國立政治大學語言學研究所碩士論文

National Chengchi University

Graduate Institute of Linguistics

Master Thesis

指導教授：萬依萍 博士

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台灣華語正常及構音異常幼童之習得現象:滑音產製研究

Phonological Development and Disorder in Taiwan Mandarin: The Status of Glides

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中華民國一〇五年六月

June, 2016

Phonological Development and Disorder in Taiwan Mandarin:

The Status of Glides

BY

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A Thesis Submitted to the
Graduate Institute of Linguistics
in Partial Fulfillment of the
Requirements for the Degree of
Master of Arts

June 2016

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致謝詞

回首在政大語言所三年來奮鬥的點點滴滴，有相當多的回憶及感激，尤其論文將近完成之際，愈是會回想起剛開始摸索的過程。一本論文的誕生，不是單靠一個人自己的力量就可完成。首先，我要感謝我的指導教授萬依萍老師，感謝老師在論文撰寫的過程中不斷地指引我方向，逐字逐句地修改我的內文，並且花時間與我討論，在我口試緊張焦慮時，也不時地幫我加油打氣，給我信心。同時也很感謝美麗又溫柔的甯俐馨老師和謝佳玲老師擔任我論文的口試委員，針對我的論文給我相當多的回饋和建議，真的很謝謝老師們細心和耐心地指導。

在研究所就讀的三年期間，感謝每一位教導過我的教授們。謝謝為教室帶來歡樂的蕭宇超老師，幽默風趣又瀟灑的何萬順老師，如同仙女下凡般的黃瓊之老師，冰山美人徐嘉慧老師，和藹可親的張郇慧所長，謝謝各位老師帶我們探索語言學各個領域的奧妙，讓我對語言學的各領域有更多的理解。

另外我要感謝三年來跟我一起奮鬥的同學們，在每一次一起修課的過程中都充滿歡笑和活力。感謝大學時期跟我一起奮鬥的戰友旻欣，熱心助人常常提供給大家許多資訊，跟你一起騎車上學的日子真的超級開心，也感謝直腸直肚的曉婷，每次跟你聊天都好好笑，還有最可靠神人唐馬克，總是給我帶來無盡歡笑和學術上的建議，另外還有外務超多跨領域的楊媜媞，跟我一起在語音實驗室奮鬥的庭瑄和欣瑩，感謝你們這麼罩，互相幫忙，提供各方面的意見，最後要特別感謝在我論文統計上給我強力協助的孟璋學長，謙虛卻又實力堅強。

最後，我要感謝從小扶養我長大的阿公阿嬤和在求學路上一路支持我的父母，以及在我生活崩潰時給予我精神上陪伴的姐姐和妹妹，沒有你們在我背後做我的強力後盾，我的研究生活沒辦法這麼順利完成。另外也要感謝 Logan So 在碩三這一年給我加油打氣，以及資料分析上的莫大的幫助，有你們的陪伴，我感到無比幸運!

2016/7/14

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國　立　政　治　大　學　研　究　所　碩　士　論　文　提　要

研究所別：語言學研究所

論文名稱：台灣華語正常及構音異常幼童之習得現象:滑音產製研究

指導教授：萬依萍 博士

研究生：許馨云

論文提要內容：(共一冊，22,658 字，分五章)

本篇論文檢視台灣華語為母語之正常幼童以及構音異常幼童之滑音[j], [w], [ɥ]發展與產製表現，採長期觀察之方式，詳細描述正常幼兒滑音產製之出現及穩定年齡、頻率、正確率和發展順序，並且比較此三滑音於各音節位置之產製表現，進而比較兩組幼童之台灣華語滑音產製及音韻歷程之使用行為。本研究以標記理論及位置層級理論來檢驗幼兒滑音之發展與表現。

本研究總共觀察了四位幼童，將其分為兩組，第一組為兩位正常幼童，年齡在九個月至二十八個月和十個月至二十九個月，為期十九個月的觀察，另一組為兩位構音異常幼童，年齡在三歲十個月至四歲三個月和四歲三個月至四歲九個月，為期六個月的觀察。每兩週收錄一次長達一小時之語料，並利用錄製之高規格影音檔做譯寫及分析。

研究結果顯示，正常幼兒之滑音出現順序和穩定順序皆符合標記理論之預測，無標音早於有標音，其滑音產製之穩定度與音節位置相關，音節首位之滑音表現較音節中與音節末之滑音表現來的穩定，這與位置層級理論之推測相符合。構音異常幼童組中發現了有別於正常幼童之特殊取代模式，由較晚習得語音取代較早習得語音，其所產製的語音中會違反華語的音法限制。音韻歷程之表現在兩組幼童中皆偵測到刪除、換位、取代三種模式，其中皆以刪除為主要策略。

關鍵詞:滑音習得、標記理論、位置層級理論、台灣華語

Abstract

The purpose of the present study is to report the developmental process of three Mandarin glides [w, j, ɥ] in terms of three word positions by examining the age of emergence and stabilization, the order of stabilization, and accuracy rate of the children's production, and further compare the normative data with phonological disorder data in order to explore the possible phonological processes. This study also accounts for the developmental process of glides on the basis of markedness theory and positional prominence hierarchy.

A longitudinal study was carried out for the investigation of two normally-developing children, aged between 0;9-2;4 and 0;10-2;4, and two phonologically-disordered children, one of whom is between 4;3 and 4;9, and the other between 3;10 and 4;3. The data were collected at two-week intervals.

The results showed that the order of glide emergence and stabilization of the normally-developing group is in accordance with the markedness theory. The unmarked [j], [w] precede marked [ɥ]. Moreover, the stabilization order of the three glides in terms of the three syllable positions was found to reflect the interaction between markedness constraint and positional prominence hierarchy. The unmarked glide in the initial position is the first to stabilize and the marked glide in the non-initial position is the last to stabilize. On the other hand, the children in the phonologically-disordered group were found to consistently replace the presumably earlier-developing glide with a presumably later-developing one, which differs from the process used in the normally-developing group. Furthermore, this group of children produced the combination that violates the phonotactic constraints of Taiwan Mandarin. In addition, there are three phonological processes, including deletion, metathesis, and substitution detected in children's data. The most commonly used process is deletion in both groups of children.

Keywords: glide development, markedness, positional prominence hierarchy, Taiwan Mandarin

Chapter 1

Introduction

The phonological acquisition of consonants in young children has been well studied cross-linguistically through different approaches. Researchers have investigated the phonological development of young children for a long period of time so as to uncover the universal tendencies and language-specific patterns. The findings reported were mostly in accord with Jakobson's proposals (1914/1968) on the universal patterns of phonemic acquisition, suggesting that phonological development follows the universal patterns across languages. The early sounds acquired are the unmarked forms and unmarked features, which include nasals, stops, and front consonants. Jakobson's theory of phonological development seems to be based on the presumption that all the phonemes were acquired in all positions simultaneously, regardless of the positional differences. The phonological development of English phones in relation to word positions was described in Stoel-Gammon (1985). The results were found to accord with Jakobson's.

In addition, the fact that positional factor plays a vital role in sound production has been supported by both internal and external evidence. The syllable initial position is considered to be more prominent than other positions, and therefore, is more resistant to sound change whereas the coda position is later acquired since it involves a more complex syllable structure and is less prominent compared to the initial position (Demuth *et al*., 2006; Kirk & Demuth, 2006; Jiménez & Lloret; 2013). Furthermore, the fact that the different articulatory gestures and timing involved in the same segment in different positions might increase the difficulty of the production is attested in previous research (Krakow, 1989; Gick; 2003; Kochetov, 2006).

1.1 Segmental acquisition of glides

Regarding the development of glides [w] and [j] in English, previous studies conducting cross-sectional studies suggested that the labiovelar phoneme /w/ was acquired before the palatal glide /j/. The /w/ was acquired at around 3-year-old and /j/ at around 4-year-old (Wellman *et al*., 1931; Poole, 1934; Templin, 1957; Smit, 1990). However, other researchers suggested the opposite order. The findings in Prather's (1975) study, an opposite order on the acquisition of /w/ and /j/ was found, suggesting that the palatal /j/ was acquired prior to the labiovelar /w/. Furthermore, the study showed that the subjects acquired both /w/ and /j/ phoneme at a relatively young age (before 3-year old) comparing to the others. The gender differences were found in Smit's (1990), suggesting that girls acquired the /j/ sound by 4 years old, but the boys did not acquire the /j/ sound until they reached the age of 5. On the other hand, the longitudinal studies of a simple case or a small number of children indicated that the labiovelar glide [w] occurred before two-year-old while the [j] sound did not appear before age two. Moreover, the sounds in the initial position are the most stable whereas the glides in word-medial positions are prone to errors (Smith, 1973; Stoel-Gammon; 1985).

Glides [j, w, ɥ] in Mandarin are allophonic variants of three high vowels /i, u, y/ that are allowed to occur syllable-initially, after the initial consonant, and syllable-finally, forming initial consonants, prenuclear glides, and postnuclear glides. Among the three glides, only the labiopalatal glide [ɥ] does not occur in postnuclear position. The status of the prenuclear glides has long been an interest of several studies in terms of syllable structure (Lin, 1989, 1990; Bao, 1990; Duanmu, 1990;

Wan, 1997, 2003; Wang & Chang, 2001). Although the status of glides caused a lot of debates in Mandarin, the development of glides could only be found in few studies. Previous research accounted for Mandarin glide development in terms of diphthongs and triphthongs in vowel development. The results showed that the high front unrounded [i] was acquired error-free and relatively early and the high front rounded [y] and high back rounded [u] vowels were later acquired (Li, 1977; Jeng, 1979; Su, 1985). Lin and Lin (1993) suggested that Mandarin vowels, including diphthongs and triphthongs, were acquired before 3-year-old in Taiwan, except for the high front rounded vowel [y]. They reported children did not master the high front rounded vowel [y] until the age of 3;5. Moreover, diphthongs were found to reduce to simple vowels by dropping the onglide and offglide, retaining the most sonorant vowel within a sequence (Li, 1977; Jeng, 1979; Su, 1985, Zhu, 2000). However, the development of Mandarin glides was concerned in the development of vowel combinations, and therefore the behavior and development of Mandarin three glides [w, j, ɥ] in terms of three positions are not thoroughly inspected.

1.2 The phonetic and phonemic approaches

Psychologists and linguists have examined the patterns and sequences of child phonological acquisition for several decades, in hopes of unveiling the mystery of the language behavior and the complicated mechanisms involved in learning processes of human beings. In terms of speech production, there are two common ways, including phonetic and phonological analyses. A phonetic analysis which describes phones with regard to articulatory, acoustic, and auditory focuses on physical movements involved in the production of speech, physical properties, and speech perception of listeners, while a phonological analysis is concerned with the classification and organization of phonemes of a given language and dedicated to investigating the inventory of phonemes and their patterns of occurrence (Stoel-Gammom and Dunn, 1985; Ladefoged and Johnson, 2014). Dodd *et al*. (2003) as well pointed out the two-way distinctions in relation to the discussion of sound acquisition, including a phonetic approach and a phonemic approach. The phonetic approach focuses on the speech sound production, which refers to articulatory and motor skills involving production process whereas the phonemic approach examines functions, behaviors, and organization of the speech sound system. Most of the studies adopted the phonemic approach, with which researchers are required to determine two criteria for acquisition of phonemes: (1) whether a sound has to be produced correctly in all word positions (word-initial, word-medial and word-final) or only in word-initial and word-final position is to be determined. (2) what is the required minimum percentage of children of an age group who can produce a sound correctly as defined in the first criterion (Dodd *et al*., 2003)? Early works on phonological development of English children adopted the classical approach, which focuses on the age of mastery of individual phonemes. In the classical approach, a segment was considered acquired when it was accurately produced word-initially, word-medially, and word-finally by a certain percentage of the subjects (Wellman *et al*., 1931; Poole, 1934; Templin, 1957). For example, Poole (1934) investigated sounds acquisition in terms of the three word positions with an accuracy rate of 100% as the minimum percentage for the acquisition standard, while others, like in Wellman *et al*. (1931) and Templin (1957), the required accuracy rate for the acquisition standard of a particular sound is 70%.

The classical approach was criticized by Sander (1972) since it only reflects upper age limits for sound mastery instead of accounting the average performance of phoneme development. He then proposed the age of customary production, referring to the age level at which the correct production in at least two of three positions exceeds 50%, and the mastery of production, which was defined as the age at which the subjects achieve 90% of correct production in all positions. Furthermore, in Zhu's (2002) study, the distinction between phoneme emergence and phoneme stabilization was discussed, in which the former refers to at least one correct production of a sound, irrespective of the target, and the latter refers to correctly producing a sound on two of three opportunities.

1.3 Phonologically-disordered children

Linguistic theories on language acquisition should be able to account for both normative data as well as the disorder data. The importance of investigating and further comparing the data of normally-developing children and those who exhibit phonological disorder help construct a better view of child development and provide a better explanation for the reference in speech pathology. According to Shriberg

(1982), children with speech disorder do not form a homogeneous group. Previous research has proposed four subgroups for distinguishing children with speech disorder. Based on Bradford and Dodd (1994), the four subgroups include Articulation impairment, Delayed phonological skills, Consistent deviant disorder, and Inconsistent speech disorder.

The difficulty in perception and production of sounds in certain positions and different phonological processes were not only discussed in normally-developing children but also children with phonological disorder. Grunwell (1987) characterized disordered phonology based on structure, the complexity of which lead to simplified word shapes. Regarding the phonological patterns, several researchers detected a few odd processes used by the phonologically-disordered children. They tended to replace the presumably earlier-developing sounds with the later-occurring sounds (Lorentz, 1974; Grunwell, 1981; Weiner, 1981; Leonard, 1985). The glides performance of Mandarin phonologically-disordered children examined previously suggested a similar phonological process found in that of normally-developing children. The prenuclear glides and postnuclear glides are subjected to deletion process (Wu, 1999;

Zhu, 2000).

Although a few studies dedicated to the investigation of the development of glides both in normally-developing children and phonologically-disordered children, some aspects still remain unanswered. Therefore, this study hopes to provide a detail investigation of the acquisition of glides in terms of various positions in normally-developing children and further compare the glide performance of the normative and phonological disorder data through longitudinal observations.

1.4 Research questions

The purpose of the present study is to report the developmental order of three Mandarin glides [w, j, ɥ] in terms of three word positions, word-initially, word-medially, and word-finally, and further compare the normative data with phonological disorder data in order to explore the possible different process between the two groups of children. The development of the three vocalic vowels [i, u, y] is excluded in this study since the present study is only concerned with the performance of the phonetic surface forms, that is, the three glides [w, j, ɥ]. A longitudinal study was carried out for the investigation of two normally-developing children, one of which aged between 0;9-2;4 and the other aged between 0;10-2;5; two phonologically-disordered children, one of whom is between 4;3 and 4;9, and the other between 3;10 and 4;3.

Three research questions addressed are as follows:

1. Regarding the emergence of the three Mandarin glides [w, j, ɥ] in normally-developing children acquiring Taiwan Mandarin, at what ages do they emerge in terms of various syllable positions? In what order do the three glides emerge? In which position does each glide appear first?

2. Concerning the acquisition of the three Mandarin glides [w, j, ɥ] in normally-developing children acquiring Taiwan Mandarin, at what ages do the three glides become stabilized in terms of three syllable positions? In what sequence are they acquired? In which position do the glides become stabilized first and in which position are the glides prone to errors? What are the phonological processes involving glides used by this group of children?

3. In the light of phonologically-disordered children acquiring Mandarin, is there any odd pattern detected in glide production? What phonological processes are

involved in the production of the children? What are the differences of glides performances between the normally-developing children and phonologically-disordered children?

1.5 The framework of this study

The framework of this study is presented as follows. Chapter one provides a general overview of the research background of glides development in terms of phonetic and phonemic approaches. Three research questions are addressed in this chapter. Chapter two reviews on the phonological development of glides in both normally-developing children and phonologically-disordered children, and will have a literature review on Mandarin Phonology, including consonants, vowel inventories, and phonological accounts in terms of phonological representation and phonotactic on Mandarin glides. In addition, the phonological acquisition theories regarding Markedness theory and Positional effects and Positional prominence hierarchy will also be described. Chapter three contains two main parts. The first part is concerned with data collection, including the background of the subjects, data collecting procedures, and the recording equipment involved. The second part is concerned with data analysis. The methods to data transcription and the criteria adopted for the assessment of the development of the glides in terms of various positions are provided under this section. Chapter four presents the results found in the study. Regarding the normally-developing children, the emergence and the stabilization of the three glides in terms of various positions and the accuracy rate of the glides in relation to the various positions are shown. Furthermore, the accuracy rate of each glide of the phonologically-disordered children and the preference of the phonological are presented. Chapter five provides the theoretical account for the development of glides and a brief summary of the results in response to the three research questions addressed in this study.

Chapter 2

Literature review

In this section, the phonological development of glides in both normally-developing children and phonologically-disordered children will first be reviewed in section 2.1. Mandarin Phonology will be presented in section 2.2, including consonant and vowel inventories in 2.2.1 and phonological accounts in terms of phonological representation and phonotactic on Mandarin glides in section 2.2.2 and 2.2.3. Finally, the phonological acquisition theories regarding Markedness and Positional effects and Positional prominence hierarchy will be displayed in 2.3.

