Lexicon-Phonology Relationships in Cantonese-speaking Children: A Cross-sectional and Longitudinal Investigation

Chan Wai Yin, Cathy

A dissertation submitted in partial fulfillment of the requirements for the Bachelor of Sciences (Speech and Hearing Sciences), The University of Hong Kong, 2 May 2003

Abstract

The phonological composition of the developing vocabularies of children aged between 16 and 30 months was investigated. Data was obtained from the Cantonese Communicative Developmental Inventory (CCDI), a parent report instrument. Results showed that the sound classes found frequently in the early attempted lexicon were reported to be acquired earlier by children in the literature. The words beginning with consonants that developed later were also attempted more by the older children than the younger children in the sample. The relationship found in Cantonese is similar to that reported for English by Stoel-Gammon (1998). Further investigation on the phonological production of thirty-one children tested one year after the CCDI report showed that there was a strong correlation between the frequency of occurrence of phones in words reported in the CCDI and the acquisition of the phones by the children one year later. Children reported to have greater vocabulary size in the CCDI also developed more late developing consonants in their phonetic inventory.

KEY WORDS: lexicon, phonology, CCDI, parent report instrument, Cantonese

The lexicon-phonology interface in language acquisition in children has been studied extensively in the past several decades, especially in infants who produce fewer than 50 words (Storkel & Morrisette, 2002). A large body of literature has demonstrated that the phonetic parameters characterizing first words were also characteristics of prior babble (Ferguson & Farwell, 1975; Stoel-Gammon & Cooper, 1984; Vihman, 1993a; Vihman, Ferguson, & Elbert, 1986). Stoel-Gammon and Cooper compared the babbling consonant repertoires of three children in the month before onset of words with the consonant repertoires noted in the children's first 50 words. Results showed that the vocal patterns of the three children's first 50 words were most similar to their babble patterns. Similar findings were reported in the study by Vihman, Ferguson and Elbert. In their study of 10 subjects, they considered the development of vocalization patterns in the subjects during the transition from essentially no word to a cumulative vocabulary of about 50 words. The data reviewed a continuous interaction between the emerging early words and the contemporaneous babble.

The continuity between the babbling phonetic patterns and the forms of the child's early words has been accounted for by a model of interaction between perception and production by Vihman (1993b). During the prelinguistic stage of babbling, a subset of sound patterns of the ambient language becomes more familiar to the child by virtue of frequent occurrence and inherent interest of the child. Vocal motor schemes (VMS) are thus developed through repetitive practice on these vocal patterns. The VMS acts as "articulatory filter" which selectively enhances motoric recall of the words whose phonetic patterns matched with the child's VMS. As the child develops articulatory control, the words passed by the "articulatory filter" are more likely to be attempted by the child and, once in appropriate context, will be the earliest recognizable word production. Beyond the earliest words, with the increasing vocal motor control together with the expansion of lexicon, the early-unrelated vocal forms develop into a first holistic system and some of the child's word shapes assume the status of production "template" (McCune & Vihman, 2001). A template is defined as consistent phonetic pattern on the basis of the child's existing phonic forms (Vihman &

Velleman, 2000). Children would select target words with patterns same as the template or adapted less narrowly selected targeted words to fit the template pattern.

At this stage, the child's phonology is less systematic and the production of a single phoneme may vary considerably across words. Children make good use of their limited phonetic inventories by selecting vocabularies that contain consonants from their inventories and avoiding vocabularies with consonants not under their control – a phenomenon termed "phonological selectivity and avoidance" (Ferguson & Farwell, 1975). This can be evidenced by the experimental study of the phenomenon in 12 children (aged 1;0.21 to 1;3.15 at onset of study) by Schwartz and Leonard (1982). In their study, the 12 children were presented with 16 sets of words, eight sets involved words with phonological characteristics "in" the child's phonetic repertoire ("IN" words) and eight sets involved words with phonological characteristics "out" of the child's repertoire ("OUT" words). During ten bi-weekly experimental sessions, IN words were produced in greater numbers and in earlier sessions than OUT words by the children. This provided evidence for the influence of phonological selection and avoidance on children's early lexicon acquisition.

The effect of phonological selectivity and avoidance on lexicon acquisition was, however, limited to a time when children produced fewer than 50 words (Schwartz & Leonard, 1982). It is suggested that there is a rapid advance in word learning rate as children cross the 50-word period and there is fundamental change in word learning process. Children also transit from a holistic to an analytic phonological system, with a corresponding change in phonological learning, during that period (Ferguson & Farwell, 1975; Locke, 1983). Thus, the strong influence of a child's phonological system on lexical acquisition declines with age. Children eventually attempt words with phonetic features beyond their capabilities. As the children acquire greater productive vocabularies, they have more practice with phonological production and this practice itself enhances phonological development. The improved phonology, in turn, provides more support for the production of different words. In view of that, Paul and Jennings (1992) and Stoel-Gammon (1998) proposed a bi-directional relationship between lexical and phonological acquisition beyond

the first 50-word period.

The bi-directional relationship between lexicon and phonology beyond the first 50-word period could be viewed through Stoel-Gammon's (1991) data of 34 normal two-year-old children. Stoel-Gammon (1991) showed that there was a strong correlation between vocabulary size and size of phonetic inventories in the children. The strong tendency for synchrony between the development of the lexicon and the phonological system has also been reported in studies of late talkers (e.g., Rescorla & Ratner, 1996; Paul & Jennings, 1992; Thal, Oroz & McCaw, 1995). Paul and Jennings compared the phonological behavior of 28 toddlers with slow expressive language development with 25 normal-developing children. The results showed that the children with slow expressive language development were phonologically less advanced. They performed poorer than their normally speaking peers on all three global measures of phonological maturity: size of phonetic inventory, averaged complexity of canonical shapes, and percentage of consonants correct (PCC). These findings strengthen the suggestion made by Stoel-Gammon (1998) that lexical and phonological developments are intimately connected during the early stages of language acquisition. The direction of causation is, however, unknown yet. Paul and Jennings suggested that the late talkers might have poor phonological skills, reflecting slow oral motor or phonological processing abilities, and that this lag was a primary cause of their limited vocabulary size. On the contrary, the late talkers might have less practice with phonological production because of delayed lexical development. The lack of practice retarded their phonological development as a result.

Storkel and Morrisette (2002) tried to explain the lexicon-phonological relationships beyond the first 50-word period with a two-representation model of spoken word processing. The model assumes that two types of representation (lexical and phonological) exist and interact with one another. There are facilitory connections between the lexical and phonological representations. That is, once a lexical representation is activated, its corresponding phonological representation will also be activated and vice versa. These connections between lexical and phonological representations thus allow for interaction between lexical and phonological processing. A limited

number of experimental studies have demonstrated how intensive treatments on one domain of representation promote the development in the other representation (Storkel & Morrisette). One of these studies demonstrated that treatment focused on increasing a child's expressive vocabulary led to subsequent improvements in phonological diversity in young children with expressive language delay (Girolametto, Pearce & Weitzman, 1997). An expansion of vocabulary in this case went hand in hand with an expansion of the sound system.

To conclude, the observation of the positive relationship between lexical and phonological development in the abovementioned studies is fruitful in understanding language acquisition in children. Studies to date are however restricted for the most part to English-speaking children. The few studies that examined the lexicon-phonology relationships outside English include Stoel-Gammon, William and Buder's (1994) study of Swedish and Pye, Ingram and List's (1987) study of Quiche, a Mayan language. Stoel-Gammon, William and Buder examined the acquisition of coronal stops in English and Swedish and they found that the relatively early acquisition of the coronal stops could be accounted for by the high frequency of these phones in early words in both languages. Pye, et al., on the other hand, examined the development of phonology in Quiche-speaking children. By measuring the frequency of initial consonants in Quiche children's vocabulary, Pye et al. compared this measure to the children's order of phonological acquisition and found a statistically significant result between the two variables. It should be noted that the children's phonology is a reflection of their lexical organization, not just the frequency with which a sound occurs in adult speech. Thus, the frequency of occurrence of consonants in both studies was worked out from the child's lexicon, not the adult's input lexicon.

The lexicon-phonology relationships in Cantonese were also investigated in a study by Ma (2002). Ma collected spontaneous speech sample at three-month interval of six Cantonese-speaking children, aged between 1;04 and 2;06 at entry of study, over a year. Her findings revealed a significant correlation between lexicon size and size of phonetic inventory and she suggested a positive relationship between lexical and phonological development in Cantonese,

as in English and other language mentioned above. Nevertheless, there appears to be no previous report to date investigating the lexicon-phonology relationships in Cantonese-speaking children qualitatively. Stoel-Gammon (1998) has tried to examine the issue in English-speaking children. She examined general phonological characteristics of children's early vocabularies by analyzing words from the MacArthur Communicative Development Inventory (CDI), a parent report instrument (Fenson et al., 1993). The study showed that the sound classes found frequently in the early attempted lexicon were acquired earlier than sound classes that occurred less frequently. For example, bilabial consonants occurred most frequently in word-initial position and were shown to be the earliest manner class acquired by children. Besides, Stoel-Gammon (1998) also showed that younger children attempted more words that started with earlier developed sound class than words that started with later developed sound class.

Aims of the present study

The aim of the present study was to examine the link between lexical and phonological development in Cantonese beyond the first 50-word period quantitatively as well as qualitatively. In order to do so, the study of Stoel-Gammon (1998) was replicated, with adaptation to the phonological system in Cantonese mentioned in the following sections. The possibility for any language-specific difference in the interaction of lexical and phonological development would be located.

