

## Chapter 2

# Phonological Development

### 2.1 General Literature on Phonological Development

#### 2.1.1 *Theories of the Acquisition of Phonology*

Before understanding children's phonological development, the theories of the acquisition of phonology will be introduced. On the topic of phonological development, there are two theories which present opposite positions and are respectively advocated by different scholars. One is nativist theory, and the other is behaviorist theory. Nativist theories of development hold the belief that children acquire language according to their inborn programs, i.e., children assimilate and construct the external information by themselves. That is, a nativist theory focuses on the similarities among children. As for a behaviorist theory, it claims that children acquire language from external reward and thus improve their pronunciation. That is, adults may demand children to say the words which could be the objects he wanted, and thus, children would learn to say the words.

Nevertheless, 'regression' in the acquisition of phonology is as key evidence against both nativist and behaviorist theories. Menn's (1971) study showed that children's pronunciation may become worse as the appearance of regression phenomenon in nasal assimilation. One of his subject produced *beans* as [minz] ('means'), and then, he would apply this rule to a word which he had pronounced correctly, i.e., *down* [dæwn] would become [næwn] ('noun'). Consequently, this kind of phenomenon provides a counter-example for the behaviorist theories, which assume external reward for improved pronunciation. And, another regression phenomenon of Menn's participant is as well a disproof of nativist theories. The participant was unable to utter a sound in new words but could maintain the correct pronunciation in familiar words. That is, he had initial [h] in greeting words such as *hi* and *hello*, but was unable to pronounce words beginning with /h/ such as *horse* and *hat*. Therefore, nativist theories seem not to be flexible enough to explain such kind of variation between words.

Since both nativist and behaviorist theories cannot deal with regression in sound production, an appropriate way is to adopt a cognitive problem-solving approach to the acquisition of phonology. The cognitive problem-solving approach could offer a better explanation for the regression phenomenon mentioned above. First, nasalization regression could be the children's overgeneralization in his trial-and-error articulation attempts. For the second problem, the problem-solving approach tends to claim that most of the reward is internal instead of the traditional view of behaviorism (Gleason 2012).

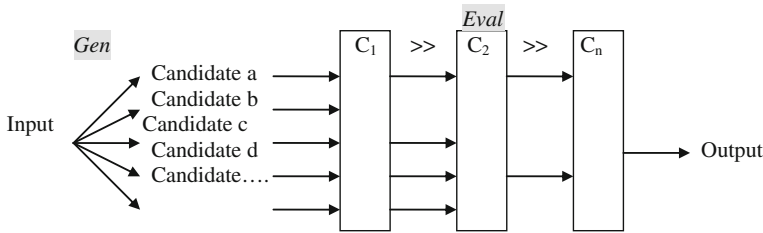
### 2.1.1.1 Introduction to Optimality Theory (OT)

Optimality theory (OT), proposed by Prince and Smolensky (2004, 1997), is a constraint-based theory of phonology. OT represents a language or grammar by ranking a set of universal constraints. The constraints are universal, while the ranking is not. Thus, languages differ in the ranking of constraints. The universal constraints are violable, but they must be minimal. A surface form is 'optimal' in that it violates the least number of constraints and the constraints are low-ranked in a language-specific hierarchy (Kager 1999).

OT is a development of Generative Grammar, a derivational and rule-based theory focusing on formal description and questing for universal principles from language typology and language acquisition. Both theories aim to build Universal Grammar (UG), but they are fundamentally different. First, Generative Grammar defines UG as a set of inviolable principles and rule schemata (or 'parameters') but from the viewpoint of OT, UG is defined as a set of violable universal constraints. Accordingly, to explain cross-linguistic variation, earlier generative model claimed that the cross-linguistic variation is owing to 'parametric' variation of inviolate principles; however, OT assumes languages differ in rankings of universal constraints. Second, Generative Grammar is a derivational theory, which is motivated by rewriting rules. Hence, the surface forms are derived from the underlying forms through derivational rules. It is a serial order of rule application. In contrast, OT is comparative. In the mechanism of OT, given an input, there will be infinite candidate output for the input. Then, those candidates will be evaluated by a language-specific constraint hierarchy. However, there is no parsing order of constraints and of candidate output. Therefore, constraints are parsed all at once, and candidate outputs are evaluated all at once (Kager 1999; Liu 1999; Prince and Smolensky 2004, 1997; Tesar and Smolensky 2000). In the next section, the mechanism of OT will be introduced.

### 2.1.1.2 The Architecture of an OT Grammar

The OT grammar is an input-output mechanism which assumes that each input has precisely one output. The process of selecting the optimal candidate as the output is accomplished by the following components:



**Fig. 2.1** The mechanism of OT (Kager 1999: 22)

**Con** The set of constraints out of which grammars are constructed (McCarthy and Prince 1994).

**Gen** A function defining, for each possible  $i$ , the range of candidate linguistic analyses available to  $i$  (McCarthy and Prince 1994).