2.1 Phonological development of glides

In this section, the acquisition of glides in both normally-developing children and phonologically-disordered children are displayed in 2.1.1. Section 2.1.2 presents normally-development and phonologically-disordered children acquiring glides in Mandarin.

2.1.1 Glides acquisition of normally and phonologically-disordered children

Considering the acquisition of sounds, researchers have studied more on consonant acquisition rather than vowels as the process of constructing consonant system involves more complicated motor skills and normally takes up a long period of time (Smith, 1976). Comparing with the research on the acquisition of stops, fricatives, and affricates, fewer studies discussed on the acquisition process of glides. Previous researchers who dedicated to examining the phonological development of English phonemes carried out cross-sectional studies. The review on the development of glides of the five studies examining English young children recruited from different areas is listed in Table 2.1 (cf., Dodd *et al*., 2003).

Table 2.1 An overview of studies on English glide phonemes (Dodd *et al*., 2003)

	Wellman *et al*. (1931)	Poole (1934)	Templin (1957)	Prather *et al*. (1975)	Smit *et al*. (1990)
Subjects	204	65	480	147	997
Age range	2;0-6;0	2;6-8;6	3;0-8;0	2;0-4;0	3;0-9;0
Word-position	I, M, F	I, M, F	I, M, F	I, F	I, F
% age group	75%	100%	75%	75%	N/A
[w]	3	3;6	3	2;8	3
[j]	4	4;6	3;6	2;4	4 (girl)/ 5 (boy)

Notes:

1. For the row word position, I, M, and F refer to word-initial, -medial, and –final positions.
2. % age group refers to the minimum percentage of children of an age group required in deciding the acquisition of phoneme.
3. In the results section, Smit *et al*. (1990) list different age of acquisition for some of the phonemes at different word positions.

The five studies adopted the phonemic approach in investigating sound development in English children. The differences between them include subject number, age range, numbers of word positions and the percentage of an age group considered for the acquisition standard. For the three oft-cited studies (Wellman, 1931; Poole, 1934; Templin, 1957), all word positions were taken into account, while in Prather *et al*. (1975) and Smit *et al*. (1990), only two positions were considered in the studies. The criteria of 75% age group in deciding the acquisition of phoneme were adopted in Wellman (1931), Templin (1957), and Prather *et al*. (1975), whereas Pool (1934) adopted a stricter standard for determining the acquisition of a phoneme, 100%. The differences in the findings might be resulted from the various criteria and the methods employed in these studies.

Early work on phoneme acquisition adopted the classical approach (Wellman, 1931; Poole, 1934; Templin, 1957). Wellman (1931) studied 204 children from the

University of Iowa Laboratory Preschools, aged from 2;0-6;0. In total, 133 sounds were examined in the three positions, word-initially, word-medially, and word-finally. The data were collected by spontaneous speech or imitation. The minimum percentage of children of an age group required in deciding the acquisition of the phoneme was 75%; in other words, 75% of the children of an age group were required to have mastered a sound in three positions for a sound to be considered acquired. The results showed that [w] was acquired earlier than [j], for the former was acquired at the age of 3 and the latter was not acquired until the age of 4. Poole (1934) recruited 65 children between 2;6 and 8;6 of age at the laboratory schools of the University of Michigan. In total, 23 consonants were tested in the three positions, word-initially, -medially, and -finally. The speech mode includes both spontaneous speech and imitations. In her study, the assignment of a sound to an age level required 100% of the children to utter correctly in all three syllable positions. The results of the age acquiring glides found in Poole (1934) were 6 months later than those of Wellman (1931) in both [w] (3;6) and [j] (4;6). Templin (1957) conducted an experiment by investigating 480 children, consisting of 240 boys and 240 girls, ranging from 3 to 8 years with similar socioeconomic status. Of the 480 subjects, 58 were excluded since they did not complete all of the tests. The subjects were tested on 176 sound elements in the initial, medial, and final positions. Moreover, different words were used for children 3 to 5 and children 6 to 8. Both the repetition data and spontaneous picture identification utterances were obtained for the data analysis. The assignment of the developmental age level required 75% of the subjects of a group to have mastered a sound. The finding of labiovelar [w] is identical with that of Wellman *et al*. (1931), indicating that children acquired [w] at the age of 3, but in Templin's (1957), the [j] sound was acquired at the age of 3;6, earlier than the findings in Wellman *et al*. (1931). Sander (1972) reanalyzed Templin's (1957) and Wellman *et al*.'s (1931) data for average age estimates and upper limits of customary consonant usage he proposed. The former refers to the ages at which correct production reach 50% and the latter refers to the ages at which correct production reach 90% in all positions. He found that the average age estimates and the upper age limits for [w] sound were before two years old and at three years old. In other words, the children reached 50% correct production of [w] sound before two years old and did not attain 90% correct production until age three. In addition, the average age estimates and upper limits for the sound [j] were 2;6 and 4;0. Prather *et al*. (1975) adopted both the classical and distinctive feature approaches attempting to inspect 147 subjects between the ages of 2 to 4 years. The subjects were selected from the study for Sequenced Inventory of Communication Development in Seattle (Hedrick *et al*., 1975). The subjects were asked to name pictures spontaneously and repetition was requested when needed. Moreover, assignment of a sound to an age level demands the accurate usage in only two positions by 75%, word-initial and word-final positions. In contrast to the previous studies, Prather *et al*. (1975) reported that [w] and [j] were assigned to 2;8 and 2;4 respectively, differing from the order found in previous studies, in which the labiovelar [w] was acquired prior to the palatal [j]. Smit (1990) analyzed the production data of 997 children age 3 to 9 gathered from Iowa Nebraska. Two word positions, word-initial and word-final were considered in the study. The assessing instrument contained 80 photographs and 108 phoneme targets. The imitation production was avoided unless the target sounds were not elicited. The study further tested on the urban-rural distinction as well as gender differences. The results suggested that the urban and rural distinction did not play a role in the acquisition process whereas gender seemed to exert a great difference. The girls acquired the [j] sound by 4 years old, but the boys did not acquire the [j] sound until they reached the age of 5. In more recent studies, Dodd *et al*. (2003) collected 684 children, aged between 3;0 to 6;11 years, from nurseries and schools in eight different areas of the UK. The study reported on two aspects of speech development, inclusive of the age at which a sound is correctly pronounced (phonetic acquisition) and the accurate production of a phoneme in terms of word contexts and the percentage of children of an age group reaching the level of accuracy (phonemic production). The subjects were asked to name 30 pictures for articulatory assessment and 50 pictures for error type assessment. Both word-initial and word-final positions were taken into account. A 90% criterion was adopted for the assessment of phonetic acquisition. Moreover, three factors influencing the process of speech development were discussed, including age, gender, and socioeconomic status. They found that [w] and [j] reached the acquisition criterion at the group of 3;0-3;5. Furthermore, they concluded that age and gender affect speech development while socioeconomic status did not play a prominent role in speech development.

The acquisition process of sounds involves complicated processes and therefore progress gradually within a long period of time (Olmsted, 1971). For the purpose of tracking sequential development of particular children and identifying the individual variations performed in different children, researchers preferred longitudinal observations to cross-sectional experiments. Given much data on consonant acquisition, the data of glide could only be drawn from few studies. Smith (1973) conducted a case study via observing his son, Amahl, acquiring English from the age of 26 months until four-year-old. In most cases the data were spontaneous utterances produced by Amahl. The production forms of Amahl were clearly listed in Appendix C, from which we found the error productions of [w] and [j]. The sound [w] occurred relatively early with fewer errors like [vaif] for ‘wife’. In contrast, the [j] sound appeared to display various forms, as in yellow [lɛlo]/[dɛlo]/[ɛlo] and yes [ḍɛt]/[rɛt]. Furthermore, he pointed out that the complexity of syllable structures might bring about increasing error rate in reduction error type, suggesting that glides and liquids[1] which attach to the first consonant in a syllable are subjected to reduction; in other words, glides are likely to be omitted in word-medial positions (Smith, 1973). Stoel-Gammon (1985) analyzed longitudinal samples of meaningful speech of 34 normally-developing children involving 19 boys and 15 girls from Seattle area. The data were collected at 3-month intervals between 9 months to 24 months of age. The spontaneous speech was limited to the subjects who had reached the onset of meaningful speech. The onset of meaningful speech referred to the age at which subjects reached 10 different word types during an hour recording session. In addition to age of emergence, the order of appearance of phones in terms of different positions and a given position was investigated. The results implicated that the [w] sound occurred before age of 2 based on the criterion of 50% of the subjects producing the sound. However, the [j] sound did not appear in half of the subjects' inventories before 2-year-old.

Linguistic theories on language acquisition should be able to account for both normative data as well as disorder data. The importance of investigating and further

[1] The glides will be the focus of this paper.

comparing the data of normally-developing children and those who exhibit phonological disorder help construct a better view for child development and provide a better explanation for the reference in speech pathology. Regarding glides development in phonologically-disordered children, very few reported on the performance of glides. The few studies presented the performance of glides in English phonologically-disordered children have shown that they tended to replace the presumably earlier-developing sounds with the later-occurring sounds (Lorentz, 1974; Grunwell, 1981; Weiner, 1981; Leonard, 1985). Lorentz (1974) analyzed a 4-year-old child, who replaced the labiovelar glide [w] with a liquid [l] in the C_2 position in a sequence of C_1C_2 clusters such as [tlɛl] for *twelve*. Weiner (1981) also found this unusual process from the observation of a child at the age of 4;3, replacing the consonants in the initial position with the later acquired sounds, interdental voiceless [θ] and voiced [ð]. For example, the [j] sound in the word *young* and the [w] sound in the word *wagon* were replaced with interdental fricative [θ]. A similar process was found in the data presented in Grunwell (1981), who studied a phonologically-disordered child, age 6;3. Several unusual behaviors were found in the child's data. The child produced interdental fricative [ð] as an alternative for all adult forms involving fricatives, liquids, and glides in the initial position as in the word *yellow* [ðɛʔdʊŋ]. Stoel-Gammon & Dunn (1985) identified seven idiosyncratic processes that occur in the speech of phonologically-disordered children and the one that is relevant to the study is that glides were replaced with stops[2] (i.e., [wɪl] 'will' → [bɪl]).

There are a few cross-linguistics studies in relation to the development of glides in phonologically-disordered children. Dodd & So (1995) discovered a few odd substitution patterns of glides in 17 monolingual Cantonese-speaking children with phonological disorder aged between 3;6 to 6;4. The results described that the palatal [j] and labiovelar [w] were replaced by glottal fricative [h] and nasal stop [m] respectively. The inconsistent initial consonant reductions were identified in velar stop [k] and palatal [j] and cluster reductions did not show a consistent pattern. Two cases such as [kw]→ [f] and [k^hw] being omitted were presented in the study. In the first case, [f] replaced [kw] in the initial position and in the second case, the CG [k^hw]

[2] The rest of the processes include *Atypical Cluster Reduction, Initial Consonant Deletion, Glottal Replacement, Backing, Fricatives substituted for stops,* and *Sound preference*.

was omitted. Golstein (2005) examined the substitution patterns in 39 typically developing Spanish-speaking children, ranging from 3;2-4;11, and 39 Spanish-speaking children with phonological disorders between the age of 3;1 and 4;9, from Puerto Rico. The accurate percentage and substitutions tokens of each sound were listed, in which we found that typically developing children performed glides with high accuracy rate. The labiovelar [w] was produced without any errors and only three error tokens for palatal [j], showing the accuracy rate of 97.89%. The substitutes include the segments [t, h, ɾ]. However, the subjects with phonological disorders demonstrated a few substitution patterns for labiovelar [w] and palatal [j]. They used the segments [b, m, d] as the substitutes for labiovelar [w] once within all the data. On the other hand, the substitutes for palatal [j] were labiovelar [w] (3 tokens), the segments [b, t, d] (2 tokens each), and the segments [g, f, tʃ, m, n] (1 token each).

2.1.2 Glide development in Mandarin children

Unlike the glide development in English was mostly described in the acquisition process of consonants, the acquisition process of glides in Mandarin was discussed through the acquisition of vowels as the glides in Mandarin are widely considered to be the allophonic variants of the three high vowels [i, u, y], creating vowel combinations, that is, diphthongs and triphthongs. Li (1977) observed a boy, aged between 2;0 and 3;0, and a girl, aged between 1;1 and 1;8. The findings showed that the corner vowels [i] and [u] were acquired without errors. Jeng (1979) examined one boy aged between 2 months and 1;8 and the other boy aged between 1;3 and 2;7 for testing on the Jakobson's laws of irreversible solidarity. The findings suggested that high front vowel [i] was acquired earlier than rounded back vowels [u] and [y]. Su (1985) studied two Mandarin-Taiwanese bilingual aged 1;5 to 2;4 and 1;2 to 1;11. The results reported that the order of three high vowel development is as follows: [i] → [u] → [y], in which high front unrounded [i] was acquired earlier than the high back rounded [u], followed by the high front rounded [y]. These studies have agreed on the development of diphthongs were acquired later than the monophthongs. Moreover, the acquisition processes of diphthongs and triphthongs involving /i, u, y/ demonstrate the stage of deletion, addition and were substituted with single vowels before their stabilization (Chao, 1951; Li, 1977; Jeng, 1979; Su, 1985). Furthermore, children employ deletion at early stages and the substitution occurred later. In contrast, the addition strategy does not appear frequently in young children's production errors. Hsu (1987) found that children acquiring Mandarin developed monophthongs first, followed by the diphthongs [aj, ej, ɑw, ow]. The last acquired were rhymes ending in nasals [an, ən, ɑŋ, oŋ], which refers to the combinations of a vowel followed by a nasal coda. Lin & Lin (1993), who investigated young children acquiring Mandarin in Taiwan, suggested that 15 vowels, including monophthongs [i, u, a, ɔ, ɤ, ɛ, ɝ], diphthongs [aj, ej, ɑw, ow] and rhymes ending in nasals [an, ən, ɑŋ, oŋ] were acquired by 90% criterion before 3-year-old, except for the rounded vowel [y]. They reported children do not master the vowel [y] sound until the age of 3;5.

Zhu (2000) adopted a view that Mandarin vowel system consists of nine surface forms, which contain nine monophthongs /i, y, u, ɤ, o, ɑ, ə, ɛ, ɚ/, nine diphthongs /ae, ei, ɑo, ou, ia, iɛ, uɑ, uo, yɛ/, and four triphthongs /iɑo, iou, uae, uei/. She examined the phonological development of Mandarin young children by conducting both cross-sectional study and a longitudinal one. In total, 129 normally-developing children aged from 1;6 to 4;0 were recruited in Beijing for the cross-sectional study and four Mandarin-speaking young children aged 1;0 to 2;0 were observed for the longitudinal study. Regarding the vowel development in her cross-sectional study on normally-developing children, she found that they tended to reduce triphthongs and diphthongs into diphthongs and single vowels respectively. The most frequent deleted sequence of triphthong was [iɑo], simplified by 37% of the subjects, in which 29% replaced it with [ia] and only 8% replaced it with [ɑo]. Another frequently reduced sequence was [uei], simplified by 10% of the subjects, in which 7% of them were reduced to [ei]. On the other hand, diphthongs were found to reduce to simple vowels by dropping the onglide and offglide, retaining the most sonorant vowel within a sequence. Aside from the cross-sectional study, the results found in longitudinal study showed that [ei] and [iou] emerged first among all diphthongs and triphthongs, but the [yɛ] combination was the last sound to appear.

The findings suggested by the previous research seem to imply that children encounter difficulty in producing onglide and offglide in triphthongs and diphthongs, producing the subtracted forms of vowels until 4 years of age. However, the study did not discuss the onglide and offglide separately since they were regarded as a whole of vowel combinations. Therefore, the performances of onglides and offglides were not clearly discussed and remained for further inspection.

In relation to the performance on glides in Chinese-speaking children with phonological disorder, Wu (1999) described two young children, aged 2;11 and 5. From the data presented in their word inventory, the younger children performed several errors containing glide deletion in both word-medial and word-final positions and substitution in word-initial position. For example, the child deleted final labiovelar [w] in [jaw] ‘want’ and palatal [j] in [pej] ‘cup’. The word [tɕ^{h}jow tɕ^{h}jow] ‘ball’ was produced as [tɔ tɔ], in which both the prenuclear glide and postnuclear glide were reduced. Moreover, the initial glide in [ɥɛ] ‘moon’ was replaced with [j]. The data collected from the 5-year-old showed a similar process. Glides were reduced in both medial and final positions, as in [kɔ pa] for [ʂow p^{h}a] ‘handkerchief’, [pi pɔ] for [p^{h}iŋ kwɔ] ‘apple’, and [ka ja] for [t^{h}aj jɑŋ] ‘sun’. Zhu (2000) as well reported that Mandarin-speaking children with phonological disorders demonstrated diphthongs and triphthongs reductions and addition as well as vowel change. For example, [kwaj] becomes [paj], showing the substitution of the initial consonants and the deletion process of medial glide [w].

2.2 An introduction to Mandarin

This section presents an introduction to Mandarin phonology. In section 2.2.1, both consonants and vowels are reviewed, followed by phonological accounts of Mandarin glides in section 2.2.2. Finally, phonotactic of glide sequences are presented in section 2.2.3.