The first section of this study was carried out in a cross-sectional study. We examined the relative frequency of different phonetic patterns of the vocabularies attempted by children aged between 16 and 30 months, as reported in a parent report instrument – Cantonese Communicative Developmental Inventory (CCDI), and investigated how it was related to the phonological behaviors of typically developing children. There were two parts:

i) Part I compared the composition of phoneme classes in the words reported to be attempted by children at 30 months with the documented patterns of early phonological acquisition reported

in the literature.

ii) Part II focused on investigating the developmental trend in the early lexicon to see how the frequency of occurrence of phonological patterns in the attempted vocabularies changed over the period of 16-30 months.

After examining the relationship between lexical and phonological development in Cantonese-speaking children in the cross-sectional data, a longitudinal study of thirty-one children was reported. The longitudinal analysis would show how the lexical development of the children, as revealed by the CCDI, related to their phonological developments one year later. This was first done by comparing the frequency of occurrence of individual consonant in words attempted by the children with the production accuracy of individual consonant one year later. The variety of consonant type in the children's phonetic inventory was then examined and related to their lexicon size as reported in the CCDI. The implications of the findings for further research on the interaction between lexical and phonological development and the possible clinical values of the findings were discussed at the end of the paper.

Cantonese Phonology

Cantonese is a Chinese dialect spoken by over 40 million speakers worldwide (Bauer and Benedict, 1997). The Cantonese system differs from English on four main dimensions: phonotactic structure, number of contrastive consonants, aspiration contrast, and tonal contrast. The phonotactic structure in Cantonese is relatively simple, with syllables consisting of C, V, VC, CV, CVV, and CVC. Onset and coda are optional while the nucleus is an obligatory element.

By traditional classification system (Hashimoto, 1972), Cantonese has 19 syllable-initial and six syllable-final segments. However, there is a trend towards deletion of initial velar nasal /ŋ-/ and the partial merging of initial /n-/ with /l-/ in modern spoken Cantonese. That is, /ŋ-/ is produced as null-initial form and /n-/ is realized frequently as [l-] (Zee, 1999). Similarly, there is a neutralization of final /-ŋ/ to /-n/ (Cheung, 2000). Thus, the inventory of Cantonese consonants

underwent changes to 17 initials and five finals (see Table 1).

The range of manner of production in Cantonese is similar to English, except with the absence of rhotic /r/. The distribution of manner of production across place of articulation and laryngeal involvement is however quite different. For example, in Cantonese, fricatives occur at labiodental (/f/), alveolar (/s/) and glottal (/h/) positions only and affricates occur at alveolar position only (/ts/ and /ts^h/). There are no clusters in Cantonese and /k^w/ and /k^{wh}/ are analyzed as labialised velars as they are coarticulated and so can be regarded as a single segment (Bauer & Benedict, 1997).

Table 1. The Cantonese Consonant System

	Bilabial	**Labiodental**	**Alveolar**	**Palatal**	**Velar**	**Glottal**
Syllabic initial						
Nasal	m					
Plosive	p p^h		t t^h		k k^h	
					k^w k^{wh}	
Affricates			ts ts^h			
Fricatives		f	s			h
Glide	w			j		
Lateral			l			
Syllabic final	m p		n t		k	

With regard to laryngeal feature, all Cantonese phonemes are unvoiced. The stops and affricates have aspirated and unaspirated pairs. As with the unvoiced/voiced contrast, the aspirated/unaspirated contrast is phonemic. Besides, unlike English, Cantonese has tone as a contrastive feature. There are six lexical tones in Cantonese, high-level (subscript 1 for example /hœŋ$_1$ tsiu$_1$/ "banana"), high-rising (subscript 2), mid-level (subscript 3), low-falling (subscript 4), low-rising (subscript 5), and low-level (subscript 6). There are 11 vowels (ɑ, i, e, u, ɐ, œ, y, ʊ, ɔ, ɛ,

ɵ) and 10 diphthongs (ɑi, ɐi, ɐi, ɔi, ui, ɑu, ɐu, ou, iu, ɐy). A large-scale cross-sectional study reported complete acquisition of vowels as well as tones before two years of age (So & Dodd, 1995). Thus, the development of the consonant system will be the target in the present study.

Method

Intake Instrument

The vocabularies analyzed in the study were extracted from the Cantonese Communicative Developmental Inventories (CCDI) (Tardif, Fletcher, C.S.B. Leung & S.L. Leung, in prep), which is an adapted version of the MacArthur Communicative Developmental Inventory (Fenson et al., 1993). The CCDI is a parent report form that assesses productive vocabulary by means of a checklist of the words most commonly found in children's early vocabularies. It was reported to have good concurrent validity with the Cantonese version of the Reynell Developmental Language Scale (Tardif et al.). The test-retest reliability of CCDI was also found to be high (Tardif et al.).

There are two sets of CCDI: CCDI: Infant (Word and Gesture) was designated for use with 8 to 16 months old children and CCDI: Toddler (Word and Sentence) was designed for use with 16 to 30 months old children. Only the CCDI: Toddler was tallied in this study and it includes two parts. Part I checks child's productive vocabulary and word combination and part II assesses child's morphological and syntactic development. Only part I of the CCDI: Toddler, which lists 804 words organized into 24 semantic categories, was considered in the study because it entails words found commonly in children from 16 to 30 months, which is the age range that word spurt commonly occurs (Ingram, 1989). Thus the CCDI: Toddler helps to explore the relationship between lexical and phonological acquisition in the period beyond the first 50-word.

The validity of parent checklists as estimates of expressive vocabulary has been discussed widely and they were found to be good indices of this variable (Dale, Bates, Reznick & Morisset, 1989). It is also relatively quick and easy for parents to mark on the CCDI and thus makes it possible to provide information about an extensive and representative list of words in a large pool

of subjects. From the CCDI, we can obtain information on the phonological make-up of vocabularies that the children are prepared to attempt. It should be noted that the information obtained is about the phonological characteristics of the targeted vocabularies, but not the child's exact production of those words.

Participants

Cross-sectional study. Nine hundred and eighty seven children (503 boys and 484 girls), ranging between 16 and 30 months of age, were selected to participate in the norming study of the CCDI: Toddler. The children were selected from five Mother Child Health Centres (MCHC) in Hong Kong. All of them were reported to have normal birth-weight, gestation period and intelligence based on records in the MCHC. The mean number of parents completing the inventory for each month is 66 (min.: 47 parents at month 16, max.: 74 parents at month 23).

Longitudinal study. Thirty-one children, 12 boys and 19 girls, served as subjects in the longitudinal study. They were invited to participate in a picture-naming task, as part of a follow-up study of children who took part in the original data collection. All of them were 18 to 20 months old by the time their parents completed the CCDI: Toddler; and aged between 30 and 32 months at entry into the follow-up study. The 31 children were divided into two subgroups based on their results in part I of the CCDI: Toddler. Of the 31 children, 19 scored in the top tenth percentile in the CCDI: Toddler for their age and were in the High group; while the remaining 12 scored in the middle tenth percentile and were in the Middle group. The mean productive vocabulary size for the High group and Middle group as reported in the CCDI were 341 words (SD: 76.3 words) and 82 words (SD: 47.0 words) respectively. Children who scored in the lowest tenth percentile in the CCDI: Toddler were not included in this study because they were at risk for delays in language development (Fenson et al., 1993). (See Appendix I for subject information)

The Corpus and Procedure

Cross-sectional study. The parents of the 987 participants completed the CCDI: Toddlers via interviews with research assistants. The parents were asked to mark the words in the CCDI: Toddler that their children could produce spontaneously.

After collecting all the CCDI: Toddler, an age of acquisition (AoA) was assigned to each word on the CCDI: Toddler. The AoA is defined as the earliest age that 50% or more of the children in one age group have attempted to produce the word as reported by the parents in the norming study. For example, the AoA for the words 媽咪 "mummy", 妹妹 "sister" and 草 "grass" were 16 months, 23 months and 30 months respectively (see Appendix II for AoA of all words on CCDI: Toddler). The phonological analysis in the present study was based on the words that met the criterion for AoA by a particular age. For example, 532 words were included by the age of 30 months. Proper names, including names of person, places, toys and games, and animal sounds were excluded from the data due to their wide variance in phonological forms (Stoel-Gammon, 1998). One hundred and eleven words were excluded from the analysis in this way.

Longitudinal study. Thirty-one children were invited to participate in a picture-naming task one year after their parents completed the CCDI: Toddler. Each child labeled 55 pictures (Wong & Stokes, 2001), selected to ensure that all Cantonese initial consonants, except /k^{wh}/ which occurred infrequently in child's language, were elicited three times in different vowel contexts (see Appendix III for the complete word list). The target words were either monosyllabic or disyllabic. The data were recorded on Sony minidisks using a Sony portable minidisk recorder MZ-R50 and an Aiwa Type CM-TS22 unidirectional microphone, which was clipped on the subjects' clothing at chest level.

The recordings were transcribed phonetically by the author using broad IPA transcription. During the transcription process, the author was blind to the subjects' performance in the CCDI: Toddler. Ten per cent of the data were transcribed independently by another undergraduate student trained in phonetics, to evaluate inter-rater transcription reliability. Another ten per cent of the data

were re-transcribed by the author about one month after the first transcription to determine the intra-rater reliability. Point-to-point inter-rater and intra-rater reliability checks on initial consonants of the data were 91% and 97% respectively.