**Eval** The function defined by composing all of the constraints in the order in which they are ranked (McCarthy 2008).

The function Gen (Generator) produces a set of candidates, all of which are logically possible analyses of the given input. Eval (Evaluator) deals with a system of ranked constraints which is a formal construction on Con that yields the grammar of an individual language. Therefore, the mechanism of OT is that Gen with the given input  $i$  generates an infinite set of candidate outputs based on UG. Then, Eval will assess the candidate outputs in terms of their relative harmony with respect to the language's ranking of the constraints (McCarthy and Prince 1994). The mechanism of OT is schematically presented in Fig. 2.1, which supposes that Con consists of  $C_1, C_2, \dots$  to the infinite  $C_n$  and that language is defined by the ranking  $C_1 \gg C_2 \gg \dots \gg C_n$ .

### 2.1.1.3 Principles of Optimality Theory

McCarthy and Prince (1994) proposed five basic principles of OT:

- Universality.** UG provides a set of Con of constraints that are universal and universality present in all grammars.
- Violability.** Constraints are violable; but violation is minimal.
- Ranking.** The constraints of Con are ranked on a language-particular basis; the notion of minimal violation is defined in terms of this ranking. A grammar is a ranking of the constraint set.
- Inclusiveness.** The constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness.
- Parallelism.** Best satisfaction of the constraint hierarchy is computed over the constraint based on whole hierarchy and the whole candidate set. There is no serial derivation.

OT is aimed to building the universality present in every grammar, so it defines UG as a set of universal constraints.

According to the principles of *violability* and *ranking*, these universal constraints are violable and ranked in language-specific way. That is, every grammar has its own specific ranking of constraints. Since these constraints are violable and strictly ranked, the output structures that minimally violate rankings are optimal and grammatical.

On the basis of principles of *inclusiveness*, Gen is free to produce all possible candidate analyses of the input that are ‘structural well-formedness,’ e.g., segmental structure, prosodic structure, morphology, and syntax. Then, Eval evaluates candidate sets with respect to particular rankings of Con. Moreover, the way of evaluation of candidate sets is parallel but not serial where one rule’s output is the next rule’s input (Dekkers et al. 2000; Kager 1999).

2.1.1.4 OT Tableau

The construction of a grammar in OT is to determine the proper ranking of Con, and the constraint tableau is a useful calculation device. A typical OT tableau is shown in Tableau 2.1.

In an OT tableau, the top row presents the constraint ranking from left to right and the first column in the left shows the possible output candidates of the given input. In the following rows, constraint violations are given for each output structure. Violation marks are indicated by asterisk ‘\*’, and one ‘\*’ means one violation of constraint. The optimal candidate is pointed out by ‘⊳’, and fatal constraint violations are signaled by ‘!’.

As shown in Tableau 2.1, constraint ranking shows that CON<sub>1</sub> dominates CON<sub>2</sub> and CON<sub>3</sub> and there are candidate A to candidate D as possible output candidates. To select the optimal candidate output, we can examine the OT tableau from left to right and determine which candidate(s) incur(s) the lowest number of violations for each column. Candidate B is the only one that violates the highest ranked constraint CON<sub>1</sub>, although B has a smaller number of violations than other candidates, this violation is fatal. Therefore, candidate B is excluded, and the three remaining candidates will be evaluated by CON<sub>2</sub>. Candidates A and D violate this constraint only once, while C does so twice. It means that candidate C is excluded because its second violation of CON<sub>2</sub> is fatal. Hence, only candidates A and D continue to be evaluated by CON<sub>3</sub>. Candidate D incurs two violations of CON<sub>3</sub>, but A violates it

**Tableau 2.1** OT tableau  
(Dekkers et al. 2000: 3)

	CON <sub>1</sub>	CON <sub>2</sub>	CON <sub>3</sub>
⊳ A		*	*
B	*!		
C		**!	*
D		*	**!

only once. Consequently, A is the optimal candidate and therefore grammatical. Note that the total number of violations is irrelevant to evaluation. That A incurs two violations and B incurs only one has no influence on evaluation (Dekkers et al. 2000).

### 2.1.1.5 Constraints

There are two primary types of constraints. One is the markedness constraints, which militate against marked structures. The other type consists of the faithfulness constraints which demand identity between input and output (Gnanadesikan 1996). In the following sections, the faithfulness constraints and markedness constraints adopted in the present study will be discussed.