2.2.1 Mandarin consonants and vowels

The possible consonant inventory in Taiwan Mandarin regarding both the place of articulation (horizontal axis) and manner of articulation (vertical axis) based on Lin's (2007) study is presented below in Table 2.1 in International Phonetic Alphabet symbols (IPA), a wildly used system for transcription of speech sounds for all languages. The sounds appear on the left of the subdivided tables are unaspirated voiceless, which share the same features of their corresponding counterparts on the right except for the aspiration feature.

Table 2.2 Mandarin consonants

	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					ʐ				j ɥ	w	
Lateral approximant				l								

Mandarin inventory contains three glides, including palatal [j], labiopalatal [ɥ], and labiovelar [w], which are considered to be the allophonic variants of the three corresponding high vowels [i], [y], and [u] respectively. The cells that contain glides were marked with the shaded color. The representation of glides will be discussed further in section 2.2.2.

In Mandarin, the widely adopted view is the five vowel system. Several researchers posited that the underlying vowel system contains five phonemes, including /i, y, u, ə, a/ (Chao 1968, Cheng 1973, Lin 1989, Duanmu 2002), as displayed in Table 2.4. based on Duanmu (2002).

Table 2.3 Standard Chinese Vowels

high	i	y	u
mid	ə		
low	a		

[i], [u], and [y] are three high vowels in Mandarin, in which [y] is a rounded front vowel. When they occupy the prenuclear position, their corresponding allophones [j], [w], and [ɥ] appear as their surface forms. In other words, Mandarin glides [j], [w], and [ɥ] are believed to derive from the three high vowels. The [i] and [u] can form diphthongs by adding to non-high vowels. Moreover, the mid vowel [ə] is changeable in frontness and rounding features depending on the environment and the low vowel [a] can change in frontness (Duanmu, 2002).

Aside from the underlying five-vowel system, Lin (1989, 2007) presented 13 surface phones of Mandarin vowels. Table 2.5 is based on the study of Lin's analysis (1989, 2007):

Table 2.4 Mandarin surface vowel phones

Classification	**Basic surface phones**	**Other surface variants**
High vowels	[i], [y], [u], [ɿ], [ʅ]	[j], [ɥ], [w] from three high vowels
Mid vowels	[e], [ə], [o], [ɤ]	[ɛ] (variant of [e]), [ɔ] (variant of [o])
Low vowels	[a], [ɑ]	

The Mandarin vowel system including both phonemes and their surface variants shown in the table above is in accordance with the vowel system presented by Wan & Jaeger (2003) from a psycholinguistics perspective on speech errors, in which the distributional evidence unveil the relationship between the underlying phonemic inventory of Mandarin vowels and their corresponding surface variants. Table 2.6 displays the surface phones of vowels in Taiwan Mandarin based on Wan & Jaeger (2003):

Table 2.5 Vowel phones in Taiwan Mandarin (Wan & Jaeger, 2003)

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

In addition, the distinction between the two apical vowels [ɿ] and [ʅ] in Lin's study was not found in the preliminary acoustic inquiry on the data produced by a 21-year old male subject. Thus, the transcription of the apical vowel following the alveolar and the post-alveolar consonants was presented with [ɨ].

2.2.2 Phonological accounts on Mandarin glides

The notion that the Mandarin glides [j, w, ɥ] is not phonemic existing in the underlying representation of Mandarin inventory but rather surface variants derived from the underlying three high vowels /i, u, y/ in Mandarin is widely posited by some researchers (Lin, 1989, 2007; Wu, 1994; Duanmu, 2002; Wan, 2003). In Wan's (2003) demonstrated a detail examination on the status of Mandarin glide from the corpus of speech errors and discovered that the glides interact with vowels more often than with the glides and consonants, indicating that the prenuclear glides in Mandarin are derived from vowels. However, researchers have not agreed on the status of Mandarin prenuclear glides within the discussion of syllable structure. Several studies have discussed on the status of the Mandarin prenuclear glides (Lin, 1989, 1990; Bao, 1990; Duanmu, 1990; Wan, 1997, 2003; Wang & Chang, 2001). Lin (1989, 1990) proposed that the prenuclear glide was neither part of the onset nor part of rime. Rather, it is part of the rhyme projection. She provided evidence of syllable-internal assimilation in backness and rounding of schwa in support of her view on the status of the prenuclear glide. When a schwa is preceded by a high front unrounded /i/ and followed by a high back rounded /u/, regressive assimilation seems to prevail over progressive assimilation, resulting in the backness and rounding of schwa, which shows that the prenuclear glide is not as closely attached to nucleus as postnuclear glide, and therefore lead to the rime projection claim. The examples are given below:

a. /uəi/ → [wej]

b. /iəu/ → [jow]

When /ə/ appear between a prenuclear glide and a postnuclear glide, it always assimilates to the one follows it, indicating that the vowel forms a closer constituent with the postnuclear glide than the prenuclear glide. This evidence provided by Lin is similar to Duanmu (1990), in which six pieces of evidence were given, one of which argued on mid vowel assimilation. Another piece of evidence lies in the fact that the pronunciations of English words are phonetically different from those in Chinese. For example, the pronunciation of [swei] 'sway'is different from [s^wei] 'age' in Standard Chinese. In his study, he suggested that the prenuclear glide is realized as one sound C^G, where G is the secondary articulation of the initial consonant, in other words, the G behaves more like a feature rather than a segment. In Bao's (1990) early work on the discussion of prenuclear glide, he believed that the prenuclear glide within the initial consonant clusters belongs to the onset through examining Chinese language games; however, in his more recent work Bao (1996, 2002), the analysis has changed. He suggested that the status of prenuclear glide is indeterminate since its behaviors in language games and speech errors were not in concordance with each other.

Wan (1997), instead, argued that the prenuclear glide being affiliated with onset or rhyme is "indeterminate" with regard to syllable structure. Her studies on slips analyses provide psycholinguistics evidence for the status of the prenuclear glide, suggesting that the place of articulation of the initial consonant plays a role in the onset-rhyme determination process. The prenuclear glide is regarded as a part of the onset within a syllable when it occurs after an anterior consonant, such as a labial, dental, or retroflexes, while the prenuclear glide which follows a posterior element, such as a palatal and velar, is considered to be a part of the rhyme. Wang & Chang (2001) conducted two phonological experiments, *fanchie* and *anti-fanchie* with a view to examining the status of prenuclear glide. The results showed that prenuclear glides were found to group with rime by the subjects, irrespective of the place of articulation of the preceding consonants, and hence Wan's proposal of Anterior/Posterior dichotomy was not supported in the study.

2.2.3 Phonotactic of glide sequences

The position at which a glide is allowed to occur within a syllable is constrained to the syllable structures in Taiwan Mandarin. In total, twelve syllable types were analyzed as legal structures, including V, CV, VG, GV, VN, CVG, CVN, CGV, GVG, GVN, CGVG, and CGVN. The maximum number of a syllable contains four segments, CGVX, which represents consonant, glide, vowel, and nasal or glide respectively in the sequence as stated in Wan (1999). A table of Mandarin syllable structure concerning word-initial, word-medial, and word-final position of glide is reorganized and presented along with examples in Table 2.6 below:

Table 2.6 Syllable types concerning glide positions in Mandarin

Positions of glide within a syllable	Syllable type	Phonetic Transcription	Gloss
Initial position	GV	[wa55]	to dig
	GVG	[jɑw214]	bite
	GVN	[joŋ51]	to use
Prenuclear position	CGV	[tɕja55]	home
	CGVG	[ɕjɑw214]	small
	CGVN	[pjɛn51]	change
Postnuclear position	VG	[aj214]	short
	GVG	[jɑw214]	to bite
	CVG	[paj214]	white
	CGVG	[ɕjɑw214]	small

In Table 2.6, legal syllable structures are categorized into three groups based on the glide occurring positions within a syllable. The first group contains three syllable types that begin with a glide, including GV, GVG, and GVN. The examples for each syllable type are listed in sequence: [wa55] 'dig', [jɑw214] 'bite', [joŋ51] 'use'; the second group contains three syllables CGV, CGVG, and CGVN, in which glides occur in the medial position, that is to say, the glide is preceded by an initial consonant and followed by a nuclear vowel. The examples are: [tɕja55] ‘home’, [ɕjɑw214] ‘small’, and [pjɛn51] ‘change’; the third group is comprised of four syllable types, inclusive of VG, GVG, CVG, CGVG, in which the glide occurs in the final position of each syllable. The examples presented are: [aj214] ‘short’, [jɑw214] ‘bite’, [paj214] ‘white’, and [ɕjɑw214] ‘small’. Among the three glides [w, j, ɥ], only the high front rounded [ɥ] is not allowed to occur in the final position. The labiovelar [w] and palatal [j] are allowed to occur in the three positions. Nevertheless, the co-occurrence of the vowels with glides is constrained by Mandarin phonotactics. Table 2.7, excerpted from Wan & Jaeger (2003), shows the possible co-occurrence of the twelve vowels [i, ɨ, y, u, e, ɛ, ə, ɔ, ɤ, o, a, ɑ] and the three glides [j, w, ɥ] in Mandarin, with the gaps being shaded.

Table 2.7 Possible co-occurrence of vowels and glides (Wan & Jaeger, 2003)

	i	ɨ	y	u	e	ɛ	ə	ɔ	ɤ	o	a	ɑ
Single												
_(C/G)										ow	aj	ɑw
p, p^h					pej					pow	paj	pɑw
t, t^h					tej					tow	taj	tɑw
k, k^h					kej					kow	kaj	kɑw
f					fej					fow		
s, ts, ts^h					tsej					sow	saj	sɑw
ʂ, tʂ, $tʂ^h$, ʐ					ʂej					ʂow	ʂaj	ʂɑw
ɕ, tɕ, $tɕ^h$												
x					xej					xow	xaj	xɑw
m					mej					mow	maj	mɑw
n					nej					now	naj	nɑw
l					lej					low	laj	lɑw
(C)j_						jɛ jɛn				joŋ jow	ja	jɑw
_(C)ɥ_						ɥɛ ɥɛn						
(C)w_					wej		wən	wɔ		woŋ	waj	

Table 2.7 presents the possible combinations of vowels and glides.[3] The palatal [j] occurs only after [e, a], forming [ej, aj] respectively and the labiovelar [w] follows [o, ɑ], forming [ow, ɑw] combinations. Among the four combinations, only [ej] does not

[3] The original table from Wan & Jaeger (2003) demonstrated a complete possible co-occurrence of Mandarin vowels with all onsets and codas. Table 2.7 only remains the combinations involving vowels and glides.

appear alone. Furthermore, lexical gaps are clearly presented in the table by shaded cells, such as *faj and *fɑw. Alveolo-palatal sounds [ɕ, tɕ, tɕ^h] do not precede [ej, aj, ow, ɑw] directly. The last three rows display the possible co-occurrence of medial glides and codas. In Mandarin, consonant-glide co-occurrence patterns in onset position are strictly limited. A detailed distribution of possible CG sequences can be referred to table 2.8 below based on (Wan, 2003):

Table 2.8 Possible CG sequences (* indicates the CG sequence is not possible) (Wan, 2003)

	Bilabial	**Labial**	**Dental**	**Retroflex**	**Palatal**	**Velar**
Unaspirated plosive	pj, pw		tj, tw			*kj, kw
Aspirated plosive	p^{h}j, p^{h}w		t^{h}j, t^{h}w			*k^{h}j, k^{h}w
Fricative		*fj, *fw	*sj, sw	*ʂj, ʂw *ʐj, ʐw	ɕj, ɕɥ, *ɕw	*xj, xw
Unaspirated affricate			*ts^{h}j, ts^{h}w	*tʂj, tʂw	tɕj, tɕɥ, *tɕw	
Aspirated affricate				*tʂ^{h}j, tʂ^{h}w	tɕ^{h}j, tɕ^{h}ɥ, *tɕ^{h}w	
Nasal	mj, mw		nj, nɥ, nw			*ŋj, *ŋw

Bilabial and dental plosives are allowed to appear with both [j, w] whereas velar plosives are not allowed to co-occur with high front [j]. Moreover, dental and retroflex fricatives and affricates can only be followed by [w] while palatal fricatives and affricates do not form legal CG sequence with it. The high front rounded [ɥ] only follows palatals and nasal [n].

2.3 Phonological acquisition theories

In this section, Markedness theory is reviewed in 2.3.1 and Positional effects and Positional prominence hierarchy discussed by previous studies are presented in section 2.3.2.

2.3.1 Markedness theory

Phonologists have devoted to proposing various phonological acquisition theories to account for the acquisition patterns of young children. The concept of markedness, an essential theory to linguistic system, originates from the language theory developed in Prague School, where the abstract notion of privative oppositions was used for the distinction between phonemes. A privative opposition refers to the presence and the absence of a certain feature within a pair of sounds. Examples of privative oppositions are “voice/voiceless’, ‘nasal/non-nasal’, and ‘round/unround’. The sound characterized by the absence of the feature is regarded as ‘unmarked’, and the one characterized by the presence of the feature is regarded as ‘marked’ (Trubetzkoy, 1939). The concept continued principally by Roman Jakobson, who adopted the concept as theoretical cornerstones for a set of distinctive features. He believed that certain phones are more essential and fundamental in human languages, which should be developed earlier than other phones. He proposed that children would acquire the unmarked sounds of language before the marked segments (Jakobson, 1941/1968). His ‘laws of irreversible solidarity’ suggested that nasals, stops and anterior feature would be developed prior to orals, fricatives and the posterior feature. The determination of degree of markedness was primarily based on the frequency and distribution of the existing sounds cross-linguistically (Greenberg, 1966). In other words, the sounds commonly seen across world languages are considered unmarked while the sounds that do not widely occurred across world languages are viewed as marked sounds. Researchers assume that segments in a phoneme inventory can be classified into three categories based on cross-linguistic evidence and phonetics: Basic articulations, elaborated articulations, and complex articulations. The basic consonant inventory contains stops [p b t d k g], a glottal stop [ʔ], nasals [m n ŋ], voiceless fricatives [f s h], voiceless affricate [tʃ], liquids [r l], and glides [w j]. On the other hand, the basic vowel system contains five vowels including [a], [i], [e], [o], and [u] (Crother, 1978; Lindblom & Maddieson, 1988).

In child language regarding phonological development, it is mostly adopted that the acquisition process begins with the unmarked forms with respect to features, segments in relation to positions, and syllable structure (Stoel-Gammon, 1985; Demuth & Fee, 1995; Gnanadesikan, 1996). Stoel-Gammon (1985) examined the positional differences in the emergence of consonantal phones in the early meaningful speech by observing 34 children from 9 to 24 months. He discovered that the early inventories containing stops, nasals, glides and the anterior phones (i.e labial, alveolar) seemed to appear in advance to the posterior phones, in accordance with the prediction of Jakobson. Furthermore, for each place and manner of articulation, the phones in initial position emerged before those in final positions. The role of positional factors within phonological acquisition will be discussed in the following section 2.3.2.

2.3.2 Positional effect and positional prominence hierarchy

The different acquisition rate of the same segment in various positions has shown that the positional factor plays a great role in phonological acquisition. Two approaches intend to account for the phenomenon. One concerns motor physical respect, suggesting that phonetic acquisition contains the process of producing particular gestures and learning to coordinate them into word-shapes. Research contributed to examining the position effects in motor physical respect found that a segment occurs in different positions of a word involves different articulatory gesture and timing (Krakow, 1989; Gick; 2003; Kochetov, 2006), causing the perceptual differences and therefore lead to the speed differences in children's acquisition of a same phoneme in different positions within a syllable.

The other approach deals with the saliency of a certain position. The concept of 'prominence' has been used to explain the segmental behaviors in different syllable positions since the idea of markedness was proposed (Trubetzkoy, 1939). The saliency of the word-initial positions has long been discussed and is attested in several psycholinguistics experiments on word recognition and lexical access. The results indicated that the initial portions of a word are the most effective cues compared to other positions (Nooteboom, 1981; Hawkins & Cutler, 1988). Moreover, the diachronic studies on language change as well exhibited the special status of the initial position, where the segments preserve longer in time and are more resistant to changes (Menéndez Pidal, 1985). Overall, the initial positions are considered to be more prominent than other positions. The positional prominence hierarchy discussed in Jiménez & Lloret (2013) is presented as follows:

a. Peak (strong position) > Margin (weak position)

b. Initial (strong position) > Non-initial (weak position)

The general view is shown in a., suggesting that the vocalic position is the strong position compared to syllable margins, such as codas. In other words, the syllable margins are vulnerable and are prone to errors. On the other hand, the word-initial position is more prominent than the non-initial positions, as presented in b, implying that the word-initial position is more resistant to change and deletion process.

Several researches concerning the acquisition order of phones regarding positional factors support the claim of positional prominence hierarchy. Most of the researchers believe that syllables with coda consonants increase the complexity of syllable structures and are typically later acquired, shown by the fact that they remain omitted for long periods of time (Demuth, Culbertson, & Alter, 2006; Kirk & Demuth, 2006).