Data analyses

Cross-sectional study. The phonological characteristics of the initial consonants of the words reaching AoA between 16 and 30 months were analyzed. Only the 17 initial consonants mentioned in Table 1 were targeted in the present study and they were analyzed based on place and manner of articulation. The place classes include: bilabial, labiodental, alveolar, palatal, velar and glottal; while the manner classes include: plosive (unaspirated/aspirated), fricative, affricate (unaspirated/aspirated), nasal, liquid and glide. We measured the frequency of occurrence of different sound classes in the attempted vocabularies and compared this measure to the order of phonological acquisition reported in the literature. After that, the initial consonants were subdivided into three groupings according to their order of development using a criterion of 90% correct production of children aged between 2;0 to 6;0 (So & Dodd, 1995). The three groupings are 'early developing sounds' /p, t, m, w, j/, 'middle developing sounds' /h, l, k, p^h, t^h, k^h/, and 'late developing sounds' /f, s, ts, ts^h/. The proportion of early, middle and late developing consonants appears in the words reaching AoA at 16-22 months and at 23-30 months were then computed.

Longitudinal study. For the word-list samples in the picture-naming task, independent, rather than relational, analyses was used. That is, the consonants that were produced twice in a child's sample, regardless of the accuracy of production relative to the target words, were included in the child's phonetic inventory (Stoel-Gammon, 1985 & 1987). Only spontaneous responses from the picture-naming task were counted in the phonetic inventory. The consonant /k^{wh}/ was excluded from the analysis because it occurred only once in the word-list. The phonetic inventory for each child was first tallied. Then, the number of children who had individual consonant in their phonetic

inventories was counted for each consonant. Pearson's correlation was computed between the frequency of occurrence of each consonant in the children's developing vocabularies, defined as the words that were reported to be attempted by half or more of the thirty-one subjects, and the number of children who had the consonants in their phonetic inventories.

In addition, the mean number of early, middle, and late developing consonants in the children's phonetic inventories was tabulated for the Middle and High groups. Independent t-test was used in analyzing any difference between the two groups.

Results

Cross-sectional Study

The goal of the analysis was to characterize the phonological systems (for initial consonants) of the lexicon of children from 16-30 months, insofar as these are revealed by words reported as attempted via the CCDI. The frequency of occurrence of sound classes in the target lexicon was then compared with the phonological behaviors of typically developing children reported in the literature.

Part I: General trends of phonological composition of the lexicon attempted by children by 30 months

A total of 532 words met the criterion for AoA by 30 months. Figure 1 and 2 presented the analyses of initial consonants of the 532 words. Manner of articulation for consonants was displaced in Figure 1 and place of articulation was in Figure 2.

From Figure 1, it could be seen that unaspirated plosives constituted the most frequent manner class, accounting for 24.6% of all initial consonants in the attempted vocabularies. Fricatives were the next most frequent manner class (23.9%), followed by aspirated plosives (10.5%) and liquids (9.0%). In comparing the unaspirated/aspirated pairs of plosives and affricates, the unaspirated counterpart always predominated in word-initial position (unaspirated plosive: 24.6%, aspirated plosive: 10.5%; unaspirated affricate: 8.8%, aspirated affricate: 8.3%).

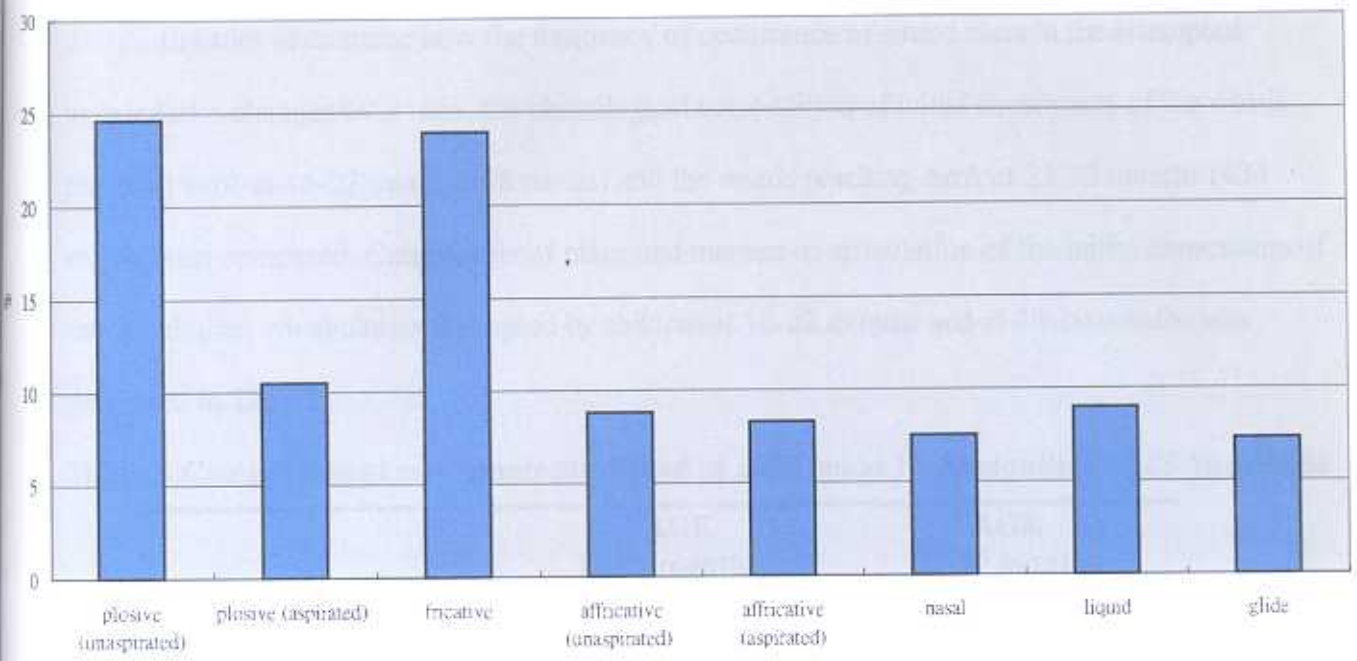

Figure 1. Words (reaching AoA by 30 months) from the CCDI classified according to manner of articulation of initial consonants.

In terms of place of articulation (Figure 2), the most prominent observation was the domination of alveolar place (53.0%) of articulation in the six possible places of articulation in Cantonese.

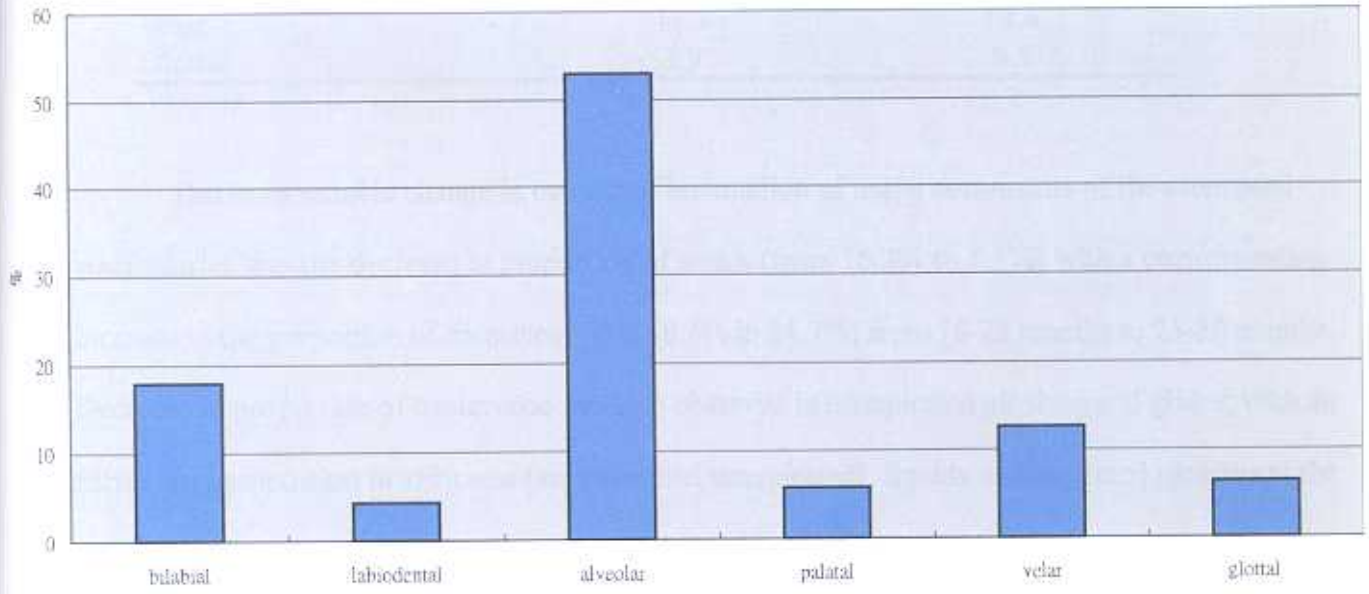

Figure 2. Words (reaching AoA by 30 months) from the CCDI classified according to place of articulation

Part II: Developmental trends of phonological patterns in early lexicon

In order to examine how the frequency of occurrence of sound class in the attempted vocabularies changes over time, the phonological composition of initial consonants of the words reaching AoA at 16-22 months (98 words) and the words reaching AoA at 23-30 months (434 words) was compared. Comparison of place and manner of articulation of the initial consonants of the developing vocabularies attempted by children at 16-22 months and at 23-30 months was presented in Table 2.