#### 2.1.1.6 Faithfulness Constraints

The faithfulness constraints adopted in the present study are shown in the following and they are elaborated with examples:

- a. Ident ( $\alpha$ retroflex): The output must be in accord with its input in retroflex. (Li 2006). For example, given the input /tʂ/, the candidate output [ts] violates this constraint, while the candidate [ʂ] does not.
- b. Ident ( $\alpha$ s.g): The output has to correspond to its input in aspiration (Li 2006). For example, given the input /tɕ<sup>h</sup>/, the candidate output [tɕ] violates this constraint, while the candidate [ts<sup>h</sup>] does not.
- c. Ident ( $\alpha$ cont): The output must be equal to the input in continuance (Li 2006). For example, given the input /ɕ/, the candidate output [tɕ] violates this constraint, while the candidate [s] does not.
- d. Ident ( $\alpha$ anterior): The segments between input and output share the same value in anterior (Li 2006). For example, given the input /f/, the candidate output [x] violates this constraint, while the candidate [p] does not.
- e. Ident ( $\alpha$ strident): The segments between input and output share the same value in strident. For example, given the input /ʂ/, the candidate output [t] violates this constraint, while the candidate [s] does not.

#### 2.1.1.7 Markedness Constraints

The markedness constraints adopted in the present study are as follows:

- f. \*Retroflex: The retroflex segments are forbidden in the output (Li 2006).  
e.g., /tʂ táu/ → [tʂ táu] *Zhi dao* ‘know’  
As shown in the example, /tʂ/ becomes [ts] in the output, which is not a retroflex.

- g.  $*(+s.g)$ : This demands the output without aspiration (Li 2006).  
 e.g., /tɕ<sup>h</sup>iəu/ → [tɕiəu] *Qiu* ‘ball’  
 As shown in the example, aspirated palatal affricate /tɕ<sup>h</sup>/ is replaced by [tɕ], which is an unaspirated one.
- h.  $*(+cont)$ : This demands the feature value [-continuant] in the output (Li 2006).  
 e.g., /fēi tēi/ → [pēi tēi] *Fei ji* ‘plane’  
 As shown in the example, /f/ in /fēi/ becomes [p] in the output, which is a non-continuant sound.
- i.  $*(+anterior)$ : This demands the feature value [-anterior] in the output.  
 e.g., /t<sup>h</sup>ou fǎ/ → [k<sup>h</sup>ou fǎ] *Tou fa* ‘hair’  
 As shown in the example, /t<sup>h</sup>/ in /t<sup>h</sup>ou/ becomes [k<sup>h</sup>] in the output, which is a segment with feature [-anterior].
- j.  $*(+strident)$ : This demands the feature value [-strident] in the output.  
 e.g., /lǎu ʃǔ/ → [lǎu tǔ] *Lao shu* ‘rat’  
 As shown in the example, /ʃ/ in /ʃǔ/ is substituted by [t] in the output, which is not a strident segment.
- k.  $*(+high)$ : This demands the feature value [-high] in the output.  
 e.g., /eiǎu ʃ xóu/ → [tsiǎu ʃ xóu] *Xiao shi hou* ‘childhood’  
 As shown in the example, /e/ in /eiǎu/ becomes [ts] in the output, which is a non-high segment.
- l.  $*Affricate$ : The affricate segment is forbidden in the output (Li 2006).  
 e.g., /tɕ<sup>h</sup> iŋ t<sup>h</sup>iŋ/ → [eiŋ t<sup>h</sup>iŋ] *Qing ting* ‘dragonfly’  
 As shown in the example, the aspirated palatal affricate /tɕ<sup>h</sup>/ in /tɕ<sup>h</sup>iŋ/ becomes [ɕ], which is a palatal fricative but not an affricate.
- m.  $*Stop$ : The stop segment is forbidden in the output.  
 e.g., /t<sup>h</sup>u/ → [ts<sup>h</sup>u] *Tu* ‘vomit’  
 As shown in the example, the aspirated stop /t<sup>h</sup>/ in /t<sup>h</sup>u/ becomes [ts<sup>h</sup>] in the output, which is not a stop segment.

Faithfulness constraints demand the input and output to share the same values in some features, represented by ‘Ident(α\_\_\_).’ Markedness constraints forbid output from bearing some features, so it has asterisk ‘\*’ as forbidness for the output. Markedness and faithfulness constraints are conflicting with each other inherently. As the constraints shown above, faithfulness constraints such as items *a*, *b*, *c*, *d*, *e* conflict with markedness constraints such as items *f*, *g*, *h*, *i*, *j*, *l*, *m* in some aspects.

### 2.1.1.8 Constraint Demotion

OT (Prince and Smolensky 2004) made a claim that learning is a process of reranking a set of universal constraints. The mechanism of reranking the constraints is by demoting the constraints that would make the winner to lose in the hierarchy. Besides, the constraints can only be demoted in the hierarchy. Therefore, those constraints violated by the winner would be demoted in the hierarchy so that they would be dominated by the constraints violated by the loser to ensure that each

winner is more harmonic than its competing losers (Tesar and Smolensky 2000). However, Boersma and Hayes (1999) developed a different theory of learning, in which the constraints can be demoted and promoted. Different from classