was the primary caretaker of the child during the whole longitudinal observation.

3.1.2 Procedures

The data collection of four children started from January 2012 to March 2014. There were eight research assistants in the research team. Two assistants were sent to a child's house to record the spontaneous speech of the natural daily activities between the child and the mother every other week. On average, a 60-minute recording was made from every observation. Sometimes the recording time might be shorter if the children were tired or cried and it might be longer if the children were reading or playing with their mothers. In order to create a natural context, the activities during recording were various, including share-book reading, object-naming, or playing with toys, and the mothers were encouraged to play with their children. For most of the time, the children played with the mothers and the mothers were the

people the children were more familiar with. The choice of home environments as observation settings was based on the studies of Lewedag, Oller and Lynch (1994) and Chen and Kent (2005). Children were reported to vocalize more frequently and produced more well-formed syllables in home environments than in laboratory settings (Lewedag et al., 1994).

In order to collect the more natural speech data from children's vocalization, no systematic planning of elicitation was done during the recording, except for natural elicitations in daily life. For instance, when the children were playing toys with their mothers, sometimes the mothers would ask them to name the toys. Therefore, the speech data of this study were ensure to be elicited from spontaneous conversations, rather than elicited and planned sounds. The target words for analysis were selected in these spontaneous speeches. Although the number and the type of children's phonetic errors might be greater than controlled experimental tasks, the data in a more natural context reflected the processes of phonological acquisition. Thus, the researcher selected these spontaneous speech data as analysis in this study.

During the observation, one of the assistants held the video recorder and the other assistant held the sound recorder. The one who held the video recorder would make sure to film the child's face, mouth and the objects they played with. The assistant who held the sound recorder had to get closer to the child in order to achieve

good quality of speech sounds. At the end of every recording, the assistants would note down every recording date and time, making it easier to file the recording data.

Before the research project, the participants have had signed the human subject consent forms. At the end of the research project, the families would receive an album of video recordings as a souvenir. Whole funds were supported by the MOST research projects (MOST 100-2410-H-004-187-, MOST 101-2410-H-004-182-, and MOST 102-2410-H-004-107-).

3.1.3 Recording equipment

To achieve flexible recording, without distracting subjects, the wireless equipment of video-recording and sound-recording were used. Sony HDR-CX380 Handycam digital video camera recorder, Sony ICD-UX543F digital voice recorder and Shure SV100 multi-purpose microphone were all used during the recording. The microphone was used to connect the voice recorder. During the observation, the video-recorder and sound-recorder were powered with batteries instead of using cables, in order to provide more flexibility in choosing observation locations in the home environments. The size of the equipment was small, so assistants could carry the equipment easily while interacting with children.

In addition, the video helped us record children’s gestures, lip movements and items they played with. It also provided us some clues to decode the referential

meaning of children's utterance. The sound-recorder offered us high quality sound files. The multi-purpose microphone with the unidirectional pattern helped reduce ambient noise and provided clear sound quality for spoken words. All recording equipment was used for providing high recording quality for perceptual transcription.

3.2 Data Analysis

The four children in the observation period were from one-word stage and two-word stage to the stage when the utterances were longer than two syllable words. Moreover, it is noted that Mandarin has a "dual-vocabulary" pattern, where most of the monosyllabic words have a disyllabic form (Duanmu, 2007). Children's syllable production may vary from monosyllables to longer utterances. Accordingly, this study will carefully analyze children's monosyllabic words, disyllabic words and multisyllabic words separately in different sections. The following sections consist of how the data have been transcribed, coded and analyzed.

3.2.1 Transcription and coding

The data from the recording files were transcribed by the researcher and the assistants of the research team. If there were disagreements, the tokens would be discussed and checked by the third assistant of research team. All the assistants were native speaker of Taiwan Mandarin and had good training of phonetic transcription of speech data.

In order to determine the participants' production in transcription and assess the coding reliability, intra-reliability and inter-reliability were concerned (Vihman & McCune, 1994; Chen & Kent, 2005). To estimate intra-transcriber reliability (93.1% for consonants and 97.7% for vowels), the researcher checked the consistency of the transcriptions by re-transcribing a random one-hour sample of the children's recordings. In addition, to check inter-transcriber reliability (92.3% for consonants and 95.6% for vowels), two other experienced transcribers of the research team were asked to transcribe the same recording data. The intra-transcriber and inter-transcriber reliability of the transcription reached a percentage higher than 90% under the study. With regard to phonetic transcription, this study focuses on syllable types and do not deal with specific segment acquisition. Thus, broad transcription was used by the IPA system.

The child's utterances of words and phrases were transcribed into five parts: actual produced words in IPA transcription, syllable type, tone, number of occurrences and possible meaning. The transcribed examples are shown below in Table 3.3.

Table 3.3 The sample of coding

IPA Transcription	Syllable Type	Tone	Occurrence	Possible Meaning
[wa]	GV	[55]	3	flower
[tswɔ]	CGV	[51]	5	sit
[ja ja]	GV-GV	[21-35]	3	goat
[pi kwɔ]	CV-CGV	[21-21]	2	apple
[lwɔ pwɔ]	CGV-CVG	[21-55]	3	carrot

Table 3.3 represents the way how the researcher coded the child's utterances. The first column showed the child's actual produced words transcribed with IPA symbols. The second column was to show the syllable type of each meaningful word. There were twelve syllable types, coded as V, CV, VG, GV, VN, CVG, CVN, CGV, GVG, GVN, CGVG, and CGVN. The third column was to mark the tone of words. The tones were coded as [55], [35], [21] and [51] in Mandarin, representing level tone, rising tone, falling rising tone, and falling tone. The neutral tone was coded without any tone number in the transcription. The forth column was the number of occurrence of each word. For example, in the row of the first example, the child produced "flower" as [wa] for 3 times. Finally, the fifth column marked the possible meaning of each word, which could be inferred by contexts, gestures or adult's repetition. The meaningless tokens were excluded in the study.

3.2.2 Criteria for target word

Since this study attempts at investigating the children's syllable patterns and

types of syllable deletion, the criteria for target word and syllables should be concerned. The following were the criteria for choosing the appropriate target words of the children's production. Based on the previous analyses (e.g., Vihman & McCune, 1994; Stoel-Gammon, 2011; Sosa and Stoel-Gammon, 2012; H. Y. Wang, 2014), there were three major criteria adopting in this study. Firstly, the participants' sound quality must be clear. The mumbling speech or overlapping speech of adults would be excluded. Moreover, since background noise from playing with toys and rustling noise from contacting with recorders would result in fuzzy sounds, these noises would be excluded. Secondly, the children's meaning of each word must be clear and plain. To be judged a meaningful word, the children's speech forms should be systematically related with the context. Furthermore, words would be chosen when a Mandarin gloss could be identified, and the meaning of words could be inferred by examination from contexts or repetition of adults' speech. For instance, if the child pointed at an animal toy and uttered [ja21 ja35], we suggested that the intended meaning was "a goat."

Thirdly, the deleted forms that were selected in the study could not be completely different from target words. Because this study focuses on the syllable deletion, the syllable of words that reduce from complex syllable types to simpler syllable types, such as from GVN-GVN in [jɑŋ21 jɑŋ35] *goat* to GV-GV [ja21 ja35],

would be included. Nevertheless, if the child produced CV-CGVN in [mi51 ljɑŋ51] *moon*, CV [mi51] would not be calculated because [mi51] was totally different from GV [ɥɛ51]. Moreover, the target lexicons should be nouns, verbs, adjectives and adverbs in children's production. If they produced a whole sentence, the lexicon within the production would be excluded in order to avoid syntactic problems.

Fourthly, the imitated production would be included in examining child acquisition (e.g., Ferguson & Farwell, 1975; Vihman & McCune, 1994; Sosa & Stoel-Gammon, 2012; Macrae, 2013). Ferguson and Farwell (1975) proposed that a large number of young children' productions were imitated words and children could imitate words spoken by adults with "a considerable separation in time." In this way, it is difficult to exclude children's imitation production from the analyses. Vihman and McCune (1994) pointed out that the assessment of the reliability of children's imitation word could use the three criteria, including imitated tokens, phonetic identity and no inappropriate uses. For the analysis of imitated tokens, if children produced the imitation with apparent understanding and clear meaning, then it should be credited. For the analysis of phonetic identity, all the instances of the words should exhibit the same phonological shape, conforming to phonetic match. For the appropriate word-use, it means that if children's word forms were not used in conflicting contexts and could infer the same word, the forms would be credited.

Furthermore, Sosa and Stoel-Gammon (2012) noted that the child's production occurred within two seconds immediately after the adult's utterance that consisting of the same target word. Imitated words or spontaneous words should be transcribed and analyzed. Finally, since this study investigates children acquiring Taiwan Mandarin, words in English, Taiwan Southern Min or other languages would be excluded.

3.2.3 Frequency of overall syllable type

To answer the research questions, the analysis of syllable type frequency will be undertaken. In order to see the significance of syllable types produced by children, One-way Analysis of Variance (One-way Anova) was performed in the analysis since the speech data was normally distributed. Besides, if the assumption of homogeneity is not met, the Welch F ratio to report the tests of equality of means was used. While it was significant, post hoc follow-up procedures needs to be conducted to test the differences between all syllable-type comparisons. Duncan's multiple range test was adopted because it could effectively deal with the data in order to show the different grouping of the syllable types. Besides, Statistical Analysis System (SAS) version 9.3 and Excel 2010 were helped to conduct and analyze the data. The syllable analysis is adopted from the study of Macrae (2013) and H. Y. Wang (2014). Evaluating the frequency of different syllable types produced by participants can reveal their preferences and interactions. Children's types of syllable deletion can be shown in

terms of the frequency. If the frequency of a certain syllable type is low, it can be explained that the syllable type is more problematic to the children in the acquisition. For example, if the frequency of CGVN (C = consonant, G = glide, V = vowel, N = nasal) is observed to be lower than other syllable types when children were one year old, it is suggested that the children have not acquired syllable type CGVN yet. In this way, we may predict that complex and marked syllable types with lower frequency will be deleted more often. The frequency of each syllable type children produced will be computed by the formula presents below.

$$\text{Percentage} = \frac{\text{Tokens of a syllable type}}{\text{Tokens of all syllable type}} \text{ X } 100\%$$

The numerators were the tokens of a particular syllable type. The fraction was presented as a percentage. The frequencies of all syllable types were ranked into an ordering in order to examine the participants' production.

Furthermore, in order to discuss child-caretaker interaction and to check whether the influence of syllable patterns in the ambient language, caretakers' frequently used syllable types should be analyzed. The researcher transcribed a random sample of the four caretakers' recordings, accounted for 10% of all recordings. The caretaker's syllable types would be compared with the child's types. Since the relationship between the children's syllable patterns and their caretakers' syllable patterns is one of the focuses, correlation analysis (Pearson correlation coefficient) was used to examine

the effects on child-caretaker's productions. If there is significant effect, it is indicated that the children's syllable outputs can be affected by the linguistic environment (i.e. caretakers' speech).