Table 2. Comparison of consonants attempted by children at 16-22 months and 23-30 months

	AGE 16-22 months %	AGE 23-30 months %
Manner of articulation		
Plosive (unaspirated)	28.6	23.7
Plosive (aspirated)	7.4	11.3
Fricative	18.4	24.7
Affricative (unaspirated)	6.1	9.0
Affricative (aspirated)	6.1	9.2
Nasal	16.3	5.5
Liquid	4.0	8.5
Glide	15.3	7.6
Place of articulation		
Bilabial	35.7	14.3
Labiodental	3.1	5.6
Alveolar	34.7	57.1
Palatal	9.2	4.1
Velar	11.3	13.4
Glottal	5.9	6.5

The most notable change in manner of articulation of initial consonants of the attempted vocabularies was the decrease in proportion of nasals (from 16.3% to 5.5%) with a corresponding increase in the proportion of fricatives (from 18.4% to 24.7%) from 16-22 months to 23-30 months. Decrease in proportion of occurrence was also observed in unaspirated plosives and glides; with an increase in proportion in affricates (aspirated and unaspirated), liquids and aspirated plosives at the same time. For place of articulation, the sharpest change was a decrease in the proportion of bilabial consonants (from 35.7% to 14.3%) and similar degree of increase in the proportion of

alveolars (from 34.7% to 57.1%) from 16-22 months to 23-30 months.

Developmental changes in frequency of occurrence of particular phonemes

The developmental trends of phonological patterns of early lexicon were also observed by looking at the developmental change in frequency of occurrence of particular phonemes of the vocabularies reported as attempted by the children. Figure 3 presented a comparison of consonants across three data sets: 1) words in the CCDI: Toddler reaching AoA at 16-22 months (Young group) (98 words); 2) words in the CCDI: Toddler reaching AoA at 23-30 months (Old group) (434 words); and 3) all words in the CCDI: Toddler (All) (693 words).

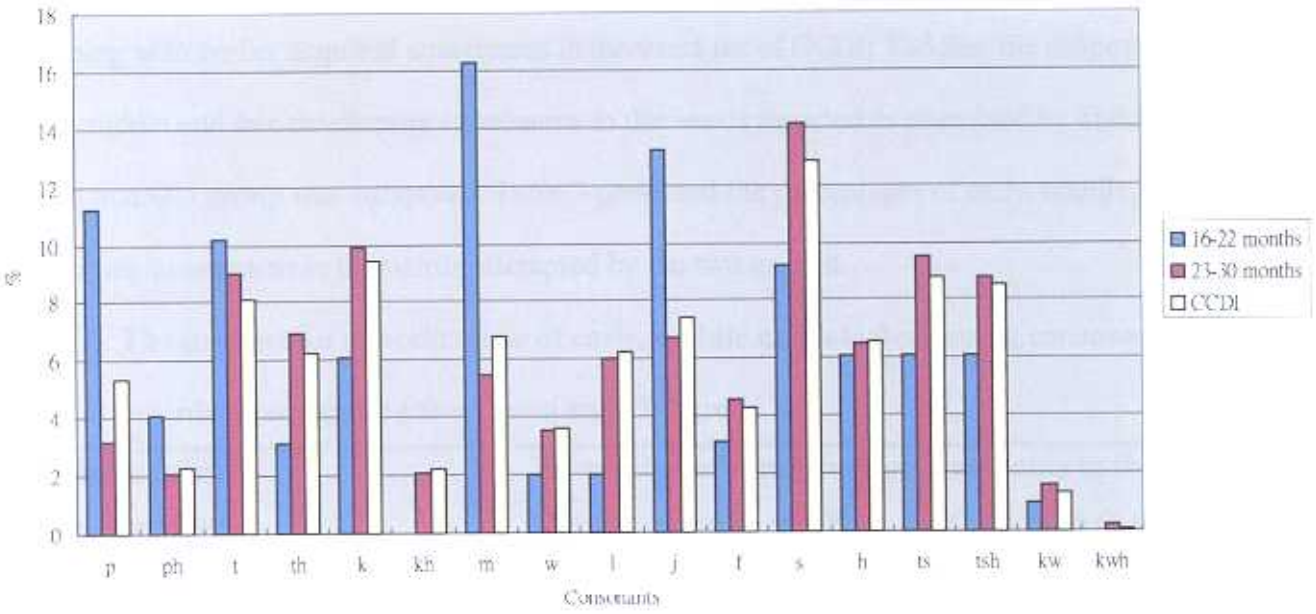

Figure 3. Comparison of consonants of the words attempted by children at 16-22 months (Young group), at 23-30 months (Old group) and all words in the CCDI: Toddler (All)

Three aspects of Figure 3 merit attention. First, the nasal /m/ accounted for 16.3% of initial phonemes of the words attempted at 16-22 months. The proportion declined dramatically, from 16.3% to 5.5%, at 23-30 months and it became more similar to the proportion included in the word list in the CCDI. A similar trend was observed for the phonemes /p/, /p^h/ and /j/.

Second, words beginning with /s/ were rare in the early vocabulary (only 9.2%); but /s/ was the most frequent initial consonants in the late vocabulary (14.1%) and the CCDI word list (12.8%). Similar patterns of changes happened with the other two fricatives (/f/ and /h/), the lateral (/l/), the affricates (/ts/ and /ts^h/) and the aspirated counterpart of alveolar and velar stops (/t^h/, /k^h/ and /k^{wh}/). The proportion of these phonemes changed substantially and became more similar to the proportion in the word list of CCDI, when we look from the Young group to the Old group and All group.

Third, the proportion of plosives in the Young group was in the descending order of /p/ (11.2%), /t/ (10.2%) and /k/ (6.1%). This was the same as Cheung's (2000) finding that the order of acquisition of plosives was usually labial /p/, alveolar /t/ and then velar /k/.

To give a clear picture that the Young group (16-22 months) showed bias towards words beginning with earlier acquired consonants in the word list of CCDI: Toddler, the proportion of early, middle and late developing consonants in the words reported as attempted by children in the Young and Old group was computed. Table 3 presented the percentages of early, middle, and late developing consonants in the words attempted by the two groups.

Table 3. The proportion of occurrence of early, middle and late developing consonants in the words attempted by the Young and Old group

Sub-category of consonants	**Proportion of occurrence of consonants in the words**	
	Young group (n = 448)	**Old group (n = 539)**
Early developing consonants /p, t, m. w, j/	51.0 %	28.3 %
Middle developing consonants /h, l , k, p^h, t^h, k^h/	23.5 %	33.0 %
Late developing consonants /f, s, ts, ts^h/	25.5 %	38.7 %

An examination of the proportion in Table 3 revealed that the Young group tended to

attempt words that begin with early developing consonants. Same bias was not observed in the Old group. The Old group attempted a greater proportion of late developing consonants and the proportion of words beginning with early, middle and late developing consonants was evenly distributed.

Longitudinal study

In the longitudinal study, the frequency of occurrence of individual consonant in the words attempted by the thirty-one subjects at 18-20 months, as reported in the CCDI, was compared with the number of children who have these consonants in their phonetic inventories, as tested in the naming task one year later at 30-32 months. In Figure 4, the bar represents the frequency of initial consonants in the words that have been attempted by 50% of the thirty-one subjects at 18-20 months; while the line represents the number of children reaching criteria for successful production on individual consonant in the picture-naming task at 30-32 months. In general, consonants that occurred more frequently in the words were produced correctly by more children one year later. The Pearson's correlation between the frequency and acquisition orders was 0.63 ($p < 0.05$).

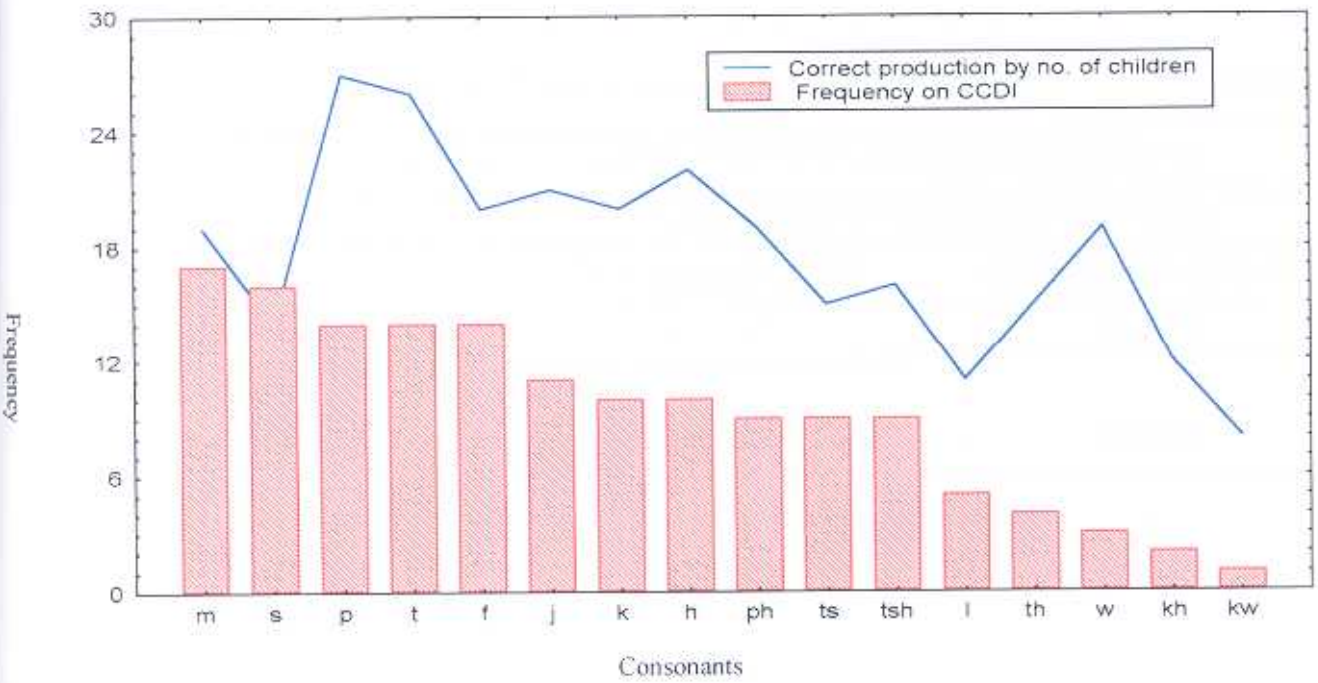

Figure 4. Comparison of frequency of occurrence of consonants in words attempted at 18-20 months with number of children producing the consonants correctly at 30-32 months

Though a significant correlation was found between the frequency of initial consonants in the words attempted by the children and the number of children producing the consonants correctly one year later, discrepancies between the two variables were apparent. For example, sharp peaks were noted in Figure 4 for the accuracy of production of the consonants /p/, /h/, and /w/. The accuracy of production of these initial consonants was greater than expected based on frequency of occurrence of these consonants in the words attempted by the children as reported in the CCDI: Toddler. On the other hand, the production of the consonants /s/, /f/ and /ts/ was less accurate than expected based on the frequency of occurrence of these consonants.