In sum, previous research showed that English-speaking children acquired labiovelar glide [w] by three years old and palatal glide [j] at around four years of age; however, the glide development in Mandarin were discussed in vowel development, diphthong and triphthong in particular. They discovered that young children performed unstable onglide and offglide productions in triphthongs and diphthongs, subtracting forms of vowels and did not arrive at unanimity for the age of acquisition. Moreover, the study did not discuss the glides in terms of positions separately since they were viewed as a whole of vowel combinations. In addition to normally-developing children, researchers dedicated to phonologically-disordered children also discovered several odd patterns in the production process. Therefore, this paper aims to examine the performance of glides of Taiwan Mandarin in relation to positions on both normally-developing children and children with phonological disorder by conducting a longitudinal study. Based on the previous research, we hypothesize that the acquisition order of the three Taiwan Mandarin glides [j, w, ɥ] will involve the interactions of both the markedness constraint and positional prominence constraint. Concerning the three glides in Taiwan Mandarin, the front rounded [ɥ] is the most marked phone among the three glides, and therefore will be acquired later than the other two phones. Moreover, for the same glide in various positions within a syllable, the glide in the initial position will be more stable than those in other positions. In other words, the glides in the initial position will be the first to stabilize in the children's production data.

Chapter 3

Methodology

There are two main parts covered in this section. The first part, section 3.1, is concerned with data collection. The background of the subjects is presented in section 3.1.1. In section 3.1.2, the data collecting procedures are described, and the recording apparatus used for the data collection are shown in 3.1.3. The second part, data analysis, is displayed in section 3.2, comprising the methods to data transcription in section 3.2.1 and the criteria adopted for the assessment of the development of the glides in terms of various positions in section 3.2.2. In each subsection, normative data are introduced first, followed by the phonologically-disordered data.

Both the normative and the phonologically-disordered data have been collected by the author and the research team in the Phonetics and Psycholinguistics Lab at National Chengchi University for years. The two groups of data presented in the study are sponsored by the Ministry of Science and Technology research projects: "Consonant Acquisition in Taiwan Mandarin" (MOST100-2410-H-004-187-), "Consonant acquisition in Taiwan Mandarin: Evidence from longitudinal and experimental studies" (MOST101-2410-H-004-182-), and the follow-up study "Consonant acquisition in Taiwan Mandarin: Evidence from observational and experimental studies" (MOST102-2410-H-004-107-) for the normally-developing children; "Consonant disorder in Mandarin children" (MOST103-2410-H-004-075-) and "Consonant disorder in Mandarin children (II)" (MOST 104-2410-H-004-137-) for the phonologically-disordered children.

3.1 Data collection

The normally-developing children were recruited from a non-profit parent forum called Babyhome (http://www.babyhome.com.tw/). An advertising poster was posted on the forum to gather the voluntary parents who were willing to have their children attend the projects. The information provided on the poster contained the age of children needed and the academic research purpose of the MOST projects. Those who were willing to participate in the research projects were required to complete a registration form created with a free online questionnaire "Google doc spreadsheet". Moreover, the subjects were asked to sign a human subject consent form in advance of the data collection.

On the other hand, the phonologically-disordered children who were engaging in language therapy in Taipei Veterans General Hospital in Beitou District were informed of the information about the purpose of the projects by a speech therapist as well the Principal Investigator Yuh-Mei Chung of the projects. Parents who were interested in participating the longitudinal observations during the language therapeutic courses were asked to fill out a Declaration of Parental/Guardian's Consent in which the approval of the Institutional Review Board of Taipei Veterans General Hospital, the academic research purpose, and a detailed description of the process executed were provided. Moreover, the author and the assistants who carried out the data collection were required to attend a training program and obtain a training certificate offered by the Institutional Review Board of Taipei Veterans General Hospital.

3.1.1 Participants

This study aims to review two normally-developing children and two phonologically-disordered children. The table below displayed the background information of the four participants recruited from the two groups.

Table 3.1 Participants' background information

	Participants	Gender	Age	Duration
Normally-developing Group	WW	Female	0;10-2;5	19 months
	NN	Female	0;9-2;4	19 months
Phonologically-disordered Group	LL	Male	4;3-4;9	6 months
	HH	Female	3;10-4;3	6 months

The normally-developing group includes two girls, labeled as WW and NN. They were 10 months old and 9 months old at the time the recording began. They both came from middle-class families in Taipei and have siblings. The caretakers were their mothers, who spoke only Mandarin Chinese in daily life, and hence, the children's native tongue was Mandarin. The parental report showed that WW and NN had no intellectual or hearing impairment. The phonologically-disordered group includes two children, labeled as LL and HH. The former was a boy and the latter was a girl, both of which were identified to have phonological disorder and have been attending language therapeutic courses provided by Taipei Veterans General Hospital. Their first recording report showed that LL and HH were at the age of 4;3 and 3;10. The recording started in April 2015.

3.1.2 Data collecting procedures

The longitudinal observations of the normally-developing children group were carried out at two-week intervals. The author and the assistants in the research team were obliged to visit the children's families twice a month for at most an hour data collection. The video-recording and audio-recording were both employed. When the children felt tired or impatient about the filming, the assistants would call off the recording, thus some of the recordings did not last for an hour. In favor of eliciting more natural spontaneous utterances from naturalistic settings, several activities, inclusive of story-telling, drawings, games, free play with their caretakers and assistants, were involved. The caretakers, usually the mothers, were encouraged to interact with the children since the children verbalize the most when they are interacting with those whom they are more familiar with.

On the other hand, the longitudinal observations of the phonologically-disordered group were carried out in the speech therapy room in Taipei Veterans General Hospital every two weeks. Only the audio recorder was used for this group of children. The data collected contained both the spontaneous speech and imitation speech since the whole process of the treatment includes natural interactions with the language therapist, naming pictures, which is a commonly applied treatment in language therapy, and the correction for the error sounds produced by the children. When the children mispronounced a target sound, the therapists would correct the children by asking the children to repeat what they had said. As a result, the data collected were composed of spontaneous speech and imitations. In the beginning of each language treatment, the assistants would place the sound recorder in the therapy room and stayed in the observation room in which a one-way mirror and a speaker were set for the purpose of observing the children during the treatment. The one-way mirror helped the assistants with identification of the children's production since the assistants were allowed to observe the whole process of the therapeutic courses without letting the children feel uncomfortable. The assistants kept a record of the sounds that the children uttered in IPA simultaneously.

3.1.3 Recording apparatus

The normally-developing group of children were both video-recorded and audio-recorded during the data collection. Sony Handycam DCR-PJ5 Camcorder with steadyshot function was used for capturing children's gestures, lips movement, and the activities they involved in when they were on the move. In addition, the audio-recording equipment used was SONY-ICD-UX543FT plugged with SV100 unidirectional microphone, which helped minimize the background noises for better sound quality. With the video camera and microphone-plugged-recorder, transcribers were allowed to identify the utterances and sounds produced by the children and to infer the intentional meaning of each production within a given context. For the phonologically-disordered group, only the SONY-ICD-UX543FT was used during the data collection in order of the protection and comfort of the subjects during the language therapeutic courses in the speech therapy room.

3.2 Data analysis

In this section, the method to transcription and coding of the collected data is presented in 3.2.1 and the criteria on how the data were selected for analysis was described in 3.2.2. Finally, the formula and assessing criteria for the correct production and stabilization of each glide in relation to various positions were shown in 3.2.3.

3.2.1 Transcription & Coding

The data collected were transcribed by the author and the assistants in the research team, who have been well-trained for transcribing children’s speech. All of the assistants are native speakers of Taiwan Mandarin and have all involved in the data collection process.

Every single utterance of the children in the recordings was transcribed with IPA broad transcription. The utterances with vague and ambiguous meanings, without clear reference or intentions, were marked and excluded from the study. Table 3.2 demonstrates the transcription samples for normally-developing children group and the children with phonological disorder.

Table 3.2 Coding samples

IPA transcription	Tone Marker	Occurrence	Possible Meaning	Age
[tow]	2	1	熊	1;9
[jɛn ɕiŋ]	22	1	圓形	1;9
[xɑŋ tɤ]	24	4	黃色	1:9
[t^{h}ej]	14	2	推	1;9

Table 3.2 contains the information about the IPA transcription and tones of each utterance produced by children. The Mandarin four tones were marked with Arabic

numerals 1, 2, 3, and 4[4] in this study. The actual numbers of tokens of each production were recorded in the occurrence column. If the utterances of the children could be easily inferred or have clear references in the given context, the transcribers would mark down the meanings in the possible meaning column. For instance, if a child produces [xɑŋ2 tɤ4] by pointing to the yellow subject in a storybook, the transcribers will infer the possible meaning for the production is 'yellow'. However, if an utterance is hard to attribute in a given context, the possible meanings will be left blank. The last column provides the age at which the child was recorded.

The inter-reliability and intra-reliability of the glides transcription for the normally-developing data are 90.3% and 95.1%, and the inter-reliability and intra-reliability of the glides transcription for the phonologically-disordered data are 86.7% and 94.6% respectively, which are slightly lower than the normally-developing data, since the sounds produced by this group were sometimes in between of the two sounds and were harder to identify. When transcribers encountered the indeterminate

[4] The four tones including *yinping, yangping, shangsheng,* and *qusheng* were described as high level [55], high rising [35], low falling-rising [214], and high falling [51] in the study of Chao (1968).

sounds or disagreements in the transcription, the data would be excluded from the data.

3.2.2 Criteria for data selection

Both the spontaneous speech and imitations were taken into account for the analysis since previous research has suggested that a very high percentage of the utterances by children are imitation and children of this age are likely to 'repeat' and 'imitate' in considerable intervals, hence no simple definition of imitation is feasible (Ferguson & Farewell, 1975).

With regard to child development, the essential problem was to determine the criterion for distinguishing the status of each of the child's vocalizations, whether it is a 'word' or 'merely babbling', for researchers have pointed out the dilemmas in distinguishing the two (Oller, 1980; Vihman *et al*., 1985). In this study, we adopted the criterion provided in Vihman *et al*. (1985) and Vihman & Miller (1986), in which the 'word' of children's spontaneous speech was considered to be 'a phonetic form that was a recognizable attempt at the adult word'. Moreover, the appropriate word forms need to be used with an apparently intentional meaning that was plausible with regard to the meaning and usage of the adult forms. In addition, onomatopoeia and conventionalized vocalizations that do not resemble any appropriate adult forms but are repeatedly used for certain communicative function by the child, referred to as protoword in Menn's (1976), were excluded from the present study. The fuzzy sounds and those integrated with the background noises were also excluded (Sosa and Stoel-Gammon, 2012).

3.2.3 Glide emergence and stabilization assessment

Considering the normally-developing children, in response to the research question one, the emergence of the three glides [w, j, ɥ] in terms of various positions, including word-initial, word-medial, and word-final position, were identified, irrespective of the target, so long as the sounds were produced phonetically accurately for the first time. For the [ɥ] sound, only the word-initial and word-medial positions were noted since the [ɥ] sound is not allowed to appear in the final position. The emergence of each glide in relation to positions was later compared.

Previous research has indicated high inconsistency in children's speech production and fluctuation in the developmental progress (Ferguson and Farwell, 1975; Zhu, 2002). For the purpose of determining the age of stabilization of the glides development, the criteria for stabilization should be decided. The present study adopted the criteria from Zhu (2002):

1. Its accuracy rating in the spontaneous speech sample reached 66.7% level. The formula for computing Percentage of Consonants Correct (PCC) and Percentage of Consonants Error (PCE) based on Shriberg & Kwiatkowski (1982) is provided below.

$$PCC = \frac{\text{the number of times of a glide produced correctly}}{\text{the number of opportunities for the glide in the sample}} \times 100\%$$

$$PCE = \frac{\text{the number of times of a glide produced incorrectly}}{\text{the number of opportunities for the glide in the sample}} \times 100\%$$

2. In order to minimize the fluctuation and regression of children's development, its accuracy rating in all the subsequent speech samples should remain higher than 66.7%. If the child's accuracy rate reaches 66.7% but drops under 66.7% in the following months, we do not consider it as stabilized.

The criteria were employed to calculate the accuracy rating across the three glides and within the same glide in various positions of the normative data as well as the phonologically-disordered data. Furthermore, the accuracy rate of the data in each position was tested with statistical method, two-proportion z-test in order to see whether the claim that the glides in the initial position are more stable than the other two positions.

For the purpose of comparing the tendencies and error types of the two groups, the error types were first identified and were calculated by the formula presented below:

$$\frac{\text{the number of times of a phonological process used in the given position}}{\text{the total glide errors identified in a given position}} \times 100\%$$

The percentage of each phonological process was compared within the same group and across the two groups after the calculation.

Chapter 4

Findings and analysis

In this section, the emergence of glides in the Mandarin in relation to various positions of normally-developing children will be presented in 4.1. Section 4.2 discusses the stabilization of each glide based on the PCC/PCE formula and describe the order of stabilization of the three glides of the normally-developing children. Section 4.3 shows the performance of glides from the phonologically-disordered group. Finally, in section 4.4, the phonological processes involved in the production of glides in both groups of children, together with the percentages of each process are reported.

4.1 Emergence of glides in normally-developing group

The speechlike sounds change drastically during the first year. Vowels seem to predominate the production of the first six months and the sound repertoire expands considerably between 6 months to 12 months of age across languages (Gleason and Ratner, 2009). Previous research has discovered that the sounds produced in children's late prelinguistic period are highly identical across languages and might later be served as the building blocks for the production of words (Stoel-Gammon, 1985).

The first question addressed in the present study is concerned with the three glides emergence in Taiwan Mandarin in relation to the various positions, including initial position, medial position (referring to as prenuclear glide), and final position (referring to as postnuclear glide). The results of the age of emergence of glides from the two normally-developing children are displayed in Table 4.1 and Table 4.2.

Table 4.1 shows the age of emergence of the Mandarin three glides in terms of the three positions regardless of the adult target forms of the normally-developing child WW (0;10-2;5). That is to say, the sounds were noted down as long as the sounds were accurately produced for the first time.

Table 4.1 Age of emergence of glides

WW	0;10	0;11	1;0	1;1	1;2	1;3	1;4	1;5	1;6	1;7	1;8	1;9	1;10
Initial				[w]	[j]							[ɥ]	
Prenuclear					[j]		[w]				[ɥ]		
Postnuclear			[j]		[w]								

The postnuclear palatal [j] first emerged at 1;0, followed by initial labiovelar [w] at 1;1. Both the initial [j] and prenuclear [j], together with postnuclear [w] appeared at the age of 1;2. Prenuclear [w] emerged at 1;4. However, the high front rounded [ɥ] did not occur in WW's system until 1;8 and 1;9, with the prenuclear [ɥ] emerged in 1;8 and initial [ɥ] in 1;9.

Table 4.2 Age of emergence of glides (NN)

NN	0;9	0;10	0;11	1;0	1;1	1;2	1;3	1;4	1;5	1;6	1;7	1;8
Initial	[w] [j]								[ɥ]			
Prenuclear	[j]	[w]										[ɥ]
Postnuclear	[w] [j]											

Table 4.2 presents the age of emergence of glides of NN. The emergence of NN's labiovelar [w] and palatal [j] is earlier than those in WW's data. The palatal [j] in three positions occurred at 0;9, along with the initial [w] and postnuclear [w]. The prenuclear [w] appeared one month later than the other positions of [w]. Unsurprisingly, the labiopalatal [ɥ] emerged later, with the initial [ɥ] occurred at age 1;5, and prenuclear [ɥ] occurred at age 1;8. Since the palatal [j] in all positions, together with the initial labiovelar [w] and postnulcear [w] emerged at the first month of the data collection, the exact age of emergence of the palatal [j] and the labiovelar [w] in the initial and postnulcear position is unknown. We could only claim that the [j] and [w] both occur at a relatively young age due to the limitation of the data.

If we overlook the positional factors, the emergence order of the three glides in Mandarin of the two normally-developing children is as follows:

(c) [j] → [w] → [ɥ] (WW)

(d) [j] / [w] → [ɥ] (NN)

(c) provides the emergence order of the child WW and (d) provides the emergence order of the child NN. For the child WW, the palatal [j] occurred first in her production, followed by the labiovelar [w]. The labiopalatal [ɥ] is the last to emerge. On the other hand, the child NN produced her first [j] and [w] at the same age, and similar to WW's data, the labiopalatal [ɥ] is the last to emerge in her system.

4.2 Stabilization of glides in normally-developing group

In this section, we deal with the stabilization of glides in normally-developing group. Section 4.2.1 displays the data and PCC/PCE throughout 17 months of data collected in this study. In section 4.2.2, the order of stabilization of glides is listed.

4.2.1 Data and PCC/PCE

The data of normally-developing child, WW and NN, were analyzed through 17 months. WW was observed from age 0;10 to 2;5 and NN was observed from age 0;9 to 2;4. The stabilization of the Mandarin three glides [w, j, ɥ] was examined in terms of the three positions. Table 4.3 lays out the total tokens of the glide production of the normally-developing group. The leftmost column includes the correct number of the sound produced, the error number produced, the total frequency of glides occurred in the normally-developing group and the PCE/PCC of glides. The three shaded columns in the middle of the table represent the subtotal of each glide, and the rightmost column shows the total number of the three glides.

Table 4.3 Glide distribution and PCC/PCE of the normally-developing group

	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	321	514	1344	2179	504	1077	760	2341	46	46	92	4612
Error	14	127	332	473	23	82	169	274	5	57	62	809
Subtotal	335	641	1676	2652	527	1159	929	2615	51	103	154	5421
PCE	4.2%	19.8%	19.8%	17.8%	4.4%	7.1%	18.2%	10.5%	9.8%	55.3%	40.3%	14.9%
PCC	95.8%	80.2%	80.2%	82.2%	95.6%	92.9%	81.8%	89.5%	90.2%	44.7%	59.7%	85.1%

Notes: I, M, and F refer to word-initial, -medial, and –final positions. The glides appeared in M are prenuclear glides, and those in F are postnuclear glides. For an easier way of presenting them, M and F are used instead.

In total, 5421 glides were collected from the two children, in which 809 glides were produced with mistakes and the other 4612 glides were accurately produced. The distribution of [w], [j], and [ɥ] is 2652, 2615, and 154. The data show that the labiovelar [w] and labiovelar [j] are distributed almost evenly in children's early utterances; however, the frequency of the labiopalatal [ɥ] is far lower than the other two glides. The 2652 labiovelar [w] are composed of 335 in the initial position, 641 in the prenuclear position, and 1676 in the postnuclear position. The 2615 palatal [j] are composed of 527 initial [j], 1159 prenuclear [j], and 929 in the postnuclear position. The 154 labiopalatal [ɥ] are composed of 51 in the initial position, and 103 in the prenuclear position. The PCC of the [w], [j], [ɥ] in I, M, F position is as follows: 95.8%, 80.2%, 80.2%; 95.6%, 92.9%, 81.8%; 90.2%, 44.7%. Two-proportion z-test showed that the PCC of the three glides in initial position are significantly higher than the prenuclear and postnuclear positions ([w] I M : $Z=6.59$, $P<.001$***; [w] I F: $Z=6.31$, $P<.001$***; [j] I M : $Z=2.13$, $P<.05$*; [j] I F : $Z=7.49$, $P<.001$***; [ɥ] I M : $Z=5.42$, $P<.001$***).

Table 4.4 and Table 4.5 show the distribution of the three glides and Percentage of Consonants Correct (PCC) and Percentage of Consonants Error (PCE) of the subgroups WW and NN.

Table 4.4 Total distribution and PCC/PCE of glides (age 0;10-2;5) of WW

0;10-2;5	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	82	186	542	810	191	390	296	877	12	20	32	1719
Error	10	66	55	131	4	30	54	88	1	26	27	246
Frequency	92	252	597	941	195	420	350	965	13	46	59	1965
PCE	10.9 %	26.2 %	9.2 %	13.9 %	2.1 %	7.1 %	15.4 %	9.1 %	7.7 %	56.5 %	45.8 %	12.5 %
PCC	89.1 %	73.8 %	90.8 %	86.1 %	97.9 %	92.9 %	84.6 %	90.9 %	92.3 %	43.5 %	54.2 %	87.5 %

Table 4.4 displays the production of WW, in which 941 are labiovelar [w], 965 are palatal [j], and 59 are labiopalatal [ɥ]. For the labiovelar [w], 92 of which are initial [w], 252 of which are prenuclear [w], and 597 are postnuclear [w]. The PCC of initial, prenuclear, and postnuclear [w] are 89.1%, 73.8%, 90.8% respectively. The 965 [j] sounds are composed of 195 [j] in the initial position, 420 in the prenuclear position, and 350 in the postnuclear position. The PCC of the three positions are 97.9%, 92.9%, and 84.6%. The frequency of [ɥ] is relatively low. Only 59 syllabic words produced by the child contain the sound, with 13 appear in the initial position and 46 appear in the prenuclear position. The PCC of the initial [ɥ] is 92.3% and prenuclear [ɥ] is 43.5%.

Table 4.5 Total distribution and PCC/PCE of glides (age 0;9-2;4) of NN

0;9-2;4	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	239	328	802	1369	313	687	464	1464	34	26	60	2893
Error	4	61	277	342	19	52	115	186	4	31	35	563
Frequency	243	389	1079	1711	332	739	579	1650	38	57	95	3456
PCE	1.7%	15.7%	25.7%	20.0%	5.7%	7.0%	19.9%	11.3%	10.5%	54.4%	36.8%	16.3%
PCC	98.4%	84.3%	74.3%	80.0%	94.3%	93.0%	80.1%	88.7%	89.5%	45.6%	63.2%	83.7%

Table 4.5 lists the production of the other normally-developing child, NN. The distribution of the labiovelar [w] includes 243 in the initial position, 389 in the prenuclear position, and 1079 in the postnuclear position. For the high front [j], the distribution includes 332 in the initial position, 739 in the prenuclear position, and 579 in the postnuclear position. The distribution of the high front rounded [ɥ] includes 38 in the initial position and 57 in the prenuclear position. To compare the PCC of various positions within the same phones, we found that both of the children demonstrated a higher accuracy rate in the initial position.

In order to investigate the developmental progress of the three glides in relation to positions, the glides are categorized in terms of the positions they appear at each age and the error production were calculated for the PCE and PCC. WW did not produce any syllabic word with possible meaning involving glides until the age of 1;1; therefore, Table 4.6 to Table 4.22 display the distribution and PCC/PCE of WW from age 1;1 to age 2;5.

Table 4.6 Distribution and PCC/PCE of glides (age 1;1) WW

1;1	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	0	1	0	1	0	0	0	0	0	0	0	1
Error	0	0	0	0	0	0	0	0	0	0	0	0
Frequency	0	1	0	1	0	0	0	0	0	0	0	1
PCE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PCC	0.0%	100%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%

Table 4.7 Distribution and PCC/PCE of glides (age 1;2) WW

1;2	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	0	0	0	0	0	0	1	1	0	0	0	1
Error	0	0	0	0	0	0	0	0	0	0	0	0
Frequency	0	0	0	0	0	0	1	1	0	0	0	1
PCE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PCC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	100.0%

Table 4.8 Distribution and PCC/PCE of glides (age 1;3) WW

1;3	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	2	0	0	2	0	0	1	1	0	0	0	3
Error	0	0	0	0	0	0	1	1	0	0	0	1
Frequency	2	0	0	2	0	0	2	2	0	0	0	4
PCE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.00%	50.00%	0.0%	0.0%	0.0%	25.0%
PCC	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%	50.00%	50.00%	0.0%	0.0%	0.0%	75.00%

Table 4.9 Distribution and PCC/PCE of glides (age 1;4) WW

1;4	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	0	0	0	0	1	0	0	1	0	0	0	1
Error	0	0	1	1	0	0	0	0	0	0	0	1
Frequency	0	0	1	1	1	0	0	1	0	0	0	2
PCE	0.0%	0.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%
PCC	0.0%	0.0%	0.0%	0.0%	100%	0.0%	0.0%	100%	0.0%	0.0%	0.0%	50.0%

From table 4.6 to table 4.9 (1;1-1;4), little data involving glide was uttered by WW. At age 1;1, only one prenuclear [w] was produced, and it was produced accurately. At age 1;2, only one postnuclear [j] appeared in the data, and it was accurately produced. The data are still limited at age 1;3 and 1;4. The child produced two [w] sounds in the initial position and two postnuclear glides at age 1;3; the two [w] sounds were produced without any error while one of the postnuclear [j] was not correctly produced. At the age of 1;4, one postnuclear [w] was not accurately produced whereas the initial [j] was correctly produced. So far, the front rounded glide [ɥ] hasn't occurred in the child's utterance.

The production of the child had an obvious surge since the age of 1;5. The data that contains glides before age 1;4 are limited to less than four but by the age 1;5, the data has increased to more than 50.

Table 4.10 Distribution and PCC/PCE of glides (age 1;5) WW

1;5	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	1	3	23	27	7	9	11	27	0	0	0	54
Error	0	2	0	2	1	0	9	10	0	0	0	12
Frequency	1	5	23	29	8	9	20	37	0	0	0	66
PCE	0.0%	40.0%	0.0%	6.9%	12.5%	0.0%	45.0%	27.0%	0.0%	0.0%	0.0%	18.2%
PCC	100.0%	60.0%	100.0%	93.1%	87.5%	100%	55.0%	73.0%	0.0%	0.0%	0.0%	81.8%

Table 4.11 Distribution and PCC/PCE of glides (age 1;6) WW

1;6	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	8	2	19	37	5	15	8	28	0	0	0	57
Error	2	0	6	8	0	2	2	4	0	0	0	12
Frequency	10	2	25	29	5	17	10	32	0	0	0	69
PCE	20.0%	0.0%	24.0%	21.6%	0.0%	11.8%	20.0%	12.5%	0.0%	0.0%	0.0%	17.4%
PCC	80.0%	100.0%	76.0%	78.4%	100.0%	88.2%	80.0%	87.5%	0.0%	0.0%	0.0%	82.6%

Table 4.12 Distribution and PCC/PCE of glides (age 1;7) WW

1;7	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	2	3	22	27	7	14	3	24	0	0	0	51
Error	0	0	1	1	0	0	0	0	0	1	1	2
Frequency	2	3	23	28	7	14	3	24	0	1	1	53
PCE	0.0%	0.0%	4.4%	3.6%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	3.8%
PCC	100.0%	100.0%	95.7%	96.4%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	96.2%

Table 4.13 Distribution and PCC/PCE of glides (age 1;8) WW

1;8	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	8	9	58	75	12	42	26	80	0	7	7	162
Error	0	16	1	17	0	7	11	18	0	5	5	40
Frequency	8	25	59	92	12	49	37	98	0	12	12	202
PCE	0.0%	64.0%	1.7%	18.48%	0.0%	14.3%	29.7%	18.4%	0.0%	41.7%	41.7%	19.8%
PCC	100.0%	36.0%	98.3%	81.5%	100.0%	85.7%	70.3%	81.6%	0.0%	58.3%	58.3%	80.2%

Table 4.14 Distribution and PCC/PCE of glides (age 1;9) WW

1;9	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	6	43	54	103	25	43	33	101	6	1	7	211
Error	1	17	8	26	0	2	6	8	0	9	9	43
Frequency	7	60	62	129	25	45	39	109	6	10	16	254
PCE	14.3%	28.3%	12.9%	20.2%	0.0%	4.4%	15.4%	7.3%	0.0%	90.0%	56.3%	16.93%
PCC	85.7%	71.7%	87.1%	79.8%	100.0%	95.6%	84.6%	92.7%	100.0%	10.0%	43.8%	83.07%

Table 4.15 Distribution and PCC/PCE of glides (age 1;10) WW

1;10	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	4	13	53	70	8	26	28	62	0	3	3	135
Error	1	10	2	13	0	2	3	5	0	3	3	21
Frequency	5	23	55	83	8	28	31	67	0	6	6	156
PCE	20.0%	43.5%	3.6%	15.7%	0.0%	7.1%	9.7%	7.5%	0.0%	50.0%	50.0%	13.5%
PCC	80.0%	56.5%	96.4%	84.3%	100%	92.9%	90.3%	92.5%	0.0%	50.0%	50.0%	86.5%

Table 4.16 Distribution and PCC/PCE of glides (age 1;11) WW

1;11	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	8	26	74	108	16	70	39	125	3	5	8	241
Error	1	4	5	10	1	4	3	8	1	4	5	23
Frequency	9	30	79	118	17	74	42	133	4	9	13	264
PCE	11.1%	13.3%	6.3%	8.5%	5.9%	5.4%	7.1%	6.0%	25.0%	44.4%	38.5%	8.7%
PCC	88.9%	86.7%	93.7%	91.5%	94.1%	94.6%	92.9%	94.0%	75.0%	55.6%	61.5%	91.3%

Table 4.17 Distribution and PCC/PCE of glides (age 2;0) WW

2;0	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	5	11	42	58	13	43	31	87	0	3	3	148
Error	0	5	2	7	1	1	2	4	0	2	2	13
Frequency	5	16	44	65	14	44	33	91	0	5	5	161
PCE	0.0%	31.3%	4.6%	10.8%	7.1%	2.3%	6.1%	4.4%	0.0%	40.0%	40.0%	8.1%
PCC	100.0%	68.8%	95.5%	89.2%	92.9%	97.7%	93.9%	95.6%	0.0%	60.0%	60.0%	91.9%

Table 4.18 Distribution and PCC/PCE of glides (age 2;1) WW

2;1	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	5	22	64	91	17	29	25	91	0	1	1	163
Error	1	4	5	10	0	4	3	4	0	2	2	19
Frequency	6	26	69	101	17	33	28	87	0	3	3	182
PCE	16.7%	6.7%	11.1%	11.5%	0.0%	12.1%	10.7%	9.0%	0.0%	66.7%	66.7%	10.4%
PCC	83.3%	93.3%	88.9%	88.5%	100.0%	87.9%	89.3%	91.0%	0.0%	33.3%	33.3%	89.6%

Table 4.19 Distribution and PCC/PCE of glides (age 2;2) WW

2;2	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	8	14	24	46	21	12	19	52	2	0	2	100
Error	2	1	3	6	0	2	0	2	0	0	0	8
Frequency	10	15	27	52	21	14	19	54	2	0	2	108
PCE	20.0%	6.7%	11.1%	11.5%	0.0%	14.3%	0.0%	3.7%	0.0%	0.0%	0.0%	7.4%
PCC	80.0%	93.3%	88.9%	88.5%	100.0%	85.7%	100.0%	96.3%	100.0%	0.0%	100.0%	92.6%

Table 4.20 Distribution and PCC/PCE of glides (age 2;3) WW

2;3	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	16	17	60	93	36	33	42	111	0	0	0	204
Error	1	4	8	13	1	3	12	16	0	0	0	29
Frequency	17	21	68	106	37	36	54	127	0	0	0	233
PCE	5.9%	19.0%	11.8%	12.3%	2.7%	8.3%	22.2%	12.6%	0.0%	0.0%	0.0%	12.4%
PCC	94.1%	81.0%	88.2%	87.7%	97.3%	91.7%	77.8%	87.4%	0.0%	0.0%	0.0%	87.6%

Table 4.21 Distribution and PCC/PCE of glides (age 2;4) WW

2;4	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	5	8	19	32	12	36	11	59	0	0	0	91
Error	1	2	0	3	0	0	1	1	0	0	0	4
Frequency	6	10	19	35	12	36	12	60	0	0	0	95
PCE	16.7%	20.0%	0.0%	8.6%	0.0%	0.0%	8.3%	1.7%	0.0%	0.0%	0.0%	4.2%
PCC	83.3%	80.0%	100.0%	91.4%	100.0%	100.0%	91.7%	98.3%	0.0%	0.0%	0.0%	95.8%

Table 4.22 Distribution and PCC/PCE of glides (age 2;5) WW

2;5	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	4	14	30	48	11	18	18	47	1	0	1	96
Error	0	1	13	14	0	3	1	4	0	0	0	18
Frequency	4	15	43	62	11	21	19	51	1	0	1	114
PCE	0.0%	6.7%	30.2%	22.6%	0.0%	14.3%	5.3%	7.8%	0.0%	0.0%	0.0%	15.8%
PCC	100.0%	93.3%	69.8%	77.4%	100.0%	85.7%	94.7%	92.2%	100.0%	0.0%	100.0%	84.2%

At age 1;5, the child produced 29 [w] sounds with two errors in the medial position, with the other positions all accurately produced, and 37 [j] sounds were produced with 10 errors, nine of which were postnuclear [j] and the other one was the initial position [j]. The prenuclear [j] was produced without any error. At 1;6, the postnuclear [j] was stabilized. At 1;7, the first target form containing postnuclear [ɥ] sound appeared, but was produced inaccurately. Few errors were detected at this age. Aside from the postnuclear [ɥ], only one postnuclear [w] was inaccurately produced. Another data explosion occurred at age 1;8, at which the data containing glides reached above 200. The distribution of the three glides [w, j, ɥ] of this age are 92, 98, and 12. The error numbers of the production for the prenuclear [w] and postnuclear [w] are 16 and 1 respectively, and for the prenuclear [j] and postnuclear [j] are 7 and 11 respectively. As for the prenuclear [ɥ], two data were produced with errors. At age 1;9, the initial [ɥ] sound appeared for the first time in the WW's system and all of them were accurately produced; however, the 10 [ɥ] sounds in the prenuclear position were all produced with errors with only one accurately produced. The distribution of the [w] sounds and [j] sounds are 129 and 109 respectively, with the [w] composed of 7 initial

[w], 60 prenulear [w], and 62 postnuclear [w] and the [j] composed of 25 initial [j], 45 prenuclear [j], and 39 postnuclear [j]. The distribution of the three glides [w, j, ɥ] at the age of 1;10 is 83, 67, and 6. The error numbers for the [w, j, ɥ] sounds in each position are as follows: one out of five for the initial [w], 10 out of 23 for the prenuclear [w], two out of 55 for the postnuclear [w], zero out of 8 for the initial [j], two out of 28 for prenuclear [j], 3 out of 31 for postnuclear [j], and three out of six for prenulcear [ɥ]. At age 2;0, the distribution of the three glides [w, j, ɥ] is 65, 91, 5 respectively. The target numbers of [w] in initial, medial, and final position are 5, 16, 44, in which 5 errors were produced in the medial position and 2 errors were produced in the final position. The target numbers of [j] in initial, medial, and final position are 14, 44, 33, in which one error was produced in the initial position, one error in the medial position, and two errors were produced in the final position. The child did not produce any initial [ɥ] at this age and the error production of the prenuclear [ɥ] is two out of five. From the data above, we noticed that the child produced the least data in the initial position; nonetheless, they were produced with the least errors with regard to the three positions. Moreover, the data of the [ɥ] sound were the least among the three glides.

Table 4.23 to Table 4.42 list the distribution of the NN's data. NN produced glides with possible meanings at a relatively young age but the number of tokens is low.

Table 4.23 Distribution and PCC/PCE of glides (age 0;9) NN

0;9	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	0	0	1	1	0	1	0	1	1	0	1	3
Error	0	0	3	0	0	2	0	2	1	0	1	6
Frequency	0	0	4	1	0	3	0	3	2	0	2	9
PCE	0.0%	0.0%	75.0%	75.0%	0.0%	66.7%	0.0%	66.7%	50.0%	0.0%	50.0%	66.7%
PCC	0.0%	0.0%	25.0%	25.0%	0.0%	33.3%	0.0%	33.3%	50.0%	0.0%	50.0%	33.3%

Table 4.24 Distribution and PCC/PCE of glides (age 0;10) NN

0;10	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	0	0	1	1	0	2	1	3	1	0	1	5
Error	0	0	4	4	0	1	0	1	0	0	0	5
Frequency	0	0	5	5	0	3	1	4	1	0	1	10
PCE	0.0%	0.0%	80.0%	80.0%	0.0%	33.3%	0.0%	25.0%	0.0%	0.0%	0.0%	50.0%
PCC	0.0%	0.0%	20.0%	20.0%	0.0%	66.7%	100.0%	75.0%	100.0%	0.0%	100.0%	50.0%

Table 4.25 Distribution and PCC/PCE of glides (age 0;11) NN

0;11	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	0	0	0	0	0	0	0	0	0	0	0	0
Error	0	0	0	0	0	0	0	0	0	0	0	0
Frequency	0	0	0	0	0	0	0	0	0	0	0	0
PCE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PCC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 4.26 Distribution and PCC/PCE of glides (age 1;0) NN

1;0	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	0	0	1	1	1	2	3	6	0	0	0	7
Error	1	0	4	5	0	2	0	2	0	1	1	8
Frequency	1	0	5	6	1	4	3	8	0	1	1	15
PCE	100.0%	0.0%	80.0%	83.3%	0.0%	50.0%	0.0%	25.0%	0.0%	100.0%	100.0%	53.3%
PCC	0.0%	0.0%	20.0%	16.7%	100.0%	50.0%	100.0%	75.0%	0.0%	0.0%	0.0%	46.7%

Table 4.27 Distribution and PCC/PCE of glides (age 1;1) NN

1;1	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	0	0	2	2	0	1	0	1	0	0	0	3
Error	0	1	13	14	0	10	1	11	0	0	0	25
Frequency	0	1	15	16	0	11	1	12	0	0	0	28
PCE	0.0%	100.0%	86.70%	87.5%	0.0%	90.9%	100.0%	91.7%	0.0%	0.0%	0.0%	89.3%
PCC	0.0%	0.0%	13.3%	100.0%	0.0%	9.1%	0.0%	8.3%	0.0%	0.0%	0.0%	10.7%

Table 4.28 Distribution and PCC/PCE of glides (age 1;2) NN

1;2	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	0	1	1	2	0	2	0	2	0	0	0	4
Error	0	3	2	5	0	4	1	5	0	0	0	10
Frequency	0	4	3	7	0	6	1	7	0	0	0	14
PCE	0.0 %	75.0 %	66.7 %	71.4 %	0.0 %	66.7 %	100. 0%	71.4 %	0.0 %	0.0 %	0.0 %	71.4 %
PCC	0.0 %	25.0 %	33.3 %	28.6 %	0.0 %	33.3 %	0.0 %	28.6 %	0.0 %	0.0 %	0.0 %	28.6 %

Table 4.29 Distribution and PCC/PCE of glides (age 1;3) NN

1;3	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	1	3	0	4	1	5	0	6	0	0	0	10
Error	1	5	7	13	0	5	1	6	0	0	0	19
Frequency	2	8	7	17	1	10	1	12	0	0	0	29
PCE	50.0 %	62.5 %	100. 0%	76.5 %	0.0 %	50.0 %	100. 0%	50.0 %	0.0 %	0.0 %	0.0 %	65.5 %
PCC	50.0 %	37.5 %	0.0 %	23.5 %	100. 0%	50.0 %	0.0 %	50.0 %	0.0 %	0.0 %	0.0 %	34.5 %

Table 4.30 Distribution and PCC/PCE of glides (age 1;4) NN

1;4	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	0	0	18	18	2	5	1	8	0	0	0	26
Error	0	0	20	20	0	4	7	11	0	0	0	31
Frequency	0	0	38	38	2	9	8	19	0	0	0	57
PCE	0.0 %	0.0 %	52.6 %	52.6 %	0.0 %	44.4 %	87.5 %	57.9 %	0.0 %	0.0 %	0.0 %	54.4 %
PCC	0.0 %	0.0 %	47.4 %	47.4 %	100. 0%	55.6 %	12.5 %	42.1 %	0.0 %	0.0 %	0.0 %	45.6 %

Table 4.31 Distribution and PCC/PCE of glides (age 1;5) NN

1;5	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	2	7	31	40	14	19	3	36	1	0	1	77
Error	0	3	20	23	0	0	2	2	0	2	2	27
Frequency	2	10	51	63	14	19	5	38	1	2	3	104
PCE	0.0%	30.0%	39.2%	36.5%	0.0%	0.0%	40.0%	5.3%	0.0%	100.0%	66.7%	26.0%
PCC	100.0%	70.0%	60.8%	63.5%	100.0%	100.0%	60.0%	94.7%	100.0%	0.0%	33.3%	74.0%

Table 4.32 Distribution and PCC/PCE of glides (age 1;6) NN

1;6	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	2	14	31	37	6	20	11	37	0	0	0	84
Error	1	7	32	8	1	3	15	19	0	9	9	68
Frequency	3	21	63	29	7	23	26	56	0	9	9	152
PCE	33.3%	33.3%	50.8%	46.0%	14.3%	13.0%	57.7%	33.9%	0.0%	100.0%	100.0%	44.7%
PCC	66.7%	66.7%	49.2%	54.0%	85.7%	87.0%	42.3%	66.1%	0.0%	0.0%	0.0%	55.3%

Table 4.33 Distribution and PCC/PCE of glides (age 1;7) NN

1;7	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	10	15	29	80	17	28	7	79	1	0	1	107
Error	1	2	23	26	1	4	22	27	0	7	7	60
Frequency	11	17	52	54	18	32	29	52	1	7	8	167
PCE	9.1%	11.8%	44.2%	32.5%	5.6%	12.5%	75.9%	34.2%	0.0%	100.0%	87.5%	35.9%
PCC	90.9%	88.2%	55.8%	67.5%	94.4%	87.5%	24.1%	65.8%	100.0%	0.0%	12.5%	64.1%

Table 4.34 Distribution and PCC/PCE of glides (age 1;8) NN

1;8	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	4	7	16	27	14	34	26	74	0	1	1	102
Error	0	6	37	43	4	3	8	15	1	5	6	64
Frequency	4	13	53	70	18	37	34	89	1	6	7	166
PCE	0.0%	46.2%	69.8%	61.4%	22.2%	8.1%	23.5%	16.9%	100.0%	83.3%	85.7%	38.6%
PCC	100.0%	53.8%	30.2%	38.6%	77.8%	91.9%	76.5%	83.1%	0.0%	16.7%	14.3%	61.4%

Table 4.35 Distribution and PCC/PCE of glides (age 1;9) NN

1;9	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	1	15	18	34	9	32	10	51	6	0	6	91
Error	0	5	21	26	1	2	10	13	1	2	3	42
Frequency	1	20	39	60	10	34	20	64	7	2	9	133
PCE	0.0%	25.0%	53.8%	43.3%	10.0%	5.9%	50.0%	20.3%	14.3%	100.0%	33.3%	31.6%
PCC	100.0%	75.0%	46.2%	56.7%	90.0%	94.1%	50.0%	79.7%	85.7%	0.0%	66.7%	68.4%

Table 4.36 Distribution and PCC/PCE of glides (age 1;10) NN

1;10	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	0	13	24	37	10	36	6	52	0	0	0	89
Error	0	0	23	23	3	3	8	14	0	3	3	40
Frequency	0	13	47	60	13	39	14	66	0	3	3	129
PCE	0.0%	0.0%	48.9%	38.3%	23.1%	7.7%	57.1%	21.2%	0.0%	100.0%	100.0%	31.0%
PCC	0.0%	100.0%	51.1%	61.7%	76.9%	92.3%	42.9%	78.8%	0.0%	0.0%	0.0%	69.0%

Table 4.37 Distribution and PCC/PCE of glides (age 1;11) NN

1;11	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	23	26	78	127	45	67	47	159	8	0	8	294
Error	0	9	30	39	1	3	9	13	1	0	1	53
Frequency	23	35	108	166	46	70	56	172	9	0	9	347
PCE	0.0%	25.7%	27.8%	23.5%	2.2%	4.3%	16.1%	7.6%	11.1%	0.0%	11.1%	15.3%
PCC	100.0%	74.3%	72.2%	76.5%	97.8%	95.7%	83.9%	92.4%	88.9%	0.0%	88.9%	84.7%

Table 4.38 Distribution and PCC/PCE of glides (age 2;0) NN

2;0	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	30	30	126	186	33	125	71	229	6	5	11	426
Error	0	2	11	13	0	0	4	4	0	0	0	17
Frequency	30	32	137	199	33	125	75	233	6	5	11	443
PCE	0.0%	6.3%	8.0%	6.5%	0.0%	0.0%	5.3%	1.7%	0.0%	0.0%	0.0%	3.8%
PCC	100.0%	93.8%	92.0%	93.5%	100.0%	100.0%	94.7%	98.3%	100.0%	100.0%	100.0%	96.2%

Table 4.39 Distribution and PCC/PCE of glides (age 2;1) NN

2;1	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	19	21	52	92	19	47	29	95	2	1	3	190
Error	0	2	7	9	1	0	15	16	0	0	0	25
Frequency	19	23	59	101	20	47	44	111	2	1	3	215
PCE	0.0%	8.7%	11.9%	8.9%	5.0%	0.0%	34.1%	14.4%	0.0%	0.0%	0.0%	11.6%
PCC	100.0%	91.3%	88.1%	91.1%	95.0%	100.0%	65.9%	85.6%	100.0%	100.0%	100.0%	88.4%

Table 4.40 Distribution and PCC/PCE of glides (age 2;2) NN

2;2	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	64	51	109	224	45	109	106	260	3	3	6	490
Error	0	4	4	8	4	2	6	12	0	0	0	20
Frequency	64	55	113	232	49	111	112	272	3	3	6	510
PCE	0.0%	7.3%	3.5%	3.4%	8.2%	1.8%	5.4%	4.4%	0.0%	0.0%	0.0%	3.9%
PCC	100.0%	92.7%	96.5%	96.6%	91.8%	98.2%	94.6%	95.6%	100.0%	100.0%	100.0%	96.1%

Table 4.41 Distribution and PCC/PCE of glides (age 2;3) NN

2;3	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	39	42	124	205	35	72	46	153	4	10	14	372
Error	0	4	8	12	1	0	3	4	0	0	0	16
Frequency	39	46	132	217	36	72	49	157	4	10	14	388
PCE	0.0%	8.7%	6.1%	5.5%	2.8%	0.0%	6.1%	2.5%	0.0%	0.0%	0.0%	4.1%
PCC	100.0%	91.3%	93.9%	94.5%	97.2%	100.0%	93.9%	97.5%	100.0%	100.0%	100.0%	95.9%

Table 4.42 Distribution and PCC/PCE of glides (age 2;4) NN

2;4	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	44	83	140	267	62	80	97	239	1	6	7	513
Error	0	8	8	16	2	4	3	9	0	2	2	27
Frequency	44	91	148	283	64	84	100	248	1	8	9	540
PCE	0.0%	8.8%	5.4%	5.7%	3.1%	4.8%	3.0%	3.6%	0.0%	25.0%	22.2%	5.0%
PCC	100.0%	91.2%	94.6%	94.3%	96.9%	95.2%	97.0%	96.4%	100.0%	75.0%	77.8%	95.0%

Similar to WW's data, the glide production of NN's data had an evident surge at age 1;5. The total production of glides is 104, 63 of which are [w], 38 of which are [j], and three of which are [ɥ]. The 63 labiovelar [w] are composed of two in the initial position, 10 in the prenuclear position, 51 in the postnuclear position, and the 38 palatal [j] sounds are composed of 14 in the initial position, 19 in the prenuclear position, and five in the postnuclear position. The three rounded palatal [ɥ] are composed of one in the initial position and two in the postnuclear position. Another burst of data occurred at age 1;11, when the total production of glides reached 347. The distribution of the three glides [w, j, ɥ] is 166, 172, 9. Table 4.38 to Table 4.42 reports the performance of glides from 2;0 to 2;4. The PCC of each glide in the three positions reaches the criteria of stabilization except for the prenuclear palatal [j] at 2;1. Moreover, we found that in all the data observed, the production of the labiovelar [w] and the palatal [j] are similar to each other while the number of labiopalatal [ɥ] is much lower than the other two glides. This was found in both WW and NN's data.

4.2.2 Order of stabilization of glides

The criteria for determining whether the glides are stabilized or not was adopted from Zhu (2002), in which the accuracy rating of the spontaneous sample is considered stabilized when it reached 66.7%. Besides, for the avoidance of the fluctuation and regression of the developmental progress, the accuracy rate in all the subsequent speech samples should not drop under 66.7%. In table 4.5, WW only produced one prenuclear glide [w]. Although the PCC is 100%, we do not consider it to be stabilized since the PCC dropped under 66.7% at the age of 1;5, 1;8, and 1;10; as a result, the stabilization of prenuclear [w] is 1;11. The first production of initial [w] occurred at age 1;3. The PCC is 100% and has remained above 66.7% since then, so 1;3 is regarded as the age of stabilization of initial [w]. The postnuclear [w] is stabilized at the age of 1;5. Following the same way of analysis, the initial [j] and prenuclear [j] are stabilized by the time the first production with possible meaning emerged, which are 1;4 and 1;5 respectively. The postnuclear [j] has undergone regression and is not stabilized until 1;6. For the late-emerging sound [ɥ], WW did not produce any syllabic word containing it with possible meaning until 1;9; however, all six syllabic words are produced without any mistakes, and the PCC is 100%; hence, 1;9 is thought of as the age of stabilization, while the prenuclear [ɥ] is not stabilized within the 17-month-data. The PCC of 2;1 is 33.3%, below the criteria of stabilization. WW did not produce any form containing prenuclear [ɥ] at 2;2 to 2;5, therefore, the performance of the prenuclear [ɥ] remains unclear. The shaded three columns demonstrated the distribution and accuracy rate of each glide without distinguishing the positions. The [j] sound is stabilized at the age of 1;4 and [w] sound at 1;5. The [ɥ] sound is stabilized at age 2;2. In other words, the order of the stabilization of the three glides is [j] → [w] →[ɥ]. Palatal [j] is the first to stabilize, followed by the labiovelar [w], and the labiopalatal [ɥ].

On the other hand, the child NN produced the target forms containing glides at the earliest data collected at age 0;9. Without the consideration of positions, the three glides [w], [j], [ɥ] are stabilized at 1;11, 1;8, and 1;11. The stabilization of the labiovelar [w] in the initial position, prenuclear position, and postnuclear position are at age 1;5, 1;9, 1;11, and the stabilization of the palatal [j] in the initial position, prenuclear position and prenuclear position are at age 1;0, 1;5, 2;2. As for the less produced labiopalatal [ɥ], the stabilization of the initial position and the prenuclear position is at age 1;9 and 2;0.

The developmental process of the Mandarin three glides [w, j. ɥ] throughout 17 months of the two normally-developing children WW and NN are presented in Figure 5.1 and Figure 5.2. The vertical axis represents the PCC and the horizontal axis represents the age. The blue line, orange line, and red line represent [w], [j] and [ɥ] respectively.

Figure 5.1 illustrates the stability trend of the Mandarin three glides in WW's data from age 0;10 to 2;5, from which we found that the labiovelar [w] and palatal [j] demonstrate higher stability than the labiopalatal [ɥ]. Moreover, the palatal [j] seems to be even more stable than the labiovelar [w] since the orange line is above the blue line throughout the developmental process.

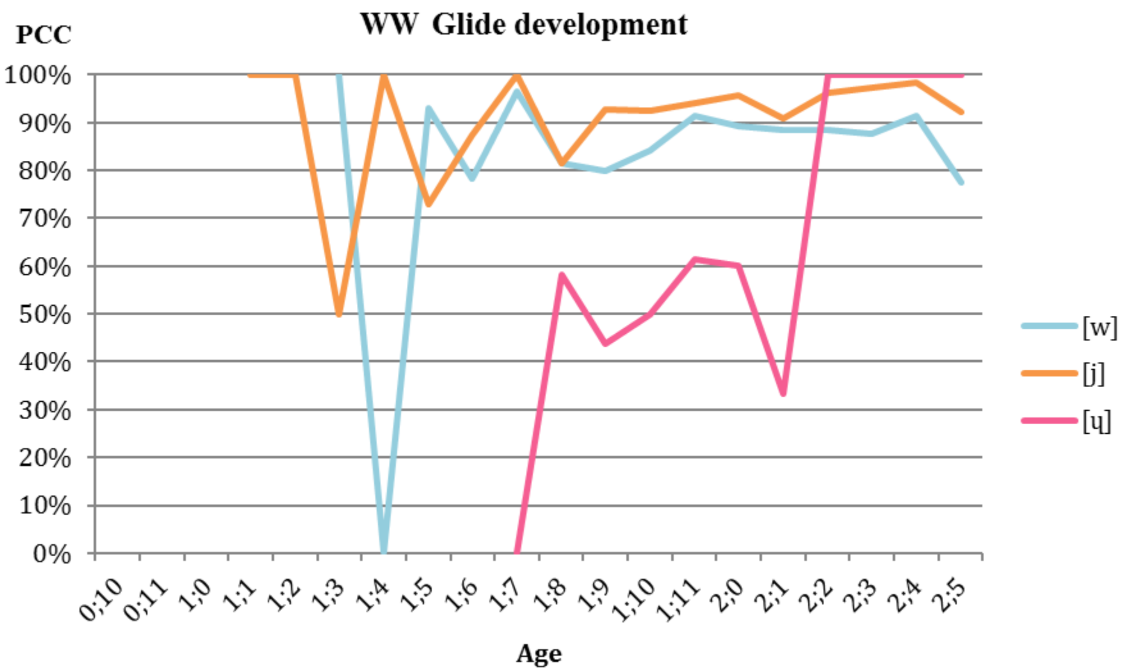

Figure 5.1 Glide development of WW

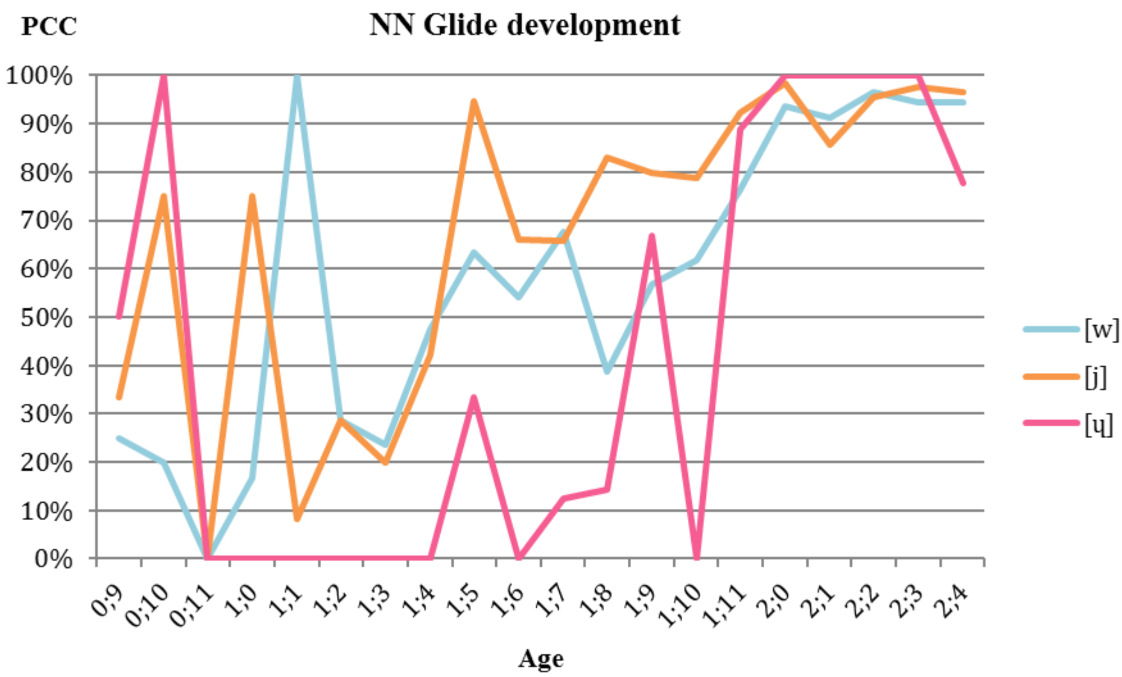

Figure 5.2 Glide development of NN

Figure 5.2 shows the glide the stability trend of the Mandarin three glides in NN’s data from age 0;9 to 2;4. Similar to WW’s stability trend, the palatal [j] performs higher stability than labiovelar [w] and labiopalatal [ɥ]. Nonetheless, to compare Figure 5.1 and Figure 5.2, we discovered that NN’s data underwent greater fluctuation.

The order of the stabilization of the three glides can be drawn from the analysis above, Table 4.43 and Table 4.44 present the age of stabilization of each glide in terms of three positions.

Table 4.43 Age of stabilization of glides in relation to three positions (WW)

WW	1;1	1;2	1;3	1;4	1;5	1;6	1;7	1;8	1;9	1;10	1;11	2;0
Initial			[w]	[j]					[ɥ]			
Prenuclear					[j]							[w]
Postnuclear					[w]		[j]					

We can summarize that the overall order of the glides stabilization is as follows:

(1e) [j] → [w] →[ɥ]

(2e) [w] Initial >> Postnuclear >> Prenuclear

[j] Initial >> Prenuclear >> Postnuclear

[ɥ] Initial >> Prenuclear

(3e) I [w] >> I [j] >> Pre [j]/ Post [w] >> Post [j] >> I [ɥ] >> Pre [w] >> Pre [ɥ]

Table 4.44 Age of stabilization of glides in relation to three positions (NN)

NN	1;0	1;1	1;2	1;3	1;4	1;5	1;7	1;8	1;9	1;11	2;0	2;1	2;2
Initial	[j]					[w]			[ɥ]				
Prenuclear						[j]			[w]		[ɥ]		
Postnuclear										[w]			[j]

(1f) [j] → [w] / [ɥ]

(2f) [w] Initial >> Prenuclear >> Postnuclear

[j] Initial >> Prenuclear >> Postnuclear

[ɥ] Initial >> Prenuclear

(3f) I [j] >> I [w] / Pre [j] >> I [ɥ] / Pre [w] >> Post [w] >> Pre [ɥ] >> Post [j]

(1e) and (1f) show the overall stabilization order of the three glides concerning all the data together in both children. The stabilization order of WW is [j], followed by [w], and [ɥ] whereas the stabilization order of NN is [j] followed by [w] and [ɥ]. (2e) and (2f) list the stabilization order of the glides in light of positions. The labiovelar [w] and labiopalatal [ɥ] have the identical order in positions. The initial positions of the two glides are the first to stabilize, followed by the prenuclear position. The postnuclear [w] is stabilized later than prenuclear [w]. However, for the palatal [j], although the initial position is the first to stabilize as the other two glides, the stabilization order of the prenuclear and postnuclear positions is the opposite to that of the other two glides. (3e) and (3f) present the overall order of the three glides in terms of the three positions.

4.3 Glide performance of the phonologically-disordered group

Regarding the phonologically-disordered group, a boy and a girl diagnosed with phonological disorder and engaged in language therapy in Taipei Veterans General Hospital have participated in the observation process for 6 months. The data of the boy, LL, included in this study are between 4;3 and 4;9 and the data of the girl, HH, are between 3;10 and 4;3. The findings of the total distribution and PCC/PCE of glides in relation to various positions during the 6-month observation were presented in Table 4.45 below.

Table 4.45 Distribution and PCC/PCE of glides in phonologically-disordered group

	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	440	564	973	1977	468	654	648	1770	29	87	116	3824
Error	14	85	160	259	16	13	203	232	4	13	17	508
Frequency	454	649	1133	2236	484	667	851	2002	33	100	133	4371
PCE	3.1 %	13.1 %	14.1 %	11.6 %	3.3 %	1.9 %	23.9 %	11.6 %	12.1 %	13.0 %	12.8 %	11.6 %
PCC	96.9 %	86.9 %	85.9 %	88.4 %	96.7 %	98.1 %	76.1 %	88.4 %	87.9 %	87.0 %	87.2 %	87.5 %

The total production of glides in the phonologically-disordered group is 4371, with 3824 produced accurately and 508 produced with errors. The distribution of the three glides [w], [j], [ɥ] is 2236, 2002, 133. Interestingly, the number of the labiovelar [w] is similar to the palatal [j]. Besides, the PCE and PCC are identical. Despite the fact that the PCC of the labiopalatal [ɥ] resembles those in other two glides, the number of tokens is far lower. The PCC differences between the initial position and other positions are highly significant in [w] and the initial-final group in [j] ([w] I M: *Z*=5.72, *P*<.001***; [w] I F: *Z*=6.36, *P*<.001***; [j] I F: *Z*=9.74, *P*<.001***); however, the initial-medial group of [j] and [ɥ] are not significant, showing that the PCC of these two groups resemble each other.

Table 4.46 and table 4.47 tell the glide performance of the two children with phonological disorder. LL's data is laid out in Table 4.46.

Table 4.46 Total distribution and PCC/PCE of glides (age 4;3-4;9) of LL

4;3-4;9	[w]			[w] sum	[j]			[j] sum	[ɥ]		[ɥ] sum	Total
	I	M	F		I	M	F		I	M		
Correct	85	308	527	920	149	297	201	647	22	8	30	1597
Error	6	67	30	103	8	4	147	159	2	0	2	264
Frequency	91	375	557	1023	157	301	348	806	24	8	32	1861
PCE	6.6%	17.9%	5.4%	10.1%	5.1%	1.3%	42.2%	19.7%	8.3%	0%	6.3%	14.2%
PCC	93.4%	82.1%	94.6%	89.9%	94.9%	98.7%	57.8%	80.3%	91.67%	100%	93.8%	85.8%

The total number of production of the Mandarin three glides is 1861, in which 1023 are [w], 806 are [j], and 32 are [ɥ]. Among the 1861 glides produced by LL, 264 were produced with errors, which consist of 103 error productions in [w], 159 inaccurate productions in [j], and only two errors in [ɥ]. The total PCC is 14.7% and the PCC for the three glides [w, j, ɥ] is 10.1%, 19.7%, and 6.3%. Taking the positional factors into account, we found that most of the glides are produced with high accuracy rate, with PCC reaching 90% level. However, the prenuclear [w] and postnuclear [j] are subjected to errors. The PCE are 17.9% and 42.2% respectively.

Table 4.47 Total distribution and PCC/PCE of glides (age 3;10-4;3) of HH

3;10-4;3	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Correct	355	256	446	1057	319	357	447	1123	7	79	86	2266
Error	8	18	130	156	8	9	56	73	2	13	15	244
Frequency	363	274	576	1213	327	366	503	1196	9	92	101	2510
PCE	2.2 %	6.6 %	11.1 %	12.9 %	2.4 %	2.5 %	11.1 %	6.1 %	22.2 %	14.1 %	14.9 %	9.7 %
PCC	97.8 %	93.4 %	88.9 %	87.1 %	97.6 %	97.5 %	88.9 %	93.9 %	77.8 %	85.9 %	85.1 %	90.2 %

Table 4.47 exhibits the glides distribution and PCC/PCE of HH from 3;10 to 4:3. In total, HH produced 2510 glides, 1213 of which are labiovelar [w], 1196 of which are palatal [j], and 101 of which are labiopalatal [ɥ]. The distribution of the labiovelar [w]

in initial position, prenuclear position, and postnuclear position is 363, 274, 576; the distribution of palatal [j] in the three positions is 327, 366, 503; and the distribution of [ɥ] in the initial and prenuclear position is 9 and 92. The [w] and [j] occurred in the postnuclear position appear to have slightly higher PCE, indicating that the glides in coda position are prone to errors comparing to the initial and prenuclear position.

4.4 Phonological processes and patterns

This section discussed the phonological processes involved in the production of two groups. The tokens are presented in section 4.3.1, and the percentages of each phonological process are computed in section 4.3.2.

4.4.1 Tokens of Phonological Processes

The phonological processes involving in young children's system are widely discussed across languages. Cross-linguistic studies reported high similarity on processes used by children (Grunwell, 1982; Bortolini & Leonard, 1991; So & Dodd, 1995; Zhu, 2002). Zhu (2002) classified the process involving glides as triphthong reduction and diphthong reduction, which refers to the reducing process of onglide and offglide. From the data collected from the normally-developing children group and phonologically-disordered group, three processes including Deletion, Substitution, and Metathesis, and were identified. If the children alter the target syllable with a totally different form of combination, leading to the indecipherable of the phonological processes, the data will be excluded.

First of all, Deletion is defined as a process that removes a segment from certain phonetic contexts, which is commonly seen in young children's production. (O'Grady, Archibald, Katamba, 2011). The examples in the normally-developing group are [ɑw] for [jɑw] 'want', [tej] for [twej] 'yes', and [ka] for [kaj] 'lid'. In the first example, the [j] sound was removed in the initial position of [jɑw] 'want' and in the second example, the prenuclear [w] was omitted. The third example shows that the postnuclear [j] was dropped in the syllable-final position. The second type of phonological process is Substitution, referring to the systematic replacement of one sound by an alternative that the child finds easier to articulate (O'Grady, Archibald, Katamba, 2011). The common substitution process involves an early-acquired sound taking the place of the later-acquired sounds. For example, WW produced [xaw jow] for [xaj jow] 'still', replacing the postnuclear [j] with [w], and [ɕjɛ] for [ɕɥɛ] 'boot', using [j] as a substitute for the later acquired [ɥ]. The third type of process is Metathesis, referring to the reordering of a sequence of segments, is found in cross-linguistic studies (Bortolini & Leonard, 1991; O’Grady, Archibald, Katamba, 2011). The examples given are [tow] for [tswɔ] ‘sit’ and [kja] for [ts^{h}aj] ‘vegetable’. The two examples show that the child exchanges the vowels with the postnuclear glides. Since the labiopalatal [ɥ] is not likely to appear in the final position of a syllable in Mandarin; as a result, we did not found any metathesis of [ɥ].

Table 4.48 Numbers of phonological processes in normally-developing group

Normally-developing group	*w*	*j*	*ɥ*	*total*
Deletion	417	237	10	664
Substitution	31	13	52	96
Metathesis	24	13		37

Table 4.48 shows the number of the three phonological processes of the three glides detected in the normally-developing group. There are 237 deletion, 13 substitution, and 13 metathesis in labiovelar [w], 417 deletion, 31 substitution, and 24 metathesis in palatal [j], 10 deletion, 52 substitution in [ɥ]. The total numbers of deletion, substitution, and metathesis of the three glides are 664, 96, 37.

Table 4.49 and Table 4.50 report the numbers of phonological processes in the subgroups. The numbers of phonological processes used by WW are shown in Table

4.49. There are 95 deletion, 18 substitution, and five metathesis in labiovelar [w], 63 deletion, nine substitution, and five metathesis in palatal [j], six deletion and 21 substitution in [ɥ]. In total, there are 164 deletion, 48 substitution, and 22 metathesis used by WW.

Table 4.49 Numbers of phonological processes in WW

WW	*w*	*j*	*ɥ*	*total*
Deletion	95	63	6	164
Substitution	18	9	21	48
Metathesis	17	5		22

Table 4.50 Numbers of phonological processes in NN

NN	*w*	*j*	*ɥ*	*total*
Deletion	322	174	4	500
Substitution	13	4	31	48
Metathesis	7	8		15

Table 4.50 shows the numbers of phonological processes in NN. For the labiovelar [w], 322 deletion, 13 substitution, and seven metathesis were used; for the palatal [j], 174 deletion, 4 substitution, and 8 metathesis were used; for the labiopalatal [ɥ], four deletion and 31 substitution were used. In total, there are 500 deletion, 48 substitution, and 15 metathesis used by NN.

Table. 4.51 Numbers of phonological processes in phonologically-disordered group

Phonologically-disordered group	*w*	*j*	*ɥ*	*total*
Deletion	169	218	6	393
Substitution	86	5	11	102
Metathesis	5	11		16

Table 4.51 presents the number of the three phonological processes of the three glides detected in the phonologically-disordered group. There are 169 deletion, 86 substitution, and five metathesis in labiovelar [w], 218 deletion, five substitution, and 11 metathesis in palatal [j], six deletion, 11 substitution in [ɥ]. The total numbers of deletion, substitution, and metathesis of the three glides are 393, 102, 16.

Table 4.52 Numbers of phonological processes in LL

LL	*w*	*j*	*ɥ*	*total*
Deletion	36	152	0	188
Substitution	65	1	2	68
Metathesis	3	8		11

The numbers of phonological processes used by LL are shown in Table 4.52. There are 36 deletion, 65 substitution, and three metathesis in labiovelar [w], 152 deletion, one substitution, and eight metathesis in palatal [j], zero deletion and two substitution in [ɥ]. In total, there are 188 deletion, 68 substitution, and 11 metathesis used by LL.