3.2.4 Frequency of syllable deletion

In order to examine the patterns of deleted syllable types produced by participants, One-way Anova was also adopted since the speech data was normally distributed. Besides, if the assumption of homogeneity is not met, the Welch F ratio to report the tests of equality of means is used. While it is significant, post hoc follow-up procedures need to be conducted to test the differences between all syllable-type comparisons. To investigate whether the token of different syllable deletion affects the development in syllable acquisition, frequency of each type would be computed and analyzed. The frequency of syllable deletion can reveal which type is preferred by the child to reduce in the syllable development. The syllables of the words that all had gone through syllable reduction can be calculated. For example, if the child produced GV-GV syllable structure in [ja21 ja35] *goat*, both syllables would be calculated. But in terms of CV-CVN-CV in [tʂʰa35 tɕin21 lu51] *giraffe*, only the former deleted syllable would be chosen while the last two canonical syllables (i.e. CVN-CV) would not be calculated. Consequently, it is predicted that the frequency of more complex syllable types would be lower while the frequency of simpler syllables types would be

higher. The frequency of each type of syllable deletion would be analyzed by the formula below:

$$\text{Percentage} = \frac{\text{Tokens of a deleted syllable type}}{\text{Tokens of all deleted syllable type}} \text{ X } 100\%$$

The numerators were the tokens of a particular reduced syllable type. The fraction was presented as a percentage. The frequency of child's syllable reduction could reveal their syllable tendencies in the development.

3.2.5 The pattern of syllable deletion

Since the children's productions of words were not mature and stable, they might delete the segments in the syllables to produce a word. The following examples showed the different categories of deletions in the analysis. There were six categories in the analyses, including deletion of initial consonant, final nasal [n]/[ŋ], prenuclear glide [j], prenuclear glide [w], postnuclear glide [j] and postnuclear glide [w].

If the children produced GVN-CVG syllable structure in [wən35 tʰaj55] *tire*, rather than CGVN-CVG in [lwən35 tʰaj55], they omitted the initial consonant. If the children produced the GV-GV in [ja21 ja35] *goat*, rather than GVN-GVN in [jɑŋ21 jɑŋ35], they deleted the final nasals. Another example showed that the children produced CV in [pʰa21] *run*, instead of CVG in [pʰaw21], showing that the postnuclear glide was omitted.

Furthermore, many studies have showed that children in early speech tended to

drop the segments in the final-syllable positions (Roark & Demuth, 2000; Demuth & Johnson, 2003) in terms of hierarchical constraints “No-Coda” (e.g., Pater, 1997; Levelt et al., 2000). For example, CVC target forms were easily to be realized as CV depending on the relative ranking of faithfulness constraints on the realization of segments. However, some researchers proposed that children might drop the syllable-initial consonant in the early speech (e.g., Zhu & Dodd, 2000; Tsay, 2006). For example, the child would produce V-CV syllable structure in [ɤ35 ma21] *hippopotamus*, instead of CV-CV in [xɤ35 ma21]. This child deleted the initial consonant in the production. Hence, the deletion patterns could show a tendency of children’s production patterns.

Chapter 4

Result and analysis

In this section we will examine the results of the analysis. This analysis follows the research questions of this study as laid out in Chapter 1. Section 4.1 presents an overview of the overall data. Section 4.2 demonstrates the results of syllable analyses based on different syllable numbers, including both the frequent overall syllable types and the frequent syllable deletion in the production. Different patterns of syllable deletion are presented in section 4.3. Finally, section 4.4 clearly presents the child-caretaker's output syllable relationship.

4.1 Data Background Information

Four children and four caretakers were enrolled in the analysis. The observation started at the age of 0;10 to 1;1 and ended at the age of 2;3 to 2;6. The children's speech data was collected from the non-reduplicated babbling stage when the children started to produce different syllable types as well as their first meaningful words.

As noted in Chapter 3, on the one hand, the analysis of this study only included sounds that have clear meaning and can be inferred from their respective contexts or from adults' repetition. Tokens without clear meanings or tokens that were acoustically unrecognizable are excluded. In total the data contains 16515 syllabic tokens produced by children and 4586 tokens produced by caretakers, as shown in

Table 4.1. Table 4.1 lists of the relevant information concerning four children, including: gender, age, duration of observation and total tokens of words that the four participants uttered.

Table 4.1 Background information regarding the children

Participant	**Gender**	**Age range**	**Duration (month)**	**Syllabic tokens**
Child #1	Female	1;0 – 2;5	18	3352
Child #2	Female	0;10 – 2;3	18	5041
Child #3	Male	1;1 – 2;6	18	5390
Child #4	Male	0;11 – 2;4	18	2732
			Total	16515

In table 4.1, the duration of observation continued for 18 months, starting from the babbling stage and continuing to the telegraphic speech stage. Child #3 was the most productive of all the children while child #4 was the least productive child. Child #1 produced 3352 types of tokens and child #2 produced 5041 tokens. Child #3 produced 5390 tokens while child #4 only produced 2732 tokens. There were 16515 syllabic tokens of utterances suitable for analysis in this study.

In addition, the following Table 4.2 displays relevant information regarding the four caretakers, including gender, age, duration of observation and total syllabic tokens.

Table 4.2 Background information regarding the caretakers

Participant	Gender	Relation	Syllabic tokens
Caretaker #1	Female	Mother of child #1	1496
Caretaker #2	Female	Mother of child #2	1071
Caretaker #3	Female	Mother of child #3	973
Caretaker #4	Female	Mother of child #4	1046
		Total	4586

The researcher transcribed a random sample of the four caretakers' recordings, accounting for 10% of all recordings. As shown in Table 4.2, Caretaker #1 was the most productive mother of all the caretakers, producing 1496 syllabic tokens. Caretaker #2 produced 1071 syllabic tokens and caretaker #3 produced 973 syllabic tokens. Caretaker #4 produced 1046 syllabic tokens. There were 4586 syllable tokens of utterances analyzed in the study.

4.2 Frequency of syllable types

The tokens of overall different syllable types in different syllable numbers were calculated in order to see the general syllable types produced by children. The tokens collected in this section included the calculations of overall syllable types and deleted syllable types.

In order to answer the research questions, the frequencies of syllable types were examined in order to indicate which syllable type was more frequently used and which type was less used. The frequency of overall syllable types is shown in section 4.2.1, and the frequency of syllable deletion is examined in section 4.2.2.

4.2.1 Frequency of overall syllable types

This section demonstrates the overall frequency of syllable types among the four children. It is noted that analysis of syllable tokens includes monosyllabic words, disyllabic words and multisyllabic words. To discuss whether different types of tokens influence the syllable development in acquisition, monosyllables, disyllables and multisyllables are analyzed accordingly. Because all the children could produce utterances longer than disyllable words when they were at two years old, there are three categories of their syllable utterances. In terms of disyllables and mulitsyllables, the tokens of syllable types in different syllable positions would not be separately analyzed. Based on the analyses of syllable frequencies, we can see the general and preferred syllable patterns occurring in children's speech. The frequency of monosyllabic words, disyllabic words and multisyllabic words is shown in section 4.2.1.1, section 4.2.1.2 and section 4.2.1.3 respectively.

4.2.1.1 Overall monosyllabic words

In terms of statistical analysis of overall monosyllables, since the assumption of homogeneity of variance was not met for the data, $F(11, 36) = 6.16$, $p<.05$, we used an alternative Welch's adjusted F ratio and reported it as Welch's $F(11, 13.90) = 15.65$, $p<.05$. The analysis using the Welch test shows that there were significant differences among the twelve syllable types in monosyllabic words. Moreover, the

result of the follow-up with Duncan's multiple range test is shown in Table 4.3.

Table 4.3 Duncan's Multiple Range Test for overall monosyllables

Duncan grouping	Mean	N	Monosyllables
A	157.00	4	CV
B	64.75	4	CVG
C	40.25	4	CGV
C	36.25	4	GV
D	31.00	4	CVN
D	28.00	4	GVG
D	26.00	4	CGVG
D	22.25	4	V
D	15.75	4	CGVN
D	7.25	4	GVN
D	5.50	4	VG
D	5.50	4	VN

According to the above Table 4.3, group A (i.e. CV) is significantly different ($p<.05$) from the B, C and D groups. Group B (i.e. CVG) is also significantly different ($p<.05$) from the other syllable types. Hence, we may ascertain that CV and CVG are superior to the other syllable types, and statistically significantly different.

In addition, the tokens and percentages of each syllable type in monosyllabic words are presented in the following Table 4.4 and Figure 4.1. The bar graph in Figure 4.1 was used to clearly compare the differences among frequencies of syllable types.

Table 4.4 Tokens and percentages of overall syllable types in monosyllabic words

Type	**V**	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Tokens	89	628	22	145	22	259	124	161	112	29	104	63
Percentage	5.1%	35.7%	1.3%	8.2%	1.3%	14.7%	7.1%	9.2%	6.4%	1.6%	5.9%	3.6%
Total tokens												1758

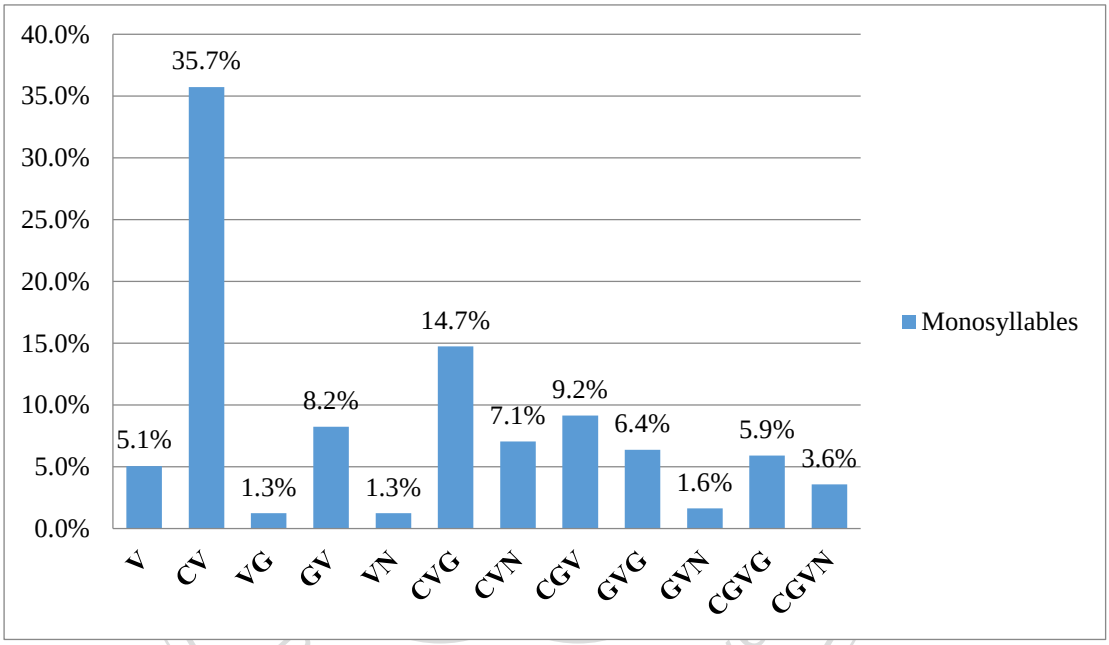


Figure 4.1 Percentages of overall syllable types in monosyllabic words

Based on Table 4.3 and Figure 4.1, CV is the most frequently used syllable type in monosyllabic words, accounting for 35.7% of the total 1758 syllables. CVG and CGV rank second and third place, with a usage of 14.7% and 9.2% of utterances respectively. GV ranks fourth place, with a usage of 8.2%. However, as for the least frequently used syllable types, VG, VN and GVN are less than 2% of all utterances. The ranking of frequencies of syllable types is thus CV > CVG > CGV > GV. The

results obviously show that the children preferred CV in monosyllables the most due to the fact that CV has the highest frequency.

Moreover, in order to discuss whether there are individual differences among children, the following Table 4.5 displays the frequencies of overall monosyllable types produced by each child.

Table 4.5 Percentages of overall syllable types of each child in monosyllabic words

	V	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Child #1	7.8%	25.0%	0.4%	7.6%	1.6%	18.1%	7.4%	8.0%	8.0%	1.3%	9.2%	5.6%
Child #2	2.8%	37.2%	1.2%	12.8%	1.2%	13.4%	7.5%	8.9%	4.5%	2.8%	4.7%	3.0%
Child #3	4.9%	38.0%	1.0%	5.5%	1.4%	14.4%	8.6%	9.2%	7.2%	1.6%	4.1%	4.3%
Child #4	5.0%	45.2%	3.0%	6.6%	0.7%	12.5%	3.3%	11.2%	5.6%	0.3%	6.3%	0.3%

As shown in Table 4.5, for the most frequently used syllable type, CV has the highest frequency of occurrences among the four children's monosyllabic words, and is followed by CVG. However, as for the third place, child #2 presented slightly different pattern compared to that of the other children. GV ranks as the third most frequently used syllable type with a usage of 12.8%. The other children exhibited similar patterns: CV was the most frequently used type, and is then followed by CVG and CGV. Briefly, CV, CVG and CGV were used more frequently than other syllable types of the children's monosyllables. For the least frequently used syllable types, although there were slightly different syllable patterns, VG, VN and GVN had lower frequencies in the production of the children.

4.2.1.2 Overall disyllabic words

Based on the statistical analysis of overall disyllables, because the assumption of homogeneity of variance was not met for the data, $F(11, 36) = 11.80$, $p<.05$, we used Welch's adjusted F ratio and reported it as Welch's $F(11, 13.77) = 24.75$, $p<.05$. This shows that the results of children's overall disyllables are significant. The analysis using the Welch test shows that there were significant differences among the twelve syllable types in disyllabic words. Moreover, the results of the follow-up in Duncan's multiple range test is shown in Table 4.6

Table 4.6 Duncan's Multiple Range Test for overall disyllables

Duncan grouping	Mean	N	Disyllables
A	957.50	4	CV
B	258.75	4	CVG
C	184.75	4	CGV
C	122.50	4	CVN
C	121.50	4	V
C	93.50	4	CGVG
C	90.00	4	CGVN
C	81.25	4	GV
C	78.25	4	GVG
C	26.50	4	GVN
C	18.25	4	VN
C	15.50	4	VG

According to Table 4.3 as seen above, group A (i.e. CV) is significantly different ($p<.05$) from the B and C groups. Group B (i.e. CVG) was also significantly different

($p<.05$) from the other syllable types. It can thus be obviously shown that CV and CVG were superior to the other syllable types, and statistically significantly different.

The tokens and percentages of each syllable type in disyllabic words are displayed in the following Table 4.7 and Figure 4.2. The bar graph in Figure 4.2 clearly compares the differences among syllable type frequencies.

Table 4.7 Tokens and percentages of overall syllable types in disyllabic words

Type	**V**	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Tokens	486	3830	62	325	73	1035	490	739	313	106	374	360
Percentage	5.9%	46.7%	0.8%	4.0%	0.9%	12.6%	6.0%	9.0%	3.8%	1.3%	4.6%	4.4%
Total tokens												8193

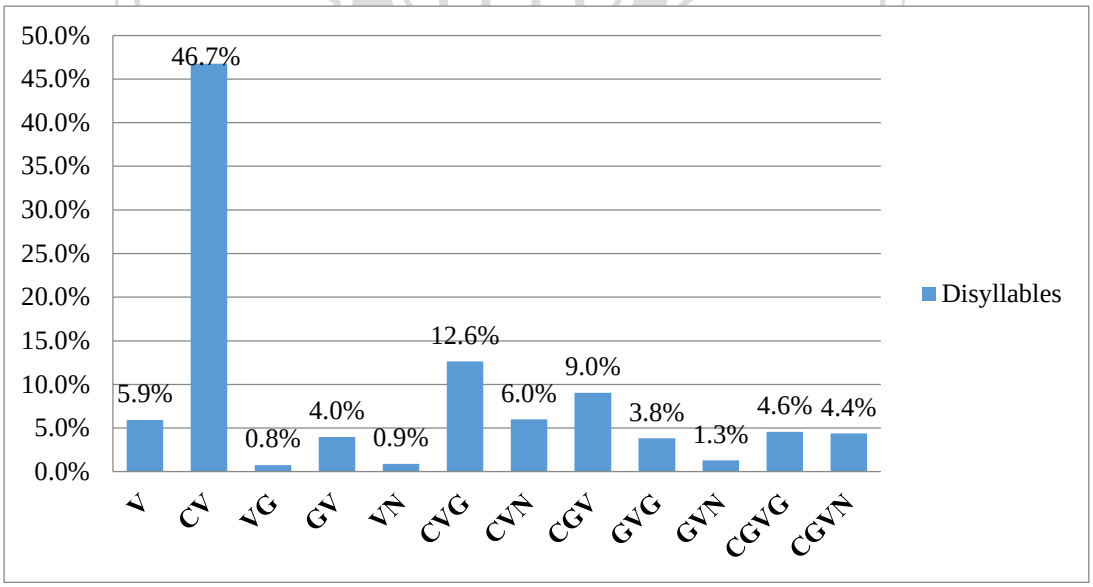


Figure 4.2 Percentages of overall syllable types in disyllabic words

As shown in Table 4.7 and Figure 4.2, we see that CV is the most frequently used syllable type in disyllabic words, accounting for 46.7%, and is then followed by CVG.

The frequencies of syllable types in disyllabic words were similar to the results in monosyllabic words, where CV, CVG, and CGV are also the most frequently used syllable types. However, as for the least frequently used syllable types, VG and VN, they make up less than 1% of disyllabic words. The frequency ranking is thus CV > CVG > CGV.

In addition, in order to determine whether there were individual differences among the children, the following Table 4.8 revealed the frequencies of overall disyllable types produced by each child.

Table 4.8 Percentages of overall syllable types of each child in disyllabic words

	V	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Child #1	7.9%	36.6%	1.3%	3.8%	1.9%	12.2%	9.6%	6.3%	4.4%	2.4%	6.6%	6.9%
Child #2	5.0%	45.9%	0.4%	6.1%	1.1%	13.0%	6.5%	9.9%	2.9%	1.2%	3.6%	4.4%
Child #3	4.1%	53.6%	0.5%	2.3%	0.3%	13.4%	5.4%	7.3%	3.9%	1.3%	3.4%	4.4%
Child #4	8.6%	47.6%	1.1%	3.8%	0.5%	11.0%	1.5%	14.6%	4.4%	0.1%	5.9%	1.0%

Based on Table 4.8, the most frequently used syllable type, CV, had the highest frequency of occurrences of disyllabic words. Child #2 and child #3 show similar patterns: CV was the most frequently used type, followed by CVG and CGV. However, child #1 and child #4 show slightly different syllable patterns and order. Child #1 preferred CVG and CVN, with the usage of 12.2% and 9.6% respectively. Child #4 instead preferred CGV and CVG, which accounted for 14.6% and 11.0% respectively.

In a nutshell, CV, CVG and CGV had higher frequencies than other syllable types in the disyllables of all children. For the least frequently used syllable types, although there were slightly different patterns, VG, VN and GVN had lower frequencies in the sample of the four children's disyllabic words.

4.2.1.3 Overall multisyllabic words

In terms of the statistical analysis of multisyllables, the assumption of homogeneity of variance was not met for the data, $F(11, 36) = 22.15$, $p<.05$, so we used Welch's adjusted F ratio and reported it as Welch's $F(11, 13.72) = 18.73$, $p<.05$. It is indicated that the results of children's overall multisyllables are significant. The analysis using the Welch test shows that there were significant differences among the twelve syllable types in disyllabic words. Results of the follow-up using Duncan's multiple range test are shown in Table 4.9.

Table 4.9 Duncan's Multiple Range Test for overall multisyllables

Duncan grouping	Mean	N	Multisyllables
A	771.00	4	CV
B	200.25	4	CVG
C	123.50	4	CVN
C	115.25	4	CGV
C	107.50	4	V
C	91.50	4	CGVN
C	66.00	4	CGVG
C	59.25	4	GV
C	52.75	4	GVG
C	29.50	4	GVN
C	14.25	4	VG
C	10.50	4	VN

According to Table 4.9, group A (i.e. CV) is significantly different ($p<.05$) from the B and C groups. Group B (i.e. CVG) is also significantly different ($p<.05$) from the other syllable types. Hence, we can see that CV and CVG are superior to the other syllable types, and statistically significantly different.

The tokens and percentages of each syllable type in disyllabic words are displayed in the following Table 4.7 and Figure 4.3. The bar graph in Figure 4.3 clearly compares the differences among syllable type frequencies in multisyllabic words.

Table 4.7 Tokens and percentages of overall syllable types in multisyllabic words

Type	**V**	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Tokens	430	3084	57	237	42	801	494	461	211	118	264	366
Percentage	6.5%	47.0%	0.9%	3.6%	0.6%	12.2%	7.5%	7.0%	3.2%	1.8%	4.0%	5.6%
Total tokens												6565

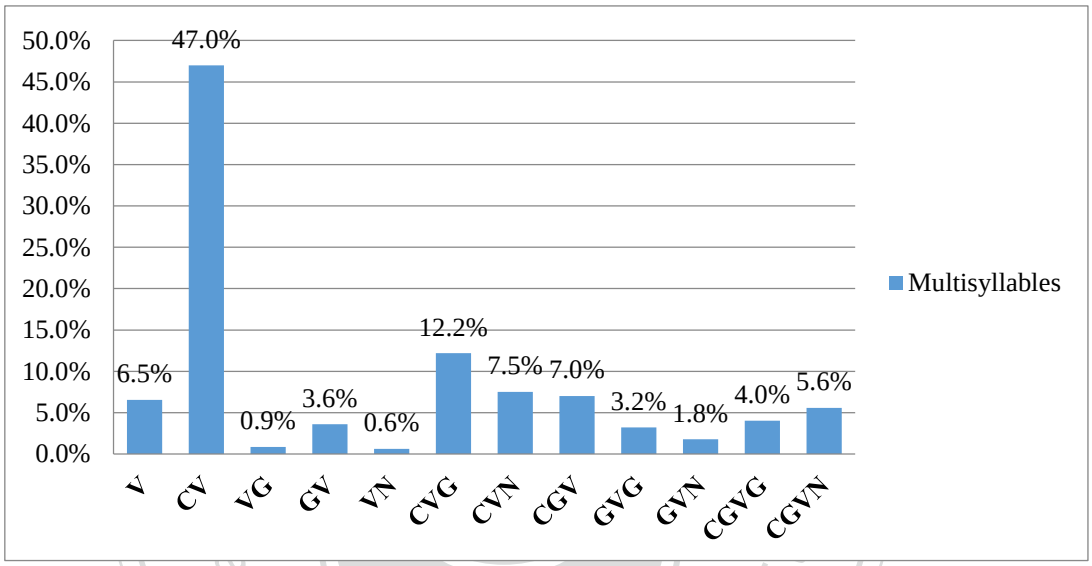


Figure 4.3 Percentages of overall syllable types in multisyllabic words

In Table 4.7 and Figure 4.3, it can be clearly seen that CV is the most frequently used syllable type in multisyllabic words, accounting for 47.0% of the total 6565 syllables, and followed by CVG. The frequency of CV is three times higher than other syllable types. The frequencies of syllable types in multisyllabic words are slightly different from the results presenting monosyllabic words and disyllabic words. However, for the least frequently used syllable types, VG and VN have the lowest frequencies of all multisyllables. The frequency ranking is thus CV > CVG > CVN > GGV.