Comparison using Subgroups based on result in the CCDI: Toddler

The mean number of initial consonants in the phonetic inventory of the High group and the Middle group of the thirty-one subjects were counted. The mean number of initial consonants produced by the High group (n = 19) was 10 (SD = 2.9); while the mean number of initial consonants produced by the Middle group (n = 12) was 7 (SD = 3.6). The difference was significant [$t(29) = 2.63$, $p < 0.05$]. Further analyses of distribution of the consonants into early, middle and late developing consonants were displayed for the High and Middle groups in Table 4.

Table 4. Mean and standard deviation for the number of early, middle and late developing consonants in the words attempted by the High group and Middle group

Sub-category of consonants	**Mean number of consonants in the words**	
	High group (n = 19)	**Middle group (n = 12)**
Early developing consonants /p, t, m. w, j/	3.9 (1.2)	3.2 (1.5)
Middle developing consonants /h, l , k, p^h, t^h, k^h/	3.6 (1.4)	2.4 (1.6)
Late developing consonants /f, s, ts, ts^h/	2.5 (1.2)	1.5 (4.5)

Note. Number in parenthesis represents the SD for the number of initial consonants in the attempted word

A comparison between the High group and Middle group in Table 4 showed that the High group acquired a greater number of consonants in all three subgroups of initial consonants than the Middle group. However, significant difference between the High group and Middle group only appeared in middle [$t(29) = 2.23$, $p < 0.05$] and late developing consonants [$p(29) = 2.13$, $p < 0.05$], but not in terms of early developing consonants.

Discussion

Cross-sectional study

The cross-sectional data examined the developing vocabularies of children acquiring Cantonese, with a focus on the phonological composition in the vocabularies attempted by children between 16 and 30 months. The data supported the notion that there was a bi-directional relationship between lexical and phonological development.

Part I: General trends of phonological composition of the lexicon attempted by children by 30 months

The CCDI: Toddler provided information on the 532 most frequently used words of 987 children aged 16-30 months. The results showed that the phonological characteristics that occurred frequently in the words reported as attempted by the children on the CCDI: Toddler matched those reported as occurring earlier in production data. The phonological characteristics reported less often via the CCDI were those reported as occurring later or more prone to error in production data. This was evidenced by the following parallels between frequency of sound class in the words reported as attempted by the children and the production data reported in the literature:

Place of articulation. The lexical analysis showed that plosive constituted the most frequent manner class in word initial position; while phonological production data also showed that plosive were acquired early in phonological development and were often served as substitutes for target fricative and affricate (i.e. stopping) (So & Dodd, 1995).

Unaspirated consonants constituted a higher proportion in words attempted by the children

than the corresponding aspirated counterparts. This coincided with the findings in the literature that unaspirated phonemes were acquired earlier than the aspirated phonemes (Cheung, 2000) and deaspiration was one of the most common phonological processes in normal children (So & Dodd, 1995).

Place of articulation. The lexical analysis showed that bilabial and alveolar consonants occurred more frequently than velar; while phonological production data also reviewed that bilabial and alveolar were acquired earlier and that alveolar was often served as substitutes for velar (i.e. velar fronting) (So & Dodd, 1995).

The domination of alveolar in word-initial position also followed the description that coronal was the default place of articulation and it was the unmarked feature at the place node in typically developing children (Bernhardt & Stoel-Gammon, 1994).

The match between frequency of occurrence of sound classes across children's lexicon and the production data was not perfect, however. In particular, fricative was the second most frequent class of consonants, accounting for approximately 23.9% of initial consonants in target lexicon (Figure 1). In contrast, the production data showed that, the class of fricative was acquired relatively late. In this case, data on frequency of occurrence in the current study was not supported by data on phonological production in the literature. The difficulty in producing fricative in children despite its high functional load might due to its articulatory difficulty and this would be discussed in the later part of this study.

To conclude, there was a close relationship between the frequency of occurrence of sound class in the lexicon attempted by the children and the phonological production data reported from children's spontaneous speech in the literature. The direction of relationship was not known from the data set. It might be that the children tried to attempt words with phonemes they were capable to produce, and the practice on production of the lexicon in turns led to early acquisition of the phonemes in the lexicon.

Part II: Developmental trends of phonological patterns in early lexicon

The bi-directional relationship between lexicon and phonology was also reviewed by looking at developing trends of phonological patterns in the early lexicon to see how frequency of occurrence of phonological patterns changed over time. This was first examined by comparing the sound classes of the initial consonants in the words reported as attempted by children at 16-22 months and in the words reported as attempted at 23-30 months. In going from younger to older age range, there was an increase in proportion of sound classes that developed later and a corresponding decrease in proportion of sound classes that developed earlier. For example, there was a decrease in the proportion of plosive consonants and a sharp increase in the proportional occurrence of fricative and affricate (Table 2). Given that fricative and affricate were reported to be acquired later than plosive (So & Dodd, 1995), the observed changes in the attempted words suggest a developmental trend toward words beginning with sound classes that developed later. Similar findings were reported in Stoel-Gammon's (1998) study. Stoel-Gammon reported that there was a decrease in the proportion of stop consonants with a corresponding increase in the proportion of fricative and liquid in word-initial position. Thus, this showed that the universal trend of later production of fricative, affricate and liquid was also observed in the lexicon attempted by children.

By looking at the developmental change in frequency of occurrence of particular phonemes in the developing vocabularies, the bias of the younger group, which were phonologically less capable, towards words beginning with earlier developed consonants in the word list of the CCDI: Toddler was clearer. This could be viewed by three significant observations in Figure 3. First of all, the phonemes /m/, /p/, /p^h/ and /j/ were all segments reported to be acquired early by children (Cheung, 2000; So & Dodd, 1995) and there was an extensive appearance of these phonemes in vocabularies of Young group (16-22 months). When compared with the vocabularies of the Old group (23-30 months), the proportion of these phonemes declined dramatically and became more similar to the proportion in the word list in the CCDI: Toddler. By contrast, the proportion of the

later developed segments /s/, /f/, /h/, /l/, /ts/ /ts^{h}/, /t^{h}/, /k^{h}/ and /k^{wh}/ increased substantially across the age range from 16-22 months to 23-30 months and became more similar to the proportion in the word list of CCDI: Toddler. Moreover, the distribution of bilabial, alveolar and velar plosives in the vocabularies attempted by the Young group was in the same order of acquisition of plosives in the data reported by Cheung (2000).

The abovementioned observations showed that, for the younger group (16-22 months), they attempted fewer words beginning with consonants that were reported to be acquired later; when they got older (23-30 months), more words beginning with late consonants were attempted. Similar patterns were observed when we examined the proportion of early, middle and late developing consonants in the Young and Old groups (Table 3). The consonants reported as attempted more in the Young group were those that typically occur earlier in the speech of normal developing children (i.e. early developing consonants).

The developmental trend of phonological patterns in the early lexicon followed similar trend with the order of phonological acquisition in typically developing children. The two developmental patterns were inter-related and seemed to be mutually influential to each other. Thus, we might make estimate of the lexicon developmental pattern based on the phonology developmental pattern or vice versa.

Longitudinal study

The longitudinal data related the lexical development of 31 children to their phonological development one year later. The frequency of occurrence of consonants in the words attempted by the children was found to be statistically significant with the number of children producing those consonants correctly one year later. That is, the more frequent the consonants reported as attempted by the children in the lexicon, the more children producing the consonants correctly one year later. The frequency of the consonants of the vocabularies attempted by the children was close to the order in which the children acquired those consonants one year later.

Despite the high correlation found between frequency of consonants in early lexicon and production accuracy one year later, discrepancies were apparent. For example, accuracy of production of the consonants /p/, /h/, and /w/ was greater than would be expected based on frequency of occurrence in the lexicon; whereas production of the consonants /s/, /f/ and /ts/ was less accurate than expected. In these cases, the variable of ease of articulation may be a contributing factor. Consonants that are easier to produce, such as stops and glides, were produced more correctly even though they occurred less frequently than consonants that were more difficult in articulation – namely, fricative and affricate. A similar finding was observed in Pye et al.'s (1987) and Stoel-Gammon's (1998) studies. Thus, in considering the strong relationship between patterns of phonological acquisition and frequency of occurrence of the sound class in the lexicon, other factors must also be considered, in particular the relative ease of articulation of particular phonemes.

Further comparison between the High group and the Middle group of the thirty-one children in terms of the number of consonants in their phonetic inventories showed that the High group acquired a greater number of consonants than the Middle group. By analyzing the consonants in terms of early, middle and late developing consonants, the High group had a significantly more middle and late developing consonants than the Middle group. The data supported the notion that children who scored higher in the CCDI: Toddler were phonologically more advanced than those who scored lower in the CCDI: Toddler one year later. These findings strengthen the suggestion made by Stoel-Gammon (1998) that speech and language development are intimately connected during the early stages of development. The direction of causation for this relation is, however, unknown. Whatever the direction of causation is, children with better vocabulary development appear to show better phonological development. The analysis of distribution of consonants in the children's phonetic inventories showed that children who attempted less vocabulary acquired significantly less phones that typically occur later (middle and late developing consonants). The finding suggested that the performance of the children in the

CCDI: Toddler might be used as a good indicator of one's phonological developments a year later. Children with severe delay in vocabulary development as revealed in the CCDI should be examined for any phonological delay/disorder as well.