Table 4.53 Numbers of phonological processes in HH

HH	*w*	*j*	*ɥ*	*total*
Deletion	133	66	6	205
Substitution	21	4	9	34
Metathesis	2	3		5

Table 4.53 lays out the numbers of phonological processes in HH. For the labiovelar [w], 133 deletion, 21 substitution, and two metathesis were used; for the palatal [j], 66 deletion, four substitution, and three metathesis were used; for the labiopalatal [ɥ], six deletion and nine substitution were used. In total, there are 205 deletion, 34 substitution, and five metathesis used by HH.

4.4.2 Percentages of phonological processes

In order to compare the preference of each phonological process in the two groups, the percentages of each phonological process were calculated. Table 4.54 demonstrated the percentage of each phonological process identified in normally-developing group.

Table 4.54 Percentages of phonological processes in normally-developing group

Normally-developing group	*w*	*j*	*ɥ*	*total*
Deletion	88.3%	90.1%	16.1%	83.3%
Substitution	6.6%	4.9%	83.9%	12.0%
Metathesis	5.1%	4.9%		4.6%

The children in normally-developing group used 88.3% of deletion, 6.6% of substitution and 5.1% of metathesis for the production of the labiovelar [w], and 90.1% of deletion, 4.9% of substitution and metathesis of the palatal [j]. In addition, the children used 16.1% of deletion and 83.9% of substitution for the labiopalatal [ɥ].

It seems normally-developing children tend to adopt more deletion than other processes. The percentage of deletion was found to be statistically significantly higher than the other two processes (p<.001***); nevertheless, if we take a closer look at the three glides themselves, we might discover that although the deletion in [w] and [j] are also significantly higher than the other two processes (p<.001***), the children tend to use substitution for the labiopalatal [ɥ] (p<.001***).

On the other hand, with respect to the child from the phonologically-disordered group, the percentages of the three phonological processes of each glide were presented in Table 4.55.

Table 4.55 Percentages of phonological processes in phonologically-disordered group

Phonologically-disordered group	*w*	*j*	*ɥ*	*total*
Deletion	65.0%	93.2%	35.3%	76.9%
Substitution	33.1%	2.1%	64.7%	20.0%
Metathesis	1.9%	4.7%		3.1%

Based on Table 4.55, the most commonly phonological process is deletion and the least applied process is metathesis, which is identical to that of the normally-developing group. The deletion process is statistically significant ($p<.001$***). The percentages of the deletion, substitution and metathesis are 83.3%, 12.0%, and 4.6% respectively. For the labiovelar [w] and palatal [j], the most commonly applied processes are deletion. The percentages are significantly higher than those in the other two processes ($p<.001$***). However, similar to the normally-developing children, the children tend to apply substitution more than deletion for the production of labiopalatal [ɥ] ($Z=1.71$, $P<.05$*).

Chapter 5

Discussion

In this section, the summary of the study and the findings will be briefly restated in section 5.1. Section 5.2 discusses the interaction of the markedness constraint and the positional effect with regard to the emergence and stabilization of glides in child's production. In section 5.3, the comparison of the glide performance and phonological processes in both normally-developing group and phonologically-disordered group are reported. Section 5.4 provides concluding remarks for the present study.

5.1 Summary of the study

This study aims to describe the developmental order and phonological processes of the three Mandarin glides [w, j, ɥ] in terms of three word positions, including initial glides, prenuclear glides, and postnuclear glides, and further compare the normative data with phonological disorder data in order to explore the possible different phonological processes between the two groups of children. The study has examined two girls through 17 months in the normally-developing group and a boy and a girl through 6 months of observation in the phonologically-disordered group. In the case of normally-developing group, three aspects are investigated, including the age of emergence of the three glides, the age of stabilization, and the phonological processes involved in the production of the children. As for the children with phonological disorder, the discussion covers the numbers and percentages of each glide and the odd patterns along with phonological processes involved in the production. In total, 9792 glides are analyzed in the study, inclusive of 5421 from the normally-developing children and 4371 from the children with phonological disorder.

5.2 Interaction of markedness and positional prominence hierarchy

In this section, the interaction of markedness constraint and positional effect affecting the performance of glides in children's data was discussed. Section 5.2.1 focuses on the interaction on the emergence and section 5.2.2 focuses on the interaction reflected in the stabilization process.

5.2.1 Markedness and positional prominence hierarchy in glide emergence

For an easy reference, the emergence order of the three glides are restated in (a) (b) (c) (d) below:

(a) [j] → [w] → [ɥ] (WW)

(b) [j] / [w] → [ɥ] (NN)

(c) Post [j] >>> I [w] >>> I [j]/ Pre [j]/ Post [w] >>> Pre [w] >>> Pre [ɥ] >>> Post [ɥ] (WW)

(d) I [j]/ Pre [j]/ Post [j]/ I [w]/ Post [w] >>> Pre [w] >>> I [ɥ] >>> Pre [ɥ] (NN)

(a) and (b) show the order of the emergence of the three glides in WW and NN's data. The unmarked palatal [j] and labiovelar [w] emerged earlier in both of the children's data whereas the marked labiopalatal [ɥ] emerged later. The findings comply with the markedness theory, suggesting that the emergence of unmarked sounds precede marked ones in children's phonetic development. On the other hand, (c) and (d) reported the emergence order in relation to the three positions, from which we found that the positional factor might not be critical to the emergence order of the three glides, since the glides in each position did not appear with a positional order. Accordingly, the order of glide emergence in children's data seems to be predominated by the markedness constraints, while the positional effect does not seem to play a main role in it.

5.2.2 Markedness and positional prominence hierarchy in glide stabilization

The order of the stabilization of Mandarin three glides [w, j, ɥ] and the stabilization of the three glides in relation to the three positions are laid out again below for an easier reference. (1a), (1b), and (1c) report the order of stabilization in WW's data and (2a), (2b), and (2c) report the order of stabilization in NN's data.

The stabilization order of WW:

(1a) [j] → [w] →[ɥ]

(1b) [w] Initial >> Postnuclear >> Prenuclear

[j] Initial >> Prenuclear >> Postnuclear

[ɥ] Initial >> Prenuclear

(1c) I [w] >> I [j] >> Pre [j]/ Post [w] >> Post [j] >> I [ɥ] >> Pre [w] >> Pre [ɥ]

The stabilization order of NN:

(2a) [j] → [w] / [ɥ]

(2b) [w] Initial >> Prenuclear >> Postnuclear

[j] Initial >> Prenuclear >> Postnuclear

[ɥ] Initial >> Prenuclear

(2c) I [j] >> I [w] / Pre [j] >> I [ɥ] >> Pre [w] >> Post [w] >> Pre [ɥ] >> Post [j]

Firstly, the order of the stabilization of the three glides without considering positions is listed in (1a) and (2a), showing that the palatal [j] is the first to stabilize among the three glides. However, the stabilization of the labiovelar [w] precedes labiopalatal [ɥ] in only one child's data. The other child's data suggest that the two glides are stabilized simultaneously. The results indicate that the three glides in the surface forms follow the acquisition order of their underlying vowels reported in previous studies, in which the universal path for vowel development is the high front [i] acquired before the high back rounded [u], and the high front [y] is acquired relatively late (Li, 1977, Jeng, 1979, Su, 1985). The developmental order of glides in Taiwan Mandarin reported in present study differs from that in English shown in previous cross-sectional studies, in which the labiovelar [w] is acquired before the palatal [j] (Wellman *et al*., 1931; Poole, 1934; Templin, 1957; Smit, 1990). The order of the glide development is in accordance with the Jakobson's (1914/1968) proposal of the acquisition order of features and the markedness theory discussed in Greenberg (1966). The anterior sounds precede the posterior ones, unrounded feature before rounded feature, and the unmarked sounds are acquired before the marked ones. As a result, the relatively marked vowel [y] sound and its corresponding surface form [ɥ] were both found to acquired later in child's system comparing to the less marked [i]/[j] and [u]/[w].

Secondly, among the three positions, the glides occurred in the initial position were the first to stabilize in the two children's production, while the glides in the other two positions, namely prenuclear and postnuclear positions, underwent a longer period of fluctuation before their stabilization. A possible explanation lies in the positional prominence hierarchy theory. The initial position is more prominent in comparison to the non-initial positions within a word (Jiménez & Lloret, 2013). Furthermore, the saliency of the word-initial positions is attested in several psycholinguistics experiments on word recognition lexical access and the diachronic studies on language change (Nooteboom, 1981; Menéndez Pidal, 1985; Hawkins & Cutler, 1988). As a result, the glides occurred in the initial position are resistant to phonological processes during the developmental progress of young children. On the other hand, the prenuclear glides attached to the initial consonants, forming a CG sequence, are prone to errors as well as the postnuclear glides, which appear in the coda position. These two positions are viewed as weak positions; therefore, the glides were stabilized later in these two positions.

Thirdly, the sequences listed in (3a) and (3b) are the interaction between the markedness constraint of segments and the positional prominence hierarchy. The less marked sounds in a more prominent position namely initial [w] and [j] are the first to stabilize while the marked sound in a weak position is the last to stabilize. In addition, from the results in (3a) and (3b), we deduce that the markedness constraint prevails over the positional prominence hierarchy during the child phonological development since the unmarked sounds in the non-initial positions stabilized earlier than the marked sound in the initial position and the marked sound in the initial position stabilized later than the unmarked sounds in the non-initial position. In other words, the markedness constraint predominates the overall stabilization process in child phonological acquisition with positional prominence hierarchy regulating under it.

5.3 Comparison of glide performance in the two groups

This section compares the performance of glides in the normally-developing group and phonologically-disordered group. Section 5.3.1 report the PCC differences in the two groups and the odd patterns detected in the phonologically-disordered group. Section 5.3.2 discusses the phonological processes used in the two groups.

5.3.1 Glide performance in the two groups

Normally-developing group of children produced both the labiovelar [w] and palatal [j] steadily. However, due to the low PCC in prenuclear [ɥ], the accuracy rate of the overall [ɥ] is relatively low. On the other hand, the overall production in the phonologically-disordered group of children demonstrates relatively high PCC. The PCC of glide performance in the two groups is listed in Table 5.1. The three glides in phonologically-disordered group have statistically significantly higher PCC than that in normally-developing group except for the palatal [j] ([w]: Z=6.10, P<.001***; [ɥ]: Z=5.19, P<.001***; total: Z=4.75, P<.001***). The palatal [j] in normally-developing group has statistically significantly higher PCC than in the phonologically-disordered group ([j]: Z=7.31, P<.001***) .

Table 5.1 PCC of glides in the two groups

	[w]			[w]	[j]			[j]	[ɥ]		[ɥ]	Total
	I	M	F	sum	I	M	F	sum	I	M	sum	
Normally-developing group	95.8%	80.2%	80.2%	82.2%	95.6%	92.9%	81.8%	89.5%	90.2%	44.7%	59.7%	85.1%
phonologically-disordered group	96.9%	86.9%	85.9%	88.4%	96.7%	98.1%	76.1%	88.4%	87.9%	87.0%	87.2%	87.5%

By comparing the three glides in each position of the two groups, we found that the glides in prenuclear and postnuclear position in the phonologically-disordered group have statistically significantly higher PCC than those in the normally-developing group except for the postnuclear palatal [j]. Besides, all the glides in the initial position do not have statistical significance in differences. This is in accord with the hypothesis that the glides in the syllable-initial position are more prominent and thus are resistant to errors. Accordingly, the glides in the syllable-initial position in the two groups are both produced with high stability and do not display differences in statistical analysis.

Regarding the normally-developing group, the glides in the initial position have statistically significantly higher PCC than those in the prenulcear and postnuclear positions; however, the PCC differences between the initial position and other positions are highly significant in only [w] and the initial-final group in [j] in the phonologically-disordered group ([w] I M : Z=5.72, P<.001***; [w] I F: Z=6.36, P<.001***; [j] I F : Z=9.74, P<.001***). The initial-medial group of [j] and [ɥ] are not significant, showing that the PCC of these two groups resemble each other ([j] I M : Z=-1.44, P>0.05; [ɥ] I M : Z=0.13, P>0.05). This finding can be attributed to the age differences in the two group, in which the children in the phonologically-disordered group are older while the normally-developing children are younger. Since the prenuclear palatal [j] and the prenuclear [ɥ] have reached the higher stability reflected in their PCC. As a result, both the initial position and prenuclear position in [j] and [ɥ] have high PCC, and do not show significant differences in statistical analysis.

With respect to the group with phonological disorder, several odd patterns were detected in the glide performance. The children consistently produced the later acquired sound [ɥ] as a substitute for the earlier acquired [w] in the initial and prenuclear positions. For example, LL produced [ʂwej] 'water' as [ɕɥɛ], and [tʰi ɥɛ] for [tsʰɨ wej] 'hedgehog'. Previous research has described a similar phenomenon in

English-speaking children with phonological disorder, who consistently replaced presumably earlier developing sounds with a presumably later-developing sound (Lorentz, 1974; Weiner, 1981; Grunwell, 1981; Leonard & Brown, 1984; Leonard, 1985).

The error patterns involving glides discovered in normally-developing group do not found to violate the phonotactic constraints in Mandarin; however, the error patterns identified in the phonologically-disordered group were found to violate the phonotactic constraints in Mandarin. For example, the child produced [kʰɥɛ] for [tʂʰwej]. The combination of velar aspirated plosive and the high front rounded glide *kʰɥ is illegal formed in Taiwan Mandarin.

5.3.2 phonological processes in the two groups

The phonological processes of glides found in the two groups include deletion, substitution, and metathesis, in which the deletion process is the most common process in the two groups (p<.001***). Moreover, the two groups show the preference of applying substitution for the labiopalatal [ɥ]. The percentage of the substitution in [ɥ] is statistically more significant at the 0.05 level than the deletion process (*Z*=1.71, *P*<.05*). One possible explanation for the preference of substitution process used by both groups of children when producing the labiopalatal [ɥ] is that the [ɥ] sound is a marked sound which was acquired relatively late. Therefore, by the time the labiopalatal [ɥ] emerged, the palatal [j] and [w] had already reached a certain level of stability. Moreover, the substitution process was found to be used by older children (Zhu, 2002). As a result, when children were about to produce the labiopalatal [ɥ], they normally had the two abilities in hand, to produce unmarked glides [j, w] and to use substitution process.

One of the children in the phonologically-disordered group namely LL used more substitution in the labiovelar [w], which differs from the normally-developing group of children. This finding is attributed to the odd patterns detected in his production since he constantly replaced the earlier acquired labiovelar [w] with the later acquired labiopalatal [ɥ]. Therefore, the number of substitution is higher than in the labiovelar [w].

5.4 Concluding remarks

The purpose of the present study is to report the developmental order of three

Mandarin glides [w, j, ɥ] in terms of three word positions, word-initially, word-medially, and word-finally, and further compare the normative data with phonological disorder data in order to explore the possible different processes between the two groups of children. A longitudinal study was carried out for the investigation of two normally-developing children, aged between 0;9-2;4 and 0;10-2;4, and two phonologically-disordered children, one of whom is between 4;3 and 4;9, and the other between 3;10 and 4;3.

In response to the first research question, the order and the emergence order of each glides in relation to positions are as follows:

(c) Post [j] >>> I [w] >>> I [j]/ Pre [j]/ Post [w] >>> Pre [w] >>> Pre [ɥ] >>> I [ɥ] (WW)

(d) I [j]/ Pre [j]/ Post [j]/ I [w]/ Post [w] >>> Pre [w] >>> I [ɥ] >>> Pre [ɥ] (NN)

The emergence order of the three glides presented in (c) and (d) suggests that it is not directly influenced by the positional factor. Rather, it is more related to the level of markedness of the sounds itself. The [j] and [w] in three positions emerged at similar period while the [ɥ] sounds in two positions appear relatively late.

The second research question is concerned with the order of stabilization of the three glides in relation to three positions. The results of the order are presented below:

(3e) I [w] >> I [j] >> Pre [j]/ Post [w] >> Post [j] >> I [ɥ] >> Pre [w] >> Pre [ɥ]

(3f) I [j] >> I [w] / Pre [j] >> I [ɥ] / Pre [w] >> Post [w] >> Pre [ɥ] >> Post [j]

We found that the glides in initial positions were the first to stabilize in the children's system and were produced with fewer errors; furthermore, the order of development of the three glides without considering the position factors is accordance with the vowel developmental order found in previous studies. The results showed that the markedness constraint predominates the glide development and the positional prominence hierarchy regulates under it (Jakobson, 1914/1968; Greenberg, 1966; Jiménez & Lloret, 2013). The interactions between the markedness constraint and positional prominence hierarchy are reflected in children's developmental order of glides.

The third research question is concerned with the glide performance in the two groups and the phonological processes used by the phonologically-disordered child. The findings indicated that the glides in the syllable initial position are more resistant to errors, similar to the results found in the normative data. The three phonological processes found in both of the groups are deletion, substitution, and metathesis, in which the deletion process is most commonly seen in children's data; however, the most commonly seen process for labiopalatal [ɥ] is substitution. Moreover, we also found that the phonologically-disordered group of children consistently replaced the presumably later-developing [ɥ] with the presumably earlier-developing [w]. Concerning the phonotactic constraints in Taiwan Mandarin, the child from the phonologically-disordered group produced sound sequence like *k^{h}ɥ that violate the phonotactic constraints of Taiwan Mandarin, whereas the child from the normally-developing group tends to follow the Taiwan Mandarin's phonotactic constraints.

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