Furthermore, in order to see whether there were individual differences among children, the frequency of overall multisyllable types produced by each child is shown in the following Table 4.10.

Table 4.10 Percentages of overall syllable types of each child in multisyllabic words

	V	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Child #1	9.0%	38.4%	1.1%	3.1%	1.1%	14.4%	9.7%	3.8%	4.0%	2.0%	3.7%	9.6%
Child #2	4.3%	44.5%	0.5%	4.2%	0.5%	13.2%	9.5%	8.7%	2.9%	1.6%	3.6%	6.3%
Child #3	6.1%	50.9%	0.7%	2.4%	0.3%	11.7%	7.1%	6.2%	2.8%	2.7%	4.0%	5.1%
Child #4	9.4%	53.2%	1.6%	5.2%	1.0%	8.9%	2.0%	8.6%	3.8%	0.1%	5.3%	0.8%

Based on Table 4.10, the most frequently used syllable type, CV, has the highest frequency of occurrences of multisyllabic words. Child #4 showed slightly different syllable patterns and order from the other children. He preferred V and CVG, with a usage of 9.4% and 8.9% respectively. The least frequent syllable types produced by child #4 in multisyllables were GVN, CGVN, VN and VG. The other children showed similar patterns: CV is the most frequently used type, followed by CVG and CVN.

In brief, CV and CVG have higher frequencies than other syllable types in multisyllables of all children. For the least frequently used syllable types, although there were slightly different patterns, VG and VN have lower frequencies among the four children's multisyllabic words. Furthermore, CV is the most frequently used syllable type in the young children's speech production. The unmarked syllable CV was obviously the most frequently used type for four children.

4.2.2 Frequency of syllable deletion

The results in the previous section 4.2.1 show the rankings of the frequently used syllable types used by the four children. In order to evaluate the frequency of deleted syllables, we chose the syllables which had all gone through syllable deletion. Meaningful words that did not have reduced syllable forms are not included. Besides, since the form of syllable deletion is to omit the segments in the syllable structure, and CGVG and CGVN are two most complex syllable structures in Mandarin, these two types do not occur in the output of syllable deletion forms. As previously noted, the analysis of syllable tokens includes monosyllabic words, disyllabic words and multisyllabic words. To discuss whether different types of tokens influence the children's syllable deletion patterns, monosyllables, disyllables and multisyllables are analyzed. The frequency of monosyllabic words, disyllabic words and multisyllabic words is shown in section 4.2.2.1, section 4.2.2.2 and section 4.2.2.3 respectively.

4.2.2.1 Deleted monosyllabic words

In terms of statistical analysis of deleted monosyllables, because the assumption of homogeneity of variance was not met for the data, $F(9, 30) = 19.82$, $p<.05$, we used Welch's adjusted F ratio and reported it as Welch's $F(9, 11.92) = 8.68$, $p<.05$. The analysis using the Welch test shows that there are significant differences among the twelve syllable types in deleted monosyllabic words. Additionally, results of the

follow-up with Duncan's multiple range test are shown in Table 4.11.

Table 4.11 Duncan's Multiple Range Test for deleted monosyllables

Duncan grouping	Mean	N	Deleted monosyllables
A	31.75	4	CV
B	13.00	4	CGV
B	7.50	4	GV
B	4.75	4	CVG
B	4.50	4	V
B	2.25	4	VG
B	2.00	4	CVN
B	1.75	4	VN
B	0.75	4	GVN
B	0.75	4	GVG
B	0.00	4	CGVN
B	0.00	4	CGVG

According to the above Table 4.11, group A (i.e. CV) is significantly different ($p<.05$) from B group. Nevertheless, the other eleven syllable types which are under the same group B show no significant effect. We can tell that CV is superior to the other syllable types, and statistically significantly different while the other syllable types are not significantly different.

The tokens and percentages of each syllable type in monosyllabic words are presented in the following Table 4.12 and Figure 4.4. The bar graph in Figure 4.4 clearly compares the differences among frequencies of deleted syllable types.

Table 4.12 Tokens and percentages of deleted syllable types in monosyllabic words

Type	**V**	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Tokens	18	127	9	30	7	19	8	52	3	3	0	0
Percentage	6.5%	46.0%	3.3%	10.9%	2.5%	6.9%	2.9%	18.8%	1.1%	1.1%	0.0%	0.0%
Total tokens												276

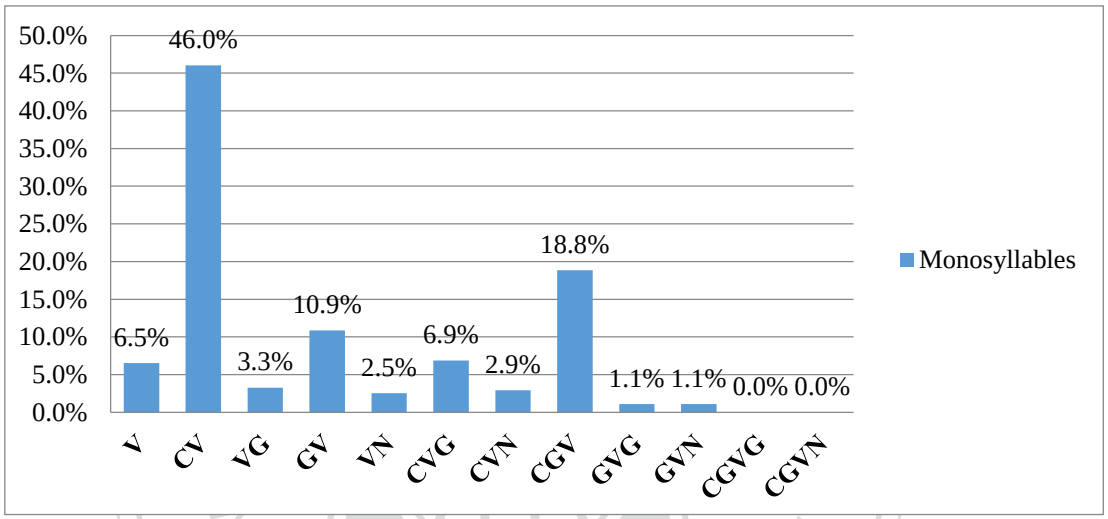


Figure 4.4 Percentages of deleted syllable types in monosyllabic words

Based on the data contained in Table 4.12 and Figure 4.4, the most frequently used syllable type, CV, still has the highest frequency of syllable deleted forms in monosyllabic words, reaching 46.0%. CGV and GV rank second and third, with a usage of 18.8% and 10.9% respectively. As for the least frequently used syllable types, GVG and GVN, they make up than 2% of all monosyllables. The frequency ranking is thus CV > CGV > GV.

It is clearly shown that CV is the most frequently used syllable type in the children's deleted syllable types and overall syllable types; however, the second place

and the third place of each ranking are different. That is, the frequency ranking is CV > CGV > GV for syllable deletion while the ranking is CV > CVG > CGV for overall syllable production.

In order to examine whether there were individual differences among the four children, the frequencies of syllable deletion types in monosyllabic words produced by each child are shown in the following Table 4.13.

Table 4.13 Percentages of syllable deletion types of each child in monosyllabic words

	V	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Child #1	16.7%	25.0%	4.2%	12.5%	10.4%	10.4%	4.2%	8.3%	4.2%	4.2%	0.0%	0.0%
Child #2	5.9%	52.9%	4.2%	10.1%	0.8%	4.2%	2.5%	18.5%	0.0%	0.8%	0.0%	0.0%
Child #3	5.0%	50.0%	0.0%	5.0%	0.0%	20.0%	5.0%	15.0%	0.0%	0.0%	0.0%	0.0%
Child #4	2.2%	47.2%	2.2%	12.4%	1.1%	5.6%	2.2%	25.8%	1.1%	0.0%	0.0%	0.0%

According to Table 4.13, CV is definitely the most frequently used type of all children's deleted forms in monosyllables. Child #1 and child #3 show different syllable patterns compared to the other two children. Firstly, the CV frequencies of child #1 are comparatively lower than those of other children's, only reaching 25.0%. Besides, child #1 preferred V and GV, with a usage of 16.7% and 12.5%. For the least frequently used type, in addition to GVG and GVN, VG and CVN still have the lower frequencies of her syllable deletion pattern. Secondly, child #3 preferred the usages of CVG and CGV, reaching 20.0% and 15.0% respectively. He did not produce VG, VN, GVG and GVN types in the deleted monosyllables. Nonetheless, the other children

show the similar patterns: CV is the most frequently used type, and is then followed by CVG and CVN.

All in all, CV has higher frequencies than the other syllable types in deleted monosyllabic words. For the least frequently used syllable types, although there are slightly different patterns, GVG and GVN generally have lower frequencies among the four children's words.

4.2.2.2 Deleted disyllabic words

On the basis of the statistical analysis of deleted disyllables, because the assumption of homogeneity of variance was not met for the data, $F(9, 30) = 3.32$, $p<.05$, we used Welch's adjusted F ratio and reported it as Welch's $F(9, 11.76) = 3.75$, $p<.05$. The analysis using the Welch test shows that there were significant differences among the twelve syllable types in deleted disyllabic words. Moreover, the results of the follow-up with Duncan's multiple range test are shown in Table 4.14.

Table 4.14 Duncan's Multiple Range Test for deleted disyllables

Duncan grouping	Mean	N	Deleted disyllables
A	121.00	4	CV
B	35.00	4	CGV
B	34.75	4	V
C	19.00	4	GV
C	10.00	4	CVG
C	7.50	4	CVN
C	5.75	4	VN
C	4.50	4	VG
C	2.25	4	GVN
C	2.00	4	GVG
C	0.00	4	CGVN
C	0.00	4	CGVG

According to the above Table 4.14, group A (i.e. CV) is significantly different ($p<.05$) from the B and C groups. We indicate that CV is superior to the other syllable types and statistically significantly different while the other syllable types were not significantly different. The tokens and percentages of each syllable type in deleted disyllabic words are presented in Table 4.15 and Figure 4.5. The bar graph in Figure 4.5 presents the differences among frequencies of deleted syllable types.