Summary

The current study showed that no cross-language difference was present in the relationship between lexical and phonological development in Cantonese-speaking children. Comparison of the phonological patterns in vocabularies attempted by the children as reported in CCDI in the current study with the patterns of phonological acquisition data reported in literature showed that the relationship is bi-directional in nature. The phonemes that occur more often tend to be acquired earlier. There was also bias in younger children in attempting lexicon. The consonants attempted by younger children in their lexicon tended to be those that other studies have shown to be acquired early in Cantonese-speaking children. Thus, the general thesis is that phonological and phonetic factors shape early lexical acquisition in certain ways and, in a reciprocal fashion; certain aspects of early lexicon determined the early phonological acquisition (see also Schwartz, 1988; Stoel-Gammon, 1998; Storkel & Morrisette, 2002).

The longitudinal data in the study also showed that phonemes that occurred more frequently in the developing vocabularies were acquired by more children one year later. Children who scored poorer in the CCDI: Toddler had a more limited size of phonetic inventory, with the major difficulty laid on the middle- and late-developing sounds. This finding suggested the predictive value of the CCDI in diagnosing children with expressive vocabulary for their phonological development.

Clinical Implication

The finding of a continued interaction between lexicon and phonology in Cantonese beyond the first 50-word period has important implications in clinical diagnosis and intervention.

First of all, clinical assessment of children who are late to develop speech should include analysis of both lexical and phonological skills. Without adequate evaluation of a child's use of both domains, it is not possible to determine whether a child has difficulty with phonological, lexical or both aspects of the target language. Thus, at least a year follow-up investigation in both lexical and phonological developments should be provided to children who are found to be delay in either domain. Besides, Paul and Jennings (1992) suggested that programs designed to address delays in children with show expressive development should consider targeting both the lexical and phonological aspects for change. This is because lexical and phonological acquisition move forward in synchrony; as the lexicon expands, so does the phonetic inventory needed to support the number of different words the children try to say. Otherwise, there will be lots of homonyms occurring in the children's speech. Intervention should aim at increasing the lexicon as well as expanding the inventory of sounds and syllable structures concurrently.

Moreover, given the evidence documenting an interaction between lexicon and phonology, lexical characteristics may play a role in promoting phoneme acquisition. Gierutt, Morrisette and Champion (1999) indicated that children with functional phonological delays made significant gains in the production accuracy of the target sounds when the children were taught sounds in frequently occurring words. Thus, there is an important role of lexical processing in promoting sound change. In the same sense, phonological variables may provide insights in constructing stimuli for treatment of delays in word learning. In Storkel (2001), children seemed to learn novel words composed of common sound sequences more rapidly than those composed of rare sound sequences. In this case, phonological processing guides novel word learning.

To conclude, as lexicon and phonology was found to influence each another, clinicians have to be careful in making diagnosis for children at risk in either aspect. Besides, they have to consider how the language training of the unaffected domain can be used in facilitating the development of the defected domain in planning treatment for children with phonological or lexical delay. Programs designed to address delays in this population should take both domains of language into

consideration when constructing stimuli in the training.

Further Research

The current study provided observational evidence in supporting the hypothesis that lexical and phonological developments influence one another. Experimental study on children with impairments in both lexical and phonological could be conducted to show how treatment focuses on increasing a child's expressive vocabulary differ from treatment targets on increasing one's phonetic inventory in leading to subsequent change in the non-treated domain. This can be used to testify how the lexical knowledge may influence phonological acquisition or vice versa.

Besides, in the present study, the knowledge of lexical development of children was based on data reported by the parents in the CCDI: Toddler. It provided information on phonological make-up of words on the CCDI word list that were reported as attempted by the children. However, the form of the productions of the vocabularies might vary from the target form (e.g. /hœŋ$_1$ tsiu$_1$/ 'banana' might be produced as /tsiu$_1$ tsiu$_1$/). Thus, the phonology of the attempted vocabularies represents more likely the phonological perception of the children rather than their production. Thus, further research done by collecting spontaneous speech sample of children helps to gain a more representative picture in examining lexical and phonological relationship in young children.

Acknowledgements

I gratefully acknowledge the advice, guidance and support offered by my supervisor, Prof. Paul Fletcher in all phases of the study. Thanks also given to Leung Ka Wai for providing all the necessary information of the CCDI in carrying analysis of the study. Last but not least, I would like to thank Peony Wong for her inspiration and spiritual support throughout the process of the completion of this study. Finally, my heartfelt gratitude follows my Lord Jesus Christ for thy Grace.

References

Benedict, P.K. & Bauer, R.S. (1997). *Modern Cantonese phonology.* Berlin: Mouton de Gruyter.

Bernhardt, B. & Stoel-Gammon, C. (1994). Nonlinear phonology: Introduction and clinical application. *Journal of Speech and Hearing Research, 37*, 123-143.

Cheung, P. (2000). Patterns of phonological disability in Cantonese-speaking children in Hong Kong. *International Journal of Language and Communications Disorders, 35 (4),* 451-493.

Dale, P., Bates, E., Reznick, S. & Morisset, C. (1989). The validity of a parent report instrument of child language at twenty months. *Journal of Child Language, 16*, 239-250.

Fenson, L., Dale, P., Reznick, J.S., Thal, D., Bates, E., Hartung, J., Pethick, S., & Reilly, J. (1993). *MacArthur Communicative Development Inventories (CDI).* San Diego: Singular Publishing Group.

Ferguson, C.A. & Farwell, C. (1975). Words and sounds in early language acquisition: English initial consonants in the first 50 words. *Language, 51*, 419-439.

Gierut, J.A., Morrisette, M.L. & Champion, A.H. (1999). Lexical constraints in phonological acquisition. *Journal of Child Language, 26*, 261-294.

Girolametto, L., Pearce, P.S. & Weitzman, E. (1997). Effects of lexical intervention of the phonology of late talkers. *Journal of Speech, Language, and Hearing Research, 40,* 338-348.

Hashimoto, A.Y. (1972). *Studies in Yue dialects, vol 1: The phonology of Cantonese.* Cambridge: Cambridge University Press.

Ingram, D. (1989). *First language acquisition: Methods, description and explanation.* Cambridge: Cambridge University Press.

Locke, J.L. (1983). Gradual emergence of developmental language disorders. *American Speech-Language-Hearing Association, 37,* 608-616.

Ma, T.W. (2002). Phonological characteristics of children's early lexicon production: Six case studies. Unpublished undergraduate dissertation. The University of Hong Kong.

MuCune, L. & Vihman, M.M. (2001). Early phonetic and lexical development: A productivity approach. *Journal of Speech, Language, and Hearing Research, 44,* 670-684.

Paul, R. & Jennings, P. (1992). Phonological behavior in toddlers with slow expressive language development. *Journal of Speech and Hearing Research, 35,* 99-107.

Pye, C., Ingram, D. & List, H. (1987). A comparison of initial consonant acquisition in English and Quiche. In K.E. Nelson & A. Van Kleeck (Eds.), *Children's language (Vol. 6) (pp. 175 –190).* Hillsdale, NJ: Lawrence Erlbaum Associates.

Rescorlas, L. & Ratner, N.B. (1996). Phonetic profiles of toddlers with expressive language development. *Journal of Speech and Hearing Research, 35*, 99-107.

Schwartz, R.G. (1988). Phonological factors in early lexical acquisition. In M.D. Smith & J.L. Locke (Eds), *The emergent lexicon: The child's development of a linguistic vocabulary.* San Diego: Academic Press.

Schwartz, R.G. & Leonard, L.B. (1982). Do children pick and choose? An examination of phonological selection and avoidance in early lexical acquisition. *Journal of Child Language, 9,* 319-336.

So, L.K.H. & Dodd, B.J. (1995). The acquisition of phonology by Cantonese-speaking children. *Journal of Child Language, 22*, 473-495.

Stoel-Gammon, C. (1985). Phonetic inventories, 15-24 months: A longitudinal study. *Journal of Speech and Hearing Research, 28*, 505-515.

Stoel-Gammon, C. (1987). Phonological skills of 2-year-olds. *Language, Speech and Hearing Services in School, 18,* 323-329.

Stoel-Gammon, C. (1998). Sounds and words in early language acquisition: the relationship between lexical and phonological development. In R. Paul (Ed.), *Exploring the speech-language connection (pp.25-32).* Baltimore: Paul Brookes Publishing.

Stoel-Gammon, C. & Cooper, J. (1984). Patterns of early lexical and phonological development. *Journal of Child Language, 11,* 247-271.

Stoel-Gammon, C. & Williams, K. & Buder, E. (1994). Cross-language differences in phonological acquisition: Swedish and American /t/. *Phonetica, 51,* 146-158.

Storkel, H. L. (2001). Learning new words: Phonotactic probability in language development. *Journal of Speech, Language, and Hearing Research, 44*, 1321-1337.

Storkel, H. L. & Morrisette, M.J. (2002). The lexicon and phonology: Interactions in language acquisition. *Language, Speech and Hearing Services in Schools, 33*, 24-37.

Tardif, T., Fletcher, P., Leung, C.S.B. & Leung. S.L. (in prep.). *Manual of the Cantonese Communicative Development Inventory.*

Thal, D., Oroz, M. & McCaw, V. (1995). Phonological and lexical development in normal and late-talking toddlers. *Applied Psycholinguistics,* 16, 407-424.