Table 4.15 Tokens and percentages of deleted syllable types in disyllabic words

Type	V	CV	VG	GV	VN	CVG	CVN	CGV	GVG	GVN	CGVG	CGVN
Tokens	139	484	18	76	23	40	30	140	8	9	0	0
Percentage	14.4%	50.1%	1.9%	7.9%	2.4%	4.1%	3.1%	14.5%	0.8%	0.9%	0.0%	0.0%
Total tokens												967

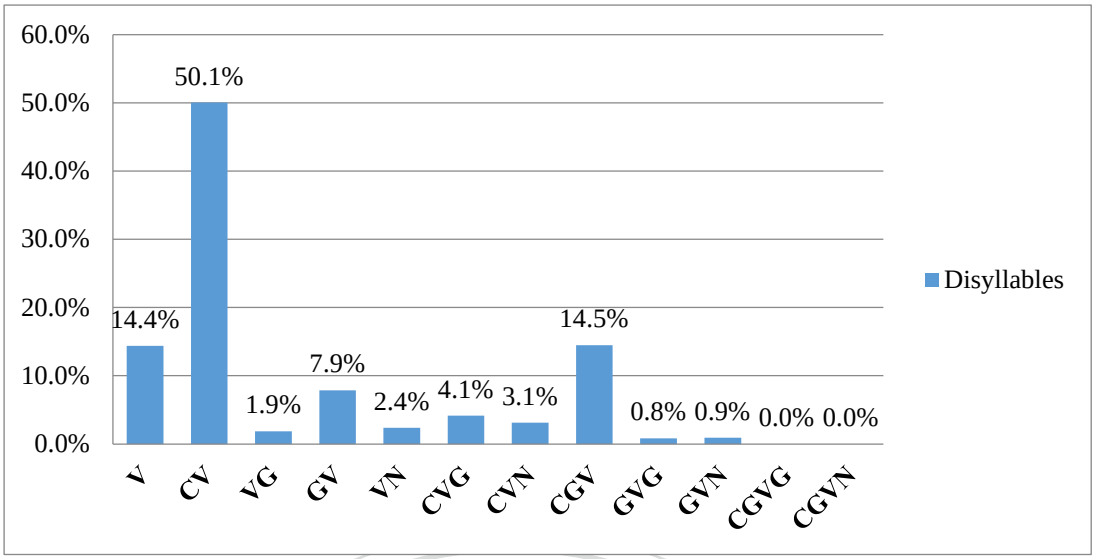


Figure 4.5 Percentages of deleted syllable types in disyllabic words

In Table 4.15 and Figure 4.5, CV is the most frequently used syllable type in deleted disyllabic words, with a usage of 50.1%. Moreover, CGV and V rank second and third place, with a usage of 14.5% and 14.4% respectively. The least frequently used syllable types, GVG and GVN, have the lowest frequencies of deleted syllable types, as deleted monosyllable types. The frequency ranking is thus CV > CGV > V.

Likewise it is clearly demonstrated that CV is the most frequently used syllable type in the children's deleted syllable types and overall syllable types; however, the second place and third place of each ranking are different. That is, the frequency ranking is CV > CGV > V in syllable deletion while ranking is CV > CVG > CGV in overall syllable production.

Furthermore, in order to see whether there were individual differences among the four children, the frequencies of syllable deletion types in disyllabic words produced

by each child are shown in the following Table 4.16.

Table 4.16 Percentages of syllable deletion types of each child in disyllabic words

	V	CV	VG	GV	VN	CVG	CVN	CGV	GVG	GVN	CGVG	CGVN
Child #1	20.1%	24.9%	7.1%	7.7%	11.2%	3.6%	10.7%	11.2%	1.2%	2.4%	0.0%	0.0%
Child #2	11.3%	58.4%	1.0%	12.6%	0.3%	0.0%	0.0%	16.1%	0.0%	0.3%	0.0%	0.0%
Child #3	4.9%	64.9%	0.0%	5.9%	0.0%	9.2%	2.7%	9.2%	1.6%	1.6%	0.0%	0.0%
Child #4	20.1%	46.5%	1.0%	4.3%	1.0%	5.6%	2.3%	17.8%	1.0%	0.3%	0.0%	0.0%

Based on Table 4.16, the most frequently used type, CV, still has the highest frequency of the four children's deleted disyllable types. However, for the second and third ordering, each child has different syllable patterns. The frequency ranking of the production of child #1 was CV > V > VN while the ranking of the production of child #2 was CV > CGV > GV. Child #3 preferred CV, CVG and CGV in the deleted disyllables, but child #4 tended to produce CV, V and CGV instead.

As for the least frequently used syllable types, it can be seen that GVG and GVN have the lower frequencies of the children. In addition, the frequencies of VN, CVG, and CVN of the production of child #2 are low. Child #3 did not produce VG and VN in the deleted disyllabic words, resulting in 0% and 0% respectively.

In summary, CV is the most frequently used syllable type in deleted disyllabic words. For the least frequently used syllable types, although there are slightly different patterns, it seems that GVG and GVN generally have lower frequencies among the four children's deleted disyllables.

4.2.2.3 Deleted multisyllabic words

According to the statistical analysis of deleted multisyllables, because the assumption of homogeneity of variance was not met for the data, $F(9, 30) = 24.38$, $p<.05$, we used Welch's adjusted F ratio and reported it as Welch's $F(9, 11.76) = 6.47$, $p<.05$. The analysis using the Welch test showed that there were significant differences among the twelve syllable types in deleted multisyllabic words. Moreover, the results of the follow-up using Duncan's multiple range test are shown in Table 4.17.

Table 4.17 Duncan's Multiple Range Test for deleted multisyllables

Duncan grouping	Mean	N	Deleted multisyllables
A	50.75	4	CV
B	15.50	4	V
B	13.25	4	CGV
B	8.50	4	GV
B	7.25	4	CVN
B	3.00	4	VG
B	2.50	4	VN
B	1.75	4	GVN
B	1.25	4	CVG
B	0.25	4	GVG
B	0.00	4	CGVN
B	0.00	4	CGVG

According to above Table 4.17, group A (i.e. CV) is significantly different ($p<.05$)

from the B group. The other eleven syllable types which were under the same group B show no significant effect. We may thus ascertain that CV is superior to the other syllable types and statistically significantly different while the other syllable types are not significantly different.

The tokens and percentages of each syllable type in mulitsyllabic words are presented in the following Table 4.18 and Figure 4.6. The bar graph in Figure 4.6 clearly shows the differences among the frequencies of the deleted syllable types in multisyllables.

Table 4.18 Tokens and percentages of deleted syllable types in multisyllabic words

Type	**V**	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Tokens	62	203	12	34	10	5	29	53	1	7	0	0
Percentage	14.9%	48.8%	2.9%	8.2%	2.4%	1.2%	7.0%	12.7%	0.2%	1.7%	0.0%	0.0%
Total tokens												416

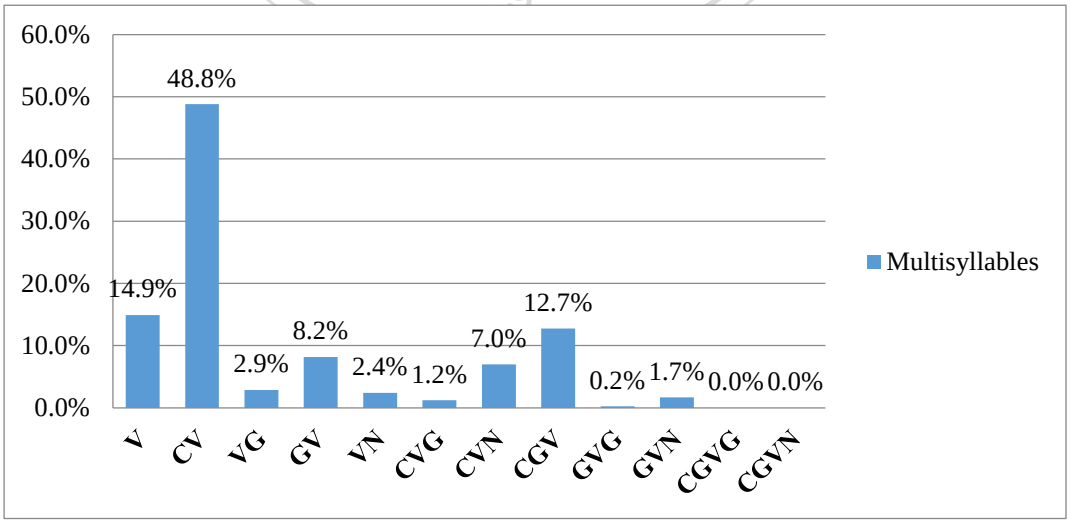


Figure 4.6 Percentages of deleted syllable types in multisyllabic words

Regarding the frequently used types, it is evident that CV still has the highest frequency of all syllable types in deleted multisyllabic words, with a usage of 48.8%. V and CGV rank second and third place, accounting 14.9% and 12.7% respectively. In terms of the least frequently used syllable types, GVG and CVG have the lowest frequencies of deleted syllable types. The frequency ranking is thus CV > V > CGV.

Obviously, CV is the most frequently used syllable type in the children's deleted mulitsyllable types. But the second place and the third place of each ranking are different: the frequency is CV > V > CGV in syllable deletion while the ranking is CV > CVG > CVN in overall syllable production.

In order to tell whether there were individual differences among the four children, the frequencies of syllable deletion types in multisyllabic words produced by each child are shown in the following Table 4.19.

Table 4.19 Percentages of syllable deletion types of each child in multisyllabic words

	V	**CV**	**VG**	**GV**	**VN**	**CVG**	**CVN**	**CGV**	**GVG**	**GVN**	**CGVG**	**CGVN**
Child #1	22.8%	28.1%	7.0%	8.8%	10.5%	1.8%	14.0%	3.5%	1.8%	1.8%	0.0%	0.0%
Child #2	11.5%	52.6%	1.3%	7.7%	0.6%	0.6%	0.6%	21.2%	0.0%	3.8%	0.0%	0.0%
Child #3	12.7%	41.7%	1.4%	12.5%	1.4%	2.8%	4.2%	22.2%	0.0%	0.0%	0.0%	0.0%
Child #4	16.7%	56.8%	3.8%	6.1%	1.5%	0.8%	12.9%	1.5%	0.0%	0.0%	0.0%	0.0%

According to Table 14, the most frequently used type, CV, has the highest frequency out of the four children's deleted disyllable types. Nevertheless, child #1 and child #4 presented similar syllable patterns in this analysis while child #2 and child #3 showed

similar patterns. The frequency rankings for child #1 and child #4 are CV > V > CVN. The other two children showed similar patterns: CV is the most frequently used type, and is then followed by CGV and V. For the less frequently used syllable types, GVG and GVN have relatively low frequencies among all syllable types. Child #3 and child #4 did not even produce these two types. Moreover, the frequencies of VN, CVG and CVN were also low in the production of child #2. It seemed that there were slightly different syllable patterns produced by the young children.

In conclusion, CV is the most frequently used syllable type in deleted multisyllabic words. The unmarked syllable CV is obviously the most frequently used type for the four children to produce since they would tend to omit the segment in complex syllable types to become simple syllable types as simplification strategies.

4.3 Patterns of syllable deletion in syllable positions

According to the previous sections revealing the different frequencies of syllable types, the rankings of overall syllable types and syllable deletion types show slightly different patterns, but CV still has the highest frequency of all the utterances. However, when we carefully investigated every syllable deletion of the children's utterances, we found that four children would reduce the segments in every syllable position. No vowel reduction occurred because the nucleus is obligatory in every syllable whereas the initial, the medial and the ending are all optional in Mandarin.

In order to examine whether the syllable positions affect the syllable deletion, we analyzed the syllable positions of each syllable in the children's production. In this study, the glides [j] and [w] are of primary interest since the glide [ɥ] did not always appear in children's production system. During the observation, there are three categories of syllable positions (initial, middle and final positions) and three categories of syllable structures (C, N and G). The tokens and percentages of deletion in different syllable positions are shown in the following Table 4.15. Furthermore, the bar graph in Figure 4.7 compares the difference of the deletion in each syllable position.

Table 4.15 Patterns of syllable deletion in different positions

	Initial Consonant	**Final Nasal [n]/[ŋ]**	**Prenuclear Glide [j]**	**Prenuclear Glide [w]**	**Postnuclear Glide [j]**	**Postnuclear Glide [w]**
Tokens	312	432	131	162	182	463
Percentage	18.5%	25.7%	7.8%	9.6%	10.8%	27.5%
Total tokens						1682

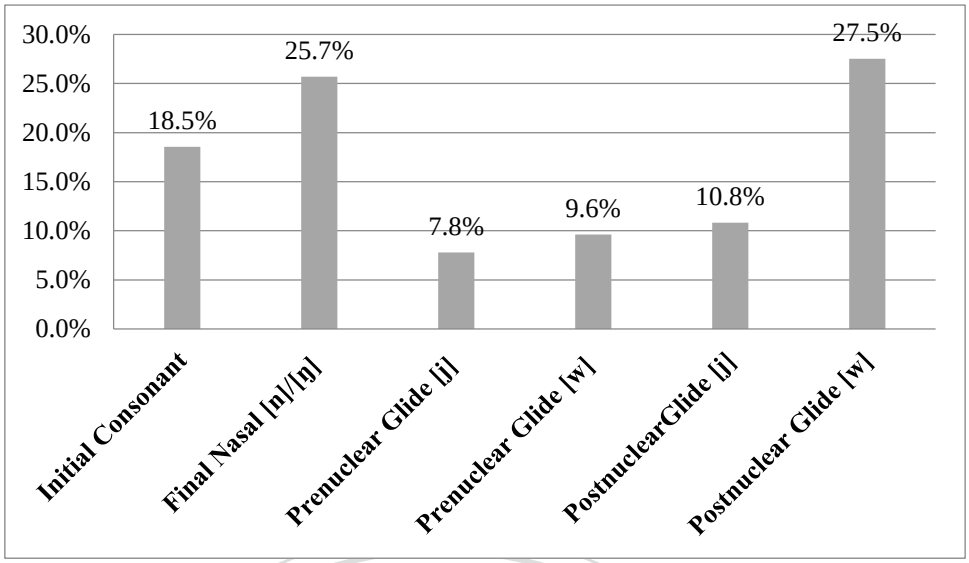


Figure 4.7 Percentages of syllable deletion in different positions

Based on Table 4.15 and Figure 4.7, we can see that children tended to produce the reduced syllable forms, especially the deletion of the postnuclear glide [w] and the final nasal [n]/ [ŋ]. The deletion of the posnuclear glide [w] has the highest percentage of all deletion categories with 27.5%, and is followed by nasals (N) in syllable-final position, which account for 25.7%. This indicated that children frequently omitted the segments which were the glide [w] and the nasal in the syllable-final position. Besides, the deletion of the initial consonant ranks as the third most frequently used deletion category with 18.5%.

However, the deletion of prenuclear glides [j] and [w] makes up the smallest percentage of all deletion categories with 7.8% and 9.6% respectively. In terms of syllable positions, the children were less likely to drop the segments in the prenuclear position or syllable-initial position. Moreover, the deletion of prenulcear and

postnuclear glides [j] has a lower frequency in the children's productions, as compared to the glides [w]. We can see that the children had a tendency to omit the postnuclear glide [w] while keeping the glide [j] in their young productions.

In order to see whether there were individual differences between the participants, the frequencies of deletion patterns produced by each child were also calculated and analyzed, and this is shown in Table 4.16 and Figure 4.8.

Table 4.16 Percentages of syllable deletion patterns of each child

	Initial Consonant	**Final Nasal [n]/[ŋ]**	**Prenuclear Glide [j]**	**Prenuclear Glide [w]**	**Postnuclear Glide [j]**	**Postnuclear Glide [w]**
Child #1	44.9%	19.7%	2.2%	19.3%	5.5%	8.4%
Child #2	11.6%	29.6%	8.4%	7.4%	14.9%	33.3%
Child #3	8.2%	23.9%	10.1%	11.9%	9.3%	36.6%
Child #4	18.9%	26.9%	9.3%	6.5%	10.5%	28.0%

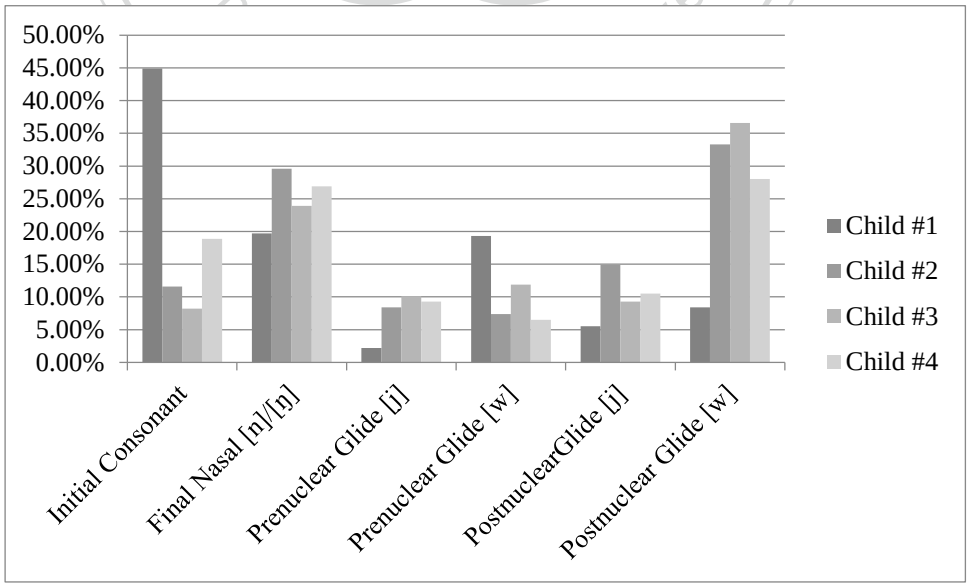


Figure 4.8 Percentages of syllable deletion patterns of each child

Based on Table 4.16 and Figure 4.8, the frequencies of each deletion pattern are calculated separately as different categories, but are put together in the same graph for easier comparison. It can be clearly seen that the four children had a tendency to delete segments in every syllable position. The patterns of the three children's deletion are similar. Child #2, child #3 and child #4 were strongly likely to omit the glide [w] occurring in the syllable-final positions in their speech productions. The pattern of the postnuclear glide [w] has the highest frequency with around 30%. The deletion of final nasal [n]/ [ŋ] ranks as the second frequently used pattern in the children's productions.

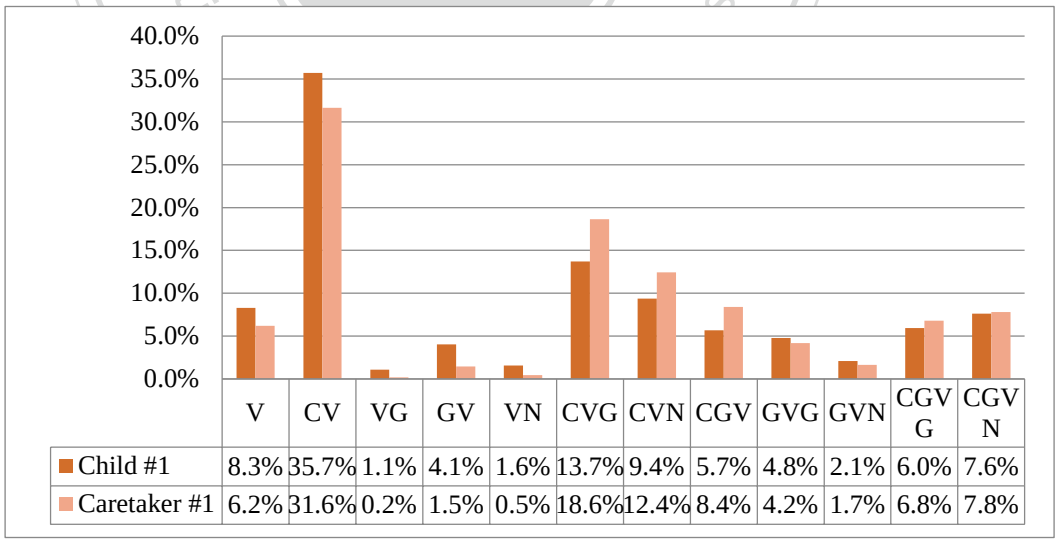
However, child #1 presented a slightly different pattern compared to the other children. She preferred the deletion of consonants in the syllable-initial positon, with a usage of 44.9% of all categories, and then followed by the deletion of final nasals and the prenuclear glide [j] coming in at 19.7% and 19.3% each. Hence, according to the syllable positions, the deletion of glide ([j] and [w]) shows a higher percentage in initial positions, and the deletion of prenuclear glide [w] occurs more frequently.

Accordingly, the four children would delete the different segments in every syllable position. It is interesting to note that the children had slightly different syllable deletion patterns in their immature language stages. Three children preferred the deletion of the postnuclear glide [w] and the final nasals [n] and [ŋ] while the

fourth tended to produce the deletion of initial consonant and the final nasals [n] and [ŋ]. Although the presented results indicated that the four children's syllable deletion patterns were exhibited differently, they still tended to drop the segments in their early stages of speech development.

4.4 Syllable relationship between children and caretakers

As previously stated, the results show the unmarked syllable type CV has the highest frequency in the production of the children's overall production and syllable deletion analysis. This following analysis demonstrates the syllable relationship between the child and his/her caretaker and whether the child's syllable productions would be affected by the caretaker's input. The percentages of the overall syllable production of each caretaker-child are shown in the following figures.



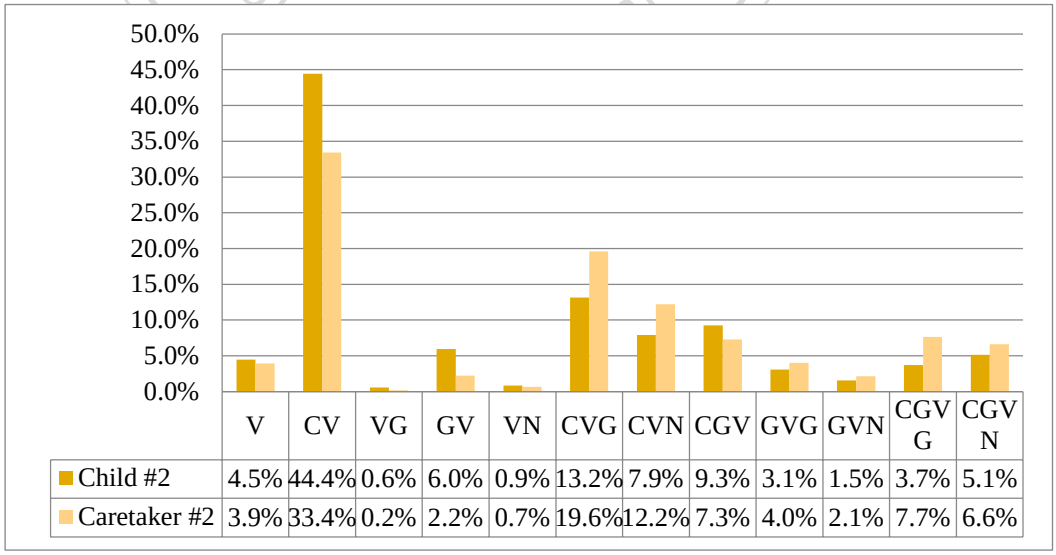
	V	CV	VG	GV	VN	CVG	CVN	CGV	GVG	GVN	CGVG	CGVN
Child #1	8.3%	35.7%	1.1%	4.1%	1.6%	13.7%	9.4%	5.7%	4.8%	2.1%	6.0%	7.6%
Caretaker #1	6.2%	31.6%	0.2%	1.5%	0.5%	18.6%	12.4%	8.4%	4.2%	1.7%	6.8%	7.8%

Figure 4.9 Percentages of syllable types of child #1 and caretaker #1

According to statistical analysis, there is a positive correlation between the

syllables of child #1 and the syllables of caretaker #1, r =.96, p<.05. The percentages are statistically significant. Based on Figure 4.9, CV is the most frequently used syllable type produced by child #1 and caretaker #1; the frequencies of CV were reported as 35.7 % and 31.6 % respectively. CVG ranks second place in their productions, with a usage of 13.7% and 18.6% of utterances. The ranking of frequencies of syllable types is thus CV > CVG > CVN. However, for the least frequently used types, VG and VN occur less frequently in speech productions. When caretaker #1 used certain syllable types more often, child #1 would be affected and produce certain syllable types more frequently. Thus, their results show that the syllable patterns of child #1 have been largely influenced by her caretaker.