Vihman, M.M. (1993a). Variable paths to early word production. *Journal of Phonetics, 21*, 61-82.

Vihman, M.M. (1993b). The construction of a phonological system. In B. de Boysson-Bardies, S. de Schonen, P. Jusczyk, P. MacNeilage & J. Morton (Eds.), *Changes in speech and face processing in infancy: A glimpse at developmental mechansisms of cognition.* Dordrecht: Kluwer.

Vihman, M.M., Ferguson, C.A. & Elbert, M. (1986). Phonological development from babbling to speech: Common tendencies and individual differences. *Applied Psycholinguistics, 7,* 3-40.

Vihman, M.M. & Melleman, S.L. (2000). Phonetics and the origins of phonology. In N. Burton-Roberts, P. Carr, & G. Docherty (Eds.), *Phonology knowledge: Conceptual and empirical issues (pp. 305-339).* Oxford, UK: Oxford University Press.

Wong, W.W-Y. & Stokes, S.F. (2001). Cantonese consonantal development: Towards a nonlinear account. *Journal of Child Language, 28,* 195-212.

Zee, E. (1999). Changes and variation in the syllable-initial and syllable-final consonants in Hong Kong Cantonese. *Journal of Chinese Linguistics, 26*, 1-48.

Appendix I (a)

Particulars of all children in the High Group in the longitudinal study

Subject ID	MCHC	MCHC Ref. No.	Sex	Age	Child's DOB	Total Score in Part I of CCDI
22118107	Anne Black	0102/00	Male	18	21.01.00	219
22218210	Kwun Tong	0185/00	Female	18	09.02.00	212
22218213	Kwun Tong	0198/00	Female	18	09.02.00	326
22318214	Ngau Tau Kok	0143/00	Female	18	18.01.00	346
22418224	Maurine Grantham	0223/00	Female	18	20.01.00	388
22119106	Anne Black	1726/99	Male	19	09.12.99	409
22119205	Anne Black	0054/00	Female	19	08.01.00	254
22319109	Ngau Tau Kok	0081/00	Male	19	11.12.99	288
22419230	Maurine Grantham	0068/00	Female	19	25.12.99	299
22519119	Wong Siu Ching	2791/99	Male	19	15.12.99	365
22519127	Wong Siu Ching	0079/00	Male	19	05.01.00	250
22120104	Anne Black	1730/99	Male	20	20.12.99	464
22120106	Anne Black	1709/99	Male	20	18.12.99	429
22120207	Anne Black	1583/99	Female	20	11.11.99	310
22220114	Kwun Tong	0784/01	Male	20	16.12.99	348
22320108	Ngau Tau Kok	1124/99	Male	20	26.11.99	381
22320209	Ngau Tau Kok	1078/99	Female	20	26.11.99	383
22520128	Wong Siu Ching	2663/99	Male	20	29.11.99	327
22520230	Wong Siu Ching	2624/99	Female	20	24.11.99	474

Appendix I (b)

Particulars of all children in the Meddle group in the longitudinal study

Subject ID	MCHC	MCHC Ref. No.	Sex	Age	Child's DOB	Total Score in Part I of CCDI
22318209	Ngau Tau Kok	0222/00	Female	18	15.01.00	41
22318215	Ngau Tau Kok	0134/00	Female	18	17.01.00	48
22518119	Wong Siu Ching	224/00	Male	18	21.01.00	75
22218233	Kwun Tong	0454/00	Female	18	21.03.00	36
22218236	Kwun Tong	0870/00	Female	18	02.04.00	36
22119201	Anne Black	0029/00	Female	19	01.01.00	61
22219137	Kwun Tong	0227/00	Male	19	02.02.00	69
22519224	Wong Siu Ching	400/00	Female	19	19.02.00	44
22220134	Kwun Tong	1718/99	Male	20	15.12.99	152
22320210	Ngau Tau Kok	0009/00	Female	20	01.12.99	148
22520220	Wong Siu Ching	2715/99	Female	20	08.12.99	137
22520231	Wong Siu Ching	2792/99	Female	20	19.12.99	135

Appendix II

The Age of Acquisition (AoA) for words in Part I of CCDI: Toddler.

Word	AoA	Word	AoA	Word	AoA	Word	AoA	Word	AoA
媽咪	16	靚	20	遮	22	抹	23	揸	24
爹哋	16	熱	20	帽	22	爛(咗)	23	企	24
姐姐	16	飽	20	有	22	黑孖孖	23	上(去)	24
奶奶	16	雨	20	污糟	22	頭髮	23	落(去)	24
麵包	16	鞋	20	面	22	牙	23	出(去)	24
拜拜	16	衫	20	耳仔	22	電視	23	街	24
波	16	褲	20	買	22	梳(頭)	23	跳	24
打	16	尿片	20	摕	22	刷(牙)	23	游水	24
哥哥	17	跌	20	知道	22	著(衫)	23	轉	24
姨姨	17	踢	20	馬	22	識	23	匿(埋)	24
啤啤	17	(打)開/開(燈)	20	妹妹	23	風扇	23	熄(燈)	24
抱	17	要	20	舅父	23	軟	23	笑	24
冇(晒)	17	驚	20	湯	23	酒樓	23	唱(歌)	24
曳	17	痛	20	爬	23	我	23	寫	24
貓	17	眼	20	飛機	23	擺	23	畫(畫)	24
狗	17	鼻	20	巴士	23	弟弟	24	聽	24
冇	17	口	20	的士	23	姑媽	24	痕	24
婆婆	18	手	20	呀(肯定)	23	姑丈	24	瞓(咗)	24
伯伯	18	腳	20	蛋糕	23	姨媽	24	快	24
水	18	二	20	肉	23	姨丈	24	廁所	24
車	18	三	20	(香)蕉	23	茶	24	煮	24
餅(乾)	18	爺爺	21	蘋果	23	貼	24	撚	24
沖涼	18	(匙)羹	21	刷牙	23	切	24	刮 (刺)	24
去街街	18	麵	21	食飯	23	剪	24	嚥	24
俾	18	唔該	21	早晨	23	踩	24	摸	24
魚	18	係	21	早抖	23	等	24	除(衫)	24
一	18	唔要	21	買(嘢)	23	冚(蓋上)	24	會	24
魚	19	唔好	21	好嘢	23	單車	24	鴨	24
嫲嫲	20	痾尿	21	快啲	23	碗	24	豬	24
公公	20	洗手	21	打電話	23	筷子	24	熊仔	24
叔叔	20	電話	21	梳	23	刀	24	地下	24
蛋	20	被	21	鎖匙	23	呢個	24	屋企	24
飯	20	錢	21	垃圾	23	粥	24	我嘅	24
杯	20	飲	21	雪糕	23	薯條	24	姑姐	25

Word	AoA	Word	AoA	Word	AoA	Word	AoA	Word	AoA
燈	20	襪	21	咳	23	蝦	24	人	25
菜	20	喊	21	拍(手)	23	腸仔	24	果汁	25
橙	20	頭	21	拖(住)	23	提子	24	嘢食	25
糖(果)	20	屁股	21	攞	23	西瓜	24	砌	25
多謝	20	門	21	殘	23	唔准	24	瞓低	25
要	20	洗	21	行	23	返學	24	倒(水)	25
痾屎	20	搽	21	去	23	一歲	24	騎	25
瞓晏覺	20	掉(垃圾)	21	歌	23	公仔	24	跟住	25
書	20	雀	21	好	23	枕頭	24	遮(住)	25
筆	20	雞	21	凍	23	藥	24	蟲蟲	25
水	20	船	22	臭	23	牙刷	24	蚊	25
花	20	(手)錶	22	濕	23	毛巾	24	地鐵	25
食	20	紙	22	瞓覺	23	廁紙	24	火車	25
錫	20	袋	22	起身	23	眼鏡	24	樽	25
坐	20	走	22	飛	23	樹葉	24	叉	25
玩	20	叻	22	閂(門)	23	咬	24	你	25
乖	20	好味	22	睇	23	吹	24	個	25
粒	25	鐘	26	花生	27	學校	27	煮飯仔	28
啦	25	較剪	26	做(嘢)	27	一樣	27	鈴啷	28
呢	25	掃把	26	做完	27	警察	27	遊戲機	28
豆	25	餵	26	好啦	27	嬸嬸	28	得意	28
啱喇	25	握(手)	26	(影)相機	27	舅母	28	肉酸	28
書包	25	放	26	電池	27	男(仔)	28	肚餓	28
要	25	攬	26	牙膏	27	女(仔)	28	底褲	28
朱古力	25	入(去)	26	盆	27	司機	28	學	28
槍	25	韆鞦	26	報紙	27	老師	28	彈	28
玩具	25	太陽	26	盒	27	汽水	28	問	28
風	25	拖鞋	26	唔該	27	綁	28	數	28
冚冚轉	25	搵	26	先	27	碌(打滾)	28	油(顏色)	28
滑梯	25	捉	26	已經	27	擒	28	望	28
星星	25	叫	26	啫喱	27	踏	28	嬲	28
月亮	25	講	26	拎	27	帶	28	病	28
跳舞	25	開心	26	扶	27	送	28	劫	28
鬧	25	眼瞓	26	追	27	接	28	慢	28
舒服	25	醒(咗)	26	車轆	27	電單車	28	肚臍	28
重	25	多	26	香	27	小巴	28	背脊	28
大	25	(衫)鈕	26	甜	27	水壺	28	電腦	28
光	25	沖	26	辣	27	佢	28	篤	28
曬	25	掃	26	裙	27	嗰啲	28	扭	28
手指	25	淆(搔癢)	26	醒	27	隻	28	掂	28

Word	AoA	Word	AoA	Word	AoA	Word	AoA	Word	AoA
肚腩	25	撕開	26	搖	27	塊	28	搵	28
房	25	多啲	26	郁	27	本	28	剝	28
廚房	25	小朋友	27	敲(門)	27	條	28	黃	28
鏡	25	姑娘	27	鍾意	27	架	28	冷氣機	28
雪櫃	25	摺	27	讀(書)	27	張	28	洗衣機	28
執(收拾/拾起)	25	趴	27	見	27	次	28	BB 床	28
攪	25	斟(水)	27	乾淨	27	枝	28	屋	28
掟	25	拉	27	壞(咗)	27	包	28	街市	28
戴(表)	25	推	27	少	27	喫	28	第一	28
記得	25	撞	27	高	27	薯	28	米	29
紅	25	排隊	27	長	27	雞(肉)	28	試	29
(烏)龜	25	搶	27	細	27	魚蛋	28	(交)換	29
牛	25	揭(開)	27	夠	27	雞翼	28	恐龍	29
大笨象	25	打爛	27	嘈	27	火腿	28	件	29
馬騮	25	整(嘢)	27	小心	27	蕃茄	28	喎	29
猩猩	25	蝴蝶	27	拉鍊	27	蘿蔔	28	水果	29
白兔	25	(螞)蟻	27	腩	27	豆腐	28	梨	29
老鼠	25	甲由	27	頸	27	芒果	28	抆 pek pek	29
樓梯	25	碟	27	腳趾	27	聽話	28	番梘	29
公園	25	奶嘴	27	趾甲	27	救命	28	畫	29
超級市場	25	你嘅	27	搬	27	衣架	28	泥	29
好多	25	嗰個	27	指	27	繩	28	沙	29
醫生	26	呢啲	27	明白	27	銀包	28	嘅	29
超人	26	我哋	27	蛇	27	桶	28	想	29
幫(手)	26	囉	27	老虎	27	鍾意	28	識(做)	29
通心粉	26	粟米	27	BB 車	27	吞	28	夜晚	29
對唔住	26	瓜	27	外面	27	停	28	汁	29
等陣	26	(冬/磨)菇	27	波波池	27	貼紙	28	啜 (手指)	29
"luer"	29	撥(開)	>30	伏匿匿	>30	風箏	>30	擰	>30
跑步	29	趕住	>30	鉛筆	>30	啤啤	>30	"lin"(住)	>30
積木	29	蝦	>30	顏色筆	>30	禮物	>30	啷(牙膏)	>30
故仔	29	借	>30	收音機	>30	蠢	>30	撳	>30

Word	AoA	Word	AoA	Word	AoA	Word	AoA	Word	AoA
壞	29	修理	>30	刷	>30	暖	>30	揩	>30
口渴	29	蜜蜂	>30	間尺	>30	涼	>30	論盡	>30
石頭	29	蜻蜓	>30	擦膠	>30	苦	>30	慘	>30
行雷	29	烏蠅	>30	布	>30	脸	>30	可憐	>30
天(空)	29	蝸牛	>30	藍	>30	軟	>30	灰	>30
山	29	龍	>30	地拖	>30	雲	>30	啡	>30
海	29	動物	>30	嚡	>30	梯	>30	(白)鴿	>30
馬路	29	直昇機	>30		>30	天橋	>30	鵝	>30
波鞋	29	私家車	>30	嘛	>30	隧道	>30	企鵝	>30
褸	29	貨車	>30	咋	>30	(游)泳池	>30	貓頭鷹	>30
用	29	輕鐵	>30	會	>30	噴水池	>30	海豚	>30
聞	29	電車	>30	可以(做)	>30	旗	>30		>30
硬	29	Bi Boo 車	>30	應該	>30	睡衣	>30	斑馬	>30
黐粗粗	29	救傷車	>30	唔捨得	>30	背心	>30	狼	>30
怕	29	消防車	>30	朝早	>30	T 恤	>30	鹿	>30
完(咗)	29	(電)飯煲	>30	日頭	>30	冷衫	>30	長頸鹿	>30
滿	29	鑊	>30	下晝	>30	牛仔褲	>30	沖涼缸	>30
惡	29	自己嘅	>30	今日	>30	口水肩	>30	痰罐	>30
(頸)鍊	29	佢嘅	>30	尋日	>30	頸巾	>30	天花(板)	>30
廳	29	你哋	>30	聽日	>30	(領)呔	>30	商場	>30
鋼琴	29	佢哋	>30	今朝	>30	皮帶	>30	圖書館	>30
拋	29	我哋嘅	>30	今晚	>30	手套/手襪	>30	醫院	>30
黑	29	你哋嘅	>30	依家	>30	眨(眼)	>30	動物園	>30
白	29	佢哋嘅	>30	之前	>30	滑	>30	有啲	>30
橙(色)	29	人哋	>30	跟住	>30	跣	>30	少啲	>30
綠	29	人哋嘅	>30	頭先	>30	傷心	>30	是但	>30
藍	29	舊	>30	早啲	>30	低	>30	另一個	>30
青蛙	29	步	>30	遲啲	>30	矮	>30	第二啲	>30
羊	29	棵	>30	晏啲	>30	短	>30	其他	>30
獅子	29	層	>30	時間	>30	輕	>30	意粉	>30
水喉	29	位	>30	同(埋)	>30	空	>30	腳板	>30
車站	29	座	>30	因爲	>30	面珠	>30	窗	>30
遊樂場	29	間	>30	所以	>30	眼眉(毛)	>30	爐	>30
全部	29	啲	>30	如果	>30	下巴	>30	晾(衫)	>30
煲	30	點心	>30	就	>30	膊頭	>30	疊(起)	>30
自己	30	腸粉	>30	雖然	>30	手臂	>30	賣	>30
蟹	30	蝦餃	>30	但係	>30	手指公	>30	插	>30

Word	AoA	Word	AoA	Word	AoA	Word	AoA
草	30	燒賣	>30	就算	>30	膝頭哥	>30
醜樣	30	豬(肉)	>30	咁樣(就)	>30	手踭	>30
酸	30	牛(肉)	>30	或者	>30	手板	>30
熊貓	30	雞脾	>30	豉油	>30		
消防員	>30	叉燒	>30	蔥	>30		
諗	>30	白菜	>30	薑	>30		
發夢	>30	boo 嘖	>30	嚟	>30		
估	>30	點蟲蟲	>30	膠水	>30		
扮	>30	包剪揼	>30	咪	>30		
滴	>30	捉伊人	>30	汽球	>30		

Appendix III

Items in the picture-naming task (Wong & Stokes, 2001)

1. /nɐu$_2$/ 'button'	20. /ji$_6$/ 'two'	40. /luk$_6$/ 'six'
2. /t^{h}ai$_1$/ 'tie'	21. /kɐi$_1$/ 'chicken'	41. /fei$_1$ kei$_1$/ 'aeroplane'
3. /t^{h}ɔ$_1$ hai$_4$/ 'slippers'	22. /pɛŋ$_2$/ 'biscuit'	42. /kwai$_2$ sɐu$_3$/ 'monster'
4. /lɐu$_1$/ 'coat'	23. /hɐp$_2$/ 'box'	43. /mou$_4$ kɐn$_1$/ 'tower'
5. /hœŋ$_1$ tsiu$_1$/ 'banana'	24. /lou$_5$ sy$_2$/ 'mouse'	44. /ŋɐn$_4$ pau$_1$/ 'purse'
6. /kwɐt$_6$ t^{h}uŋ$_2$/ 'drawer'	25. /ts^{h}i$_4$ kɐŋ$_1$/ 'spoon'	45. /k^{h}ɐt$_1$/ 'cough'
7. /pɔ$_1$/ 'ball'	26. /fan$_6$/ 'rice'	46. /syt$_3$ t^{h}iu$_2$/ 'ice-block'
8. /sam$_1$/ 'clothes'	27. /wat$_6$ t^{h}ɐi$_1$/ 'slide'	47. /k^{h}wɐn$_4$/ 'skirt'
9. /tan$_6$ kou$_1$/ 'cake'	28. /jip$_6$/ 'leaf'	48. /wun$_2$/ 'bowl'
10. /hai$_4$/ 'shoe'	29. /ts^{h}ɑŋ$_1$/ 'orange'	49. /k^{h}ɐm$_4$/ 'piano'
11. /tou$_1$/ 'knife'	30. /wu$_1$ kwɐi$_1$/ 'tortoise'	50. /ts^{h}ɛ$_1$ / 'car'
12. /kɐu$_2$/ 'dog'	31. /pa$_1$ si$_2$/ 'bus'	51. /p^{h}ɔ$_4$ p^{h}ɔ$_2$/ 'grandma'
13. /jy$_2$/ 'fish'	32. /tin$_6$ wa$_2$/ 'telephone'	52. /p^{h}ei$_5$/ 'quilt'
14. /mɐt$_6$ fuŋ$_1$/ 'bee'	33. /tsuŋ$_1$/ 'clock'	53. /mun$_4$/ 'door'
15. /ŋɐu$_4$/ 'cow'	34. /kwɐn$_2$/ 'stick'	54. /kœk$_3$/ 'foot'
16. /fa$_1$/ 'flower'	35. /p^{h}un$_4$/ 'sink'	55. /k^{h}yn$_4$ t^{h}au$_4$/ 'gist'
17. /t^{h}ɔŋ$_2$/ 'sweet'	36. /tsy$_1$/ 'pig'	
18. /tsœk$_3$ tsɐi$_2$/ 'bird'	37. /nai$_5$ tsœyi$_2$/ 'nipple'	
19. /sɛ$_4$/ 'snake'	38. /ŋa$_4$ ts^{h}at$_3$/ 'tooth-brush'	