The following Figure 4.10 presented the comparison of syllable patterns between child #2 and caretaker #2.

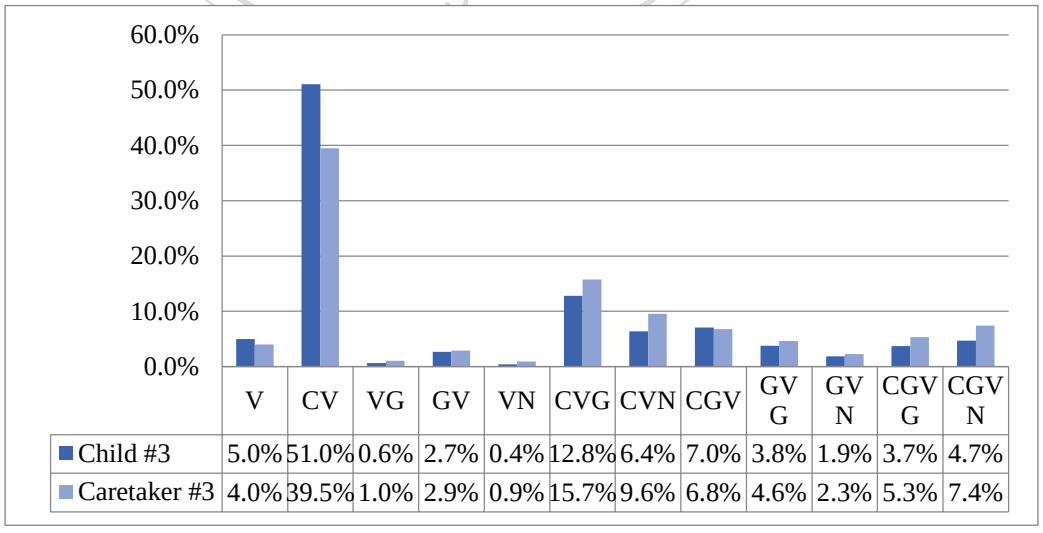


	V	CV	VG	GV	VN	CVG	CVN	CGV	GVG	GVN	CGVG	CGVN
Child #2	4.5%	44.4%	0.6%	6.0%	0.9%	13.2%	7.9%	9.3%	3.1%	1.5%	3.7%	5.1%
Caretaker #2	3.9%	33.4%	0.2%	2.2%	0.7%	19.6%	12.2%	7.3%	4.0%	2.1%	7.7%	6.6%

Figure 4.10 Percentages of syllable types of child #2 and caretaker #2

According to the statistical analysis, the syllable types of child #2 and caretaker #2 are significantly correlated, r =.94, p<.05. The percentages are proven to be statistically significant. As displayed in Figure 4.10, CV is the most frequently used syllable type produced by child #2 and caretaker #2; the frequencies of CV are reported as 44.4 % and 33.4 % respectively. Additionally, CVG ranks second place in both their productions, with a usage of 13.2% and 19.6% of utterances. The most frequently used syllable types are CV, and followed by CVG. The least frequently used types, VG and VN, appear least frequently in word productions. When caretaker #2 used certain syllable types more often, child #2 would be affected and produce certain syllable types more frequently. Thus, their results show that syllable patterns of child #2 have been largely influenced by caretaker #2.

The following Figure 4.11 presents the comparison of syllable patterns between child #3 and caretaker #3.

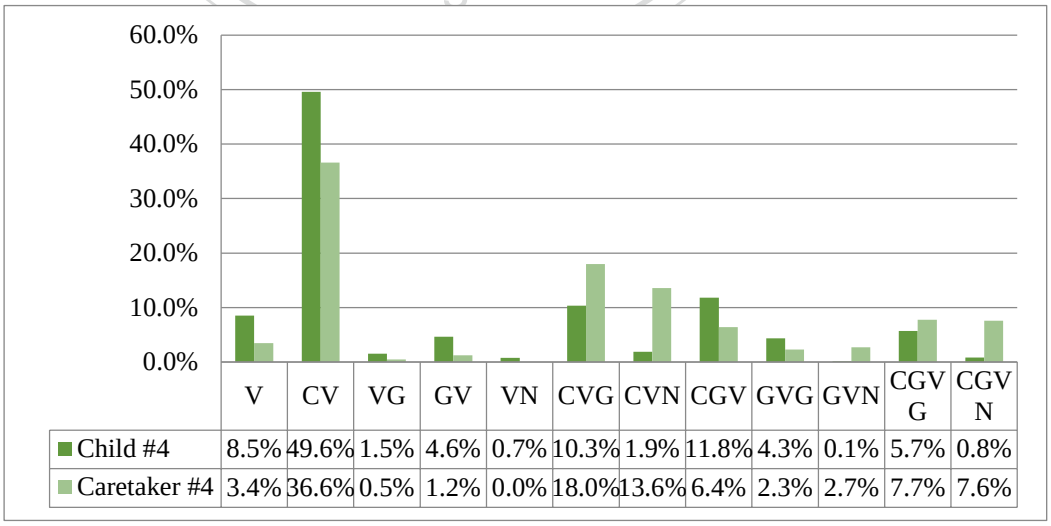


	V	CV	VG	GV	VN	CVG	CVN	CGV	GVG	GVN	CGVG	CGVN
Child #3	5.0%	51.0%	0.6%	2.7%	0.4%	12.8%	6.4%	7.0%	3.8%	1.9%	3.7%	4.7%
Caretaker #3	4.0%	39.5%	1.0%	2.9%	0.9%	15.7%	9.6%	6.8%	4.6%	2.3%	5.3%	7.4%

Figure 4.11 Percentages of syllable types of child #3 and caretaker #3

According to the statistical analysis, the syllable types of child #3 and caretaker #3 are significantly correlated, r =.98, p<.05. The percentages are proven to be statistically significant. As demonstrated in Figure 4.11, CV is obviously the most frequently used syllable type produced by child #3 and caretaker #3; the frequency of CV is reported as 51.0 % and 39.5 % respectively. Besides, CVG ranks second place, with a usage of 12.8% and 15.7% of the utterances. The most frequently used syllable types are CV, followed by CVG. For the least frequently used types, both VG and VN appeared least frequently in their productions. As caretaker #3 used certain syllable types more often, child #3 would be influenced and produce certain syllable types more frequently. Consequently, the findings show that the syllable patterns of child #3 still have been largely influenced by caretaker #3.

The following Figure 4.12 presents the comparison of syllable patterns between child #4 and caretaker #4.



	V	CV	VG	GV	VN	CVG	CVN	CGV	GVG	GVN	CGVG	CGVN
Child #4	8.5%	49.6%	1.5%	4.6%	0.7%	10.3%	1.9%	11.8%	4.3%	0.1%	5.7%	0.8%
Caretaker #4	3.4%	36.6%	0.5%	1.2%	0.0%	18.0%	13.6%	6.4%	2.3%	2.7%	7.7%	7.6%

Figure 4.12 Percentages of syllable types of child #4 and caretaker #4

According to the statistical analysis, there is a positive correlation between the syllable patterns of child #4 and the syllable patterns of caretaker #4, $r = .88$, $p < .05$. The above percentages are proven to be statistically significant. Based on figure 4.12, CV is the most frequently used syllable type produced by this child-caretaker pair; the frequencies of CV are reported as 49.6 % and 36.6 % respectively. However, the second ranking and third ranking were CGV and CVG for child #4 while the ranking was CVG and CVN for caretaker #4. Furthermore, for the less frequently used types, GVN, VN and CGVN occurred less frequently in the production of child #4; VG and VN appeared less frequently in the production of caretaker #4. This child-caretaker syllable patterns are slightly different, but their patterns are still positively correlated. While caretaker #4 used certain syllable types more often, child #4 would be affected and produce certain syllable types more frequently. Hence, their results show that syllable patterns of child #4 have largely been influenced by caretaker #4.

To sum up, for the four child-caretaker pairs, the results are significantly correlated respectively. The child's syllable pattern is positively correlated with his/her caretaker's syllable pattern; thus, we may deduce that young children's phonological systems are influenced by the caretakers' outputs.

Chapter 5

Discussion and conclusion

5.1 Summary of the findings

In this study, syllable acquisition by four Mandarin-speaking children aged between 0;10 and 2;6 is observed. Two aspects are included: the overall syllable types and patterns of syllable deletion. We calculated the frequencies of each syllable type in overall syllable production and deleted syllable production, and analyzed the deletion pattern of each syllable type. There were a total number of 16515 syllable tokens analyzed in the study. The findings are summarized in the following Table 5.1.

Table 5.1 Ranking of used syllable types patterns of each child

Overall Syllable type frequency	Monosyllable: CV > CVG > CGV
	Disyllable: CV > CVG > CGV
	Multisyllable: CV > CVG > CVN
Syllable deletion frequency	Monosyllable: CV > CGV > GV
	Disyllable: CV > CGV > V
	Multisyllable: CV > V > CGV
Patterns of syllable deletion	Postnuclear glide [w] > Final nasals [n],[ŋ] > Initial consonant > Postnuclear glide [j] > Prenuclear glide [w] > Prenuclear glide [j]
Child-caretaker syllable relationship	Child #1 – Caretaker #1: positively correlated Child #2 – Caretaker #2: positively correlated Child #3 – Caretaker #3: positively correlated Child #4 – Caretaker #4: positively correlated

(1) Frequency of overall syllable types: For four children's overall syllable production, CV has the greatest frequency of occurrence. The frequency rankings for monosyllables and disyllables are CV > CVG > CGV, with two open syllables and one closed syllable; and the ranking for multisyllables is CV > CVG > CVN, with one open syllable and two closed syllables. The syllable patterns in monosyllables were similar with the patterns in disyllables. The third ranking in multisyllables was different from the rankings in monosylables and disyllables. Generally, four children frequently use CV and CVG syllable types in the productions. The results of overall syllable types present that the children preferred unmarked syllable type, especially CV at an early age.

(2) Frequency of syllable deletion: the frequency ranking of syllable deletion is CV > CGV > GV in monosyllabic words, and the frequency ranking is CV > CGV > V in disyllabic words. Moreover, the frequency ranking is CV > V > CGV in multisyllabic words. This indicates that open syllable types are preferred, but closed syllable types occur less frequently. Furthermore, CV has the highest frequency of occurrences in children's syllable deletion production due to the fact that the children tend to omit the more complex and difficult syllable types to simpler syllable types.

(3) Patterns of syllable deletion: the syllable deletion patterns show that the children are likely to drop segments in initial-, middle-, or final-syllable position. They tend to produce the form with the deletion of postnuclear glide [w] and final nasal [n]/ [ŋ]. The deletion of posnuclear glide [w] has the highest percentage of all deletion categories with 27.5%, and is followed by nasals in the syllable-final position, which accounted for 25.7%. It is indicated that children frequently omit the segments in the syllable-final position with the glide [w] and the nasals. The deletion of prenuclear glides [j] and [w] has the least percentage of all deletion categories with 7.8% and 9.6% respectively. According to the analysis of individual differences, child #1 has the greater tendency to reduce the consonants in the syllable-initial positions, with a usage of 44.9%. However, Child #2, child #3 and child #4 are strongly likely to omit the postnuclear glide [w]. The pattern of postnuclear glide [w] has the highest frequency with around 30% of all categories.

(4) Child-caretaker syllable relationship: the statistical analysis shows that there is a positive correlation between the child's syllable types and his/ her caretaker's syllable types. For children's syllable pattern, CV is obviously the most frequently used syllable type, and is followed by CVG. For caretakers' syllable patterns, CV, CVG and CVN have higher frequencies. As the caretaker uses certain syllable

types more often, the child will produce those types more often. That is, this indicates that child's syllable patterns may be influenced by his/her caretaker's linguistic production.

5.2 Discussion on syllable analysis

This study aims to investigate the patterns of overall syllables types and syllable deletions in Taiwan Mandarin-speaking children. Since young children's productions of words are immature and unstable, they tend to use many different phonetic forms and drop the segments in the outputs. Syllable acquisition and syllable deletion can be attributed to many factors, including markedness factors, frequency effects, perception and production accounts (e.g., Ingram 1986; Echols, 1993; MacNeilage & Davis, 1993; Stites et al, 2004; Ota, 2006). In this study, the relationship between syllable type frequency and syllable deletion as well as the child-caretaker syllable relationship are carefully examined.

5.2.1 The overall syllable types

For the four children's speech productions, CV and CVG types have higher frequencies in overall syllable types while VG and VN have lower frequencies. On the one hand, in terms of the syllable types with higher frequency, CV and CVG syllable types are syllables which consist of onset consonants and do not contain consonant clusters. The results show that the frequently used syllable types generally

accord with the unmarked syllable criterion proposed by Jakobson (1968). Although CVG ranks as the second most frequently used type and it is not a complete open syllable, this type with the onset consonant and without the consonant cluster is considered to be a simple syllable type for the children. On the other hand, CV and CVG also have the higher frequencies in the caretakers' syllable productions. The frequency effect can also account for the results (e.g., Ingram, 1988; Chen & Kent, 2005, 2010; Ota, 2006). That is, a target phonological structure produced by a young child is closely related to the input frequency. It is indicated that the ambient languages may influence young children's syllable structures.

However, VG and VN have the lowest frequency of the four children's production. They are closed syllables among the twelve syllable types in Taiwan Mandarin and they do not have the onset consonant. Although they have relatively simple structure compared to CGVG or CGVN, they are the two syllable types without onset consonant and are regarded as the difficult and marked syllable types. Moreover, in terms of markedness theory, the more marked syllable types would be acquired later because young children would display unmarked linguistic structure first (Jakobson, 1968). Accordingly, because VG and VN are the more marked syllable types, young children would acquire these difficult types during the latter course of development (H. Y. Wang, 2014). Nevertheless, CGVG and CGVN

consisting of the consonant cluster do not have the lowest frequency of all utterances. The reason may be due to the fact that the age ranges during the observation. After the age of two, words learned and produced by the children are more complex so that the frequencies of CGVG and CGVN are not the lowest in the data. Thus, syllable types with the lowest frequency may also be consistent with the constraints mentioned above, including the closed syllable, the syllable without onset, and syllable contained consonant cluster which are more marked syllable types.

5.2.2 The syllable deletion types

According to results of syllable deletion in monosyllables, disyllables and multisyllables, CV, CGV and V are the frequently used syllable types among twelve types. CV still has the highest frequency in syllable deletion words, and is then followed by CGV and V in the production of four children. They are the syllables, which include onset consonant and do not contain consonant clusters and codas. Among syllable types used by children, it is clearly shown that the unmarked syllable CV is the most frequently used type since young children would tend to omit the segments in complex syllable types to become simple syllable types. As a result, the more unmarked syllable types are likely to be used in children's early immature speech.

In terms of the syllable deletion forms, the children tend to use a coda-dropping

strategy to produce reduced words in phonological development (Levitt & Aydelott Utman, 1992; So & Dodd, 1995; Tsay, 2007). The results show that CV is the most frequently used syllable type produced by four children in overall production and syllable deletion productions. The findings are consistent with the study of McCarthy and Prince (1994), who proposed that children's early words are governed by highly-ranked No-Coda constraints. For instance, complex target forms are easily to be realized as CV depending on the relative ranking of faithfulness constraints on the realization of segments. Hence, it may be predicted that CV syllable type is the most common outputs of syllable errors in children's speech.

However, for least frequent syllable types of syllable deletion forms, the frequencies of GVG, GVN, VG and VN have the low frequencies among all the deleted syllable types. The frequencies of GVG and GVN account for less than 2% of the total, being only 0.7% and 1.1% respectively. These less frequently used syllable types are closed syllables and VG and VN and thus have no onset consonant, so these syllable types appear less frequently then open syllables. These results may due to the fact that Mandarin severely limits the possible coda consonants. Some studies of syllable omission in Mandarin have claimed that open syllables are more likely to undergo phonetic reduction as opposed to closed syllables (Cheng & Xu, 2009; Burchfield & Bradlow, 2014). As a result, the findings are in accordance with

previous studies, indicating that languages favoring coda-less syllables may show overall higher rates of phonetic deletion

5.2.3 The syllable deletion patterns

In terms of the pattern of syllable deletion, the four children were likely to drop the segments in the syllable-final position than syllable-initial and syllable-middle position. On the one hand, the deletion of the glide [w] in syllable-final position has the highest percentage of all the deletion categories, and is then followed by the nasal [n] and [ŋ] in syllable-final position whereas the percentage of the prenuclear glide [j] and prenuclear glide [w] have the least frequencies of all categories. This deletion pattern is consistent with previous studies, demonstrating that young children show limited ability at final consonant production in syllable-final position (Fee & Ingram, 1982; Demuth & Johnson, 2003). Demuth and Johnson (2003) also proposed that because young children's phonological system is unstable and immature, they are inclined to drop word-final segments and produce the targets as CV words or truncated words. On the other hand, it seemed that the glide [j] in the syllable-final position does not explained by the coda-dropping strategy because the percentage of postnuclear glide [j] has the second last frequency of all categories. But, the reason may be due to the fact that the young children seldom produced the target words which contained the postnuclear glide [j]; hence, the syllable deletion of postnuclear

glide [j] occurred less frequently in the analysis.

Nevertheless, when carefully examining each child's deletion patterns, we can observe that child #1 tended to reduce the segments in the syllable-initial position rather than in the syllable-final position. The deletion of initial consonant had the highest percentage of her all reduction categories, and was then followed by final nasals and the deletion of prenuclear glide [w]. The initial consonant deletion is also in accordance with the studies of Zhu and Dodd (2000) and Tsay (2006), who claimed that young children are likely to omit the syllable-initial consonant in their early phonological acquisition. Young children are expected to delete some components such as syllable-initial consonant at the syllable level. The syllable-initial consonant deletion is very common in young children's data (Zhu & Dodd, 2000).

In general, although there are individual differences in terms of dropping the segments in positions, young children still have undergone the syllable deletion in their immature productions. Thus, the findings of syllable deletion pattern may indicate that children tend to reduce the consonants and glides in every syllable position.

5.2.4 The syllable relationship between children and caretakers

Based on the results of children's overall syllable production pattern, CV is obviously the most frequently used syllable type, and is then followed by CVG. For

caretakers' syllable patterns, CV, CVG and CVN have higher frequencies in the results. According to the statistical findings, the syllable types of the four child-caretaker pairs are positively correlated. The two highest ranking of frequencies of syllable types were CV and CVG in the productions of pair #1[3], pair #2 and pair #3. VG and VN had the least frequencies in the production of pair #1, pair #2 and pair #3. Nevertheless, pair #4 presented slightly different patterns from the other pairs. Child #4 used CV and CGV more frequently but used GVN and CGVN less frequently; caretaker #4 produced CV and CVG more frequently but VN and VG appeared less frequently. One possible reason for there being slightly different syllable patterns may lies in the individual differences (Levelt et al., 2000). The children may exhibit individual differences in the productions, preferring the different complexity of the syllable types in the syllable-initial or the syllable-final.

Nevertheless, with regard to the syllable patterns of the four children-caretakers, the results are significantly correlated. In general, our findings are congruent with those previous studies (e.g., de Boysson-Bardies & Vihman, 1991; Chen & Kent, 2005; Zamuner et al., 2005; Ota, 2006). The ambient language can be observed from children's final consonant production in their early stages (de Boysson-Bardies & Vihman, 1991). Moreover, the finding of Chen and Kent (2005) indicate that young

[3] In order to be succinct, the following child-caretaker relationship would be marked as a "pair" (e.g., pair #1 referring to child #1 and caretaker #1).

children's syllable productions are relevant to their caretakers. Children's phonological productions may be influenced by the overall productivity and the phonetic content of the ambient language. Furthermore, it can be reasoned that a young child produces a target phonological structure which is strongly related to the input frequency (Ota, 2006). To conclude, the findings lend some credence to the accounts that children's syllable patterns have largely been influenced by their linguistic environment (i.e. caretakers' speech).

5.3 Conclusion

The aim of the present study is to explore young children's syllable acquisition and deletion form composed the words in terms of frequencies and patterns. Children's overall syllable patterns, syllable deletion patterns and the child-caretakers' syllable relationship were examined. From the analysis and discussion of the four children acquiring Taiwan Mandarin, the unmarked syllable type (i.e. CV form) has the highest frequency in the analyses of overall syllable types and syllable deletion types respectively. The more marked and complex syllable structures occur less frequently in the young children's early production.

At early stage in phonological development, since the children's word productions are immature and unstable, they tend to use many different phonetic forms to reduce a word in speech development. The segments in the syllable-initial,

syllable-middle and syllable-final positions can be omitted. We can observe that children tend to delete the postnuclear glide [w] and the final nasal [n]/ [ŋ] in the productions, indicating that the segments in the final positions seem to be more difficult for children to produce. As young children's phonological systems are immature, the patterns of syllable deletion would occur. Presumably, if their phonological systems become stable and mature, the occurrences of syllable deletion patterns would decrease accordingly.

Concerning the analysis and discussion, the findings can be accounted for markedness theory proposed by Jakobson (1968) and frequency effects (e.g., Ingram, 1988; Zamuner et al., 2005). On the one hand, the children's most frequently used syllable is CV, and is then followed by CVG. Since these two types are syllables which contain onset consonant and do not contain consonant clusters, they are considered to be simple and unmarked syllable types for the children. The more unmarked syllable types occur more frequently in young children's speech. Furthermore, syllable types contain more complex structure, that is, a more marked syllable, may occur less frequently in the children's words. On the other hand, comparison of frequency effects presented that the child-caretaker has the positive correlation. Children general have the similar syllable patterns with their caretakers, suggesting that the children are sensitive to ambient language at an early age. It may

be beneficial for future word to trace patterns of syllable deletion for more participants, for longer duration, and examine the age range of each participant's syllable production.

Finally, we hope that this study may shed light on several issues to the process and pattern of syllable acquisition and syllable deletion of Taiwan Mandarin in the longitudinal observation.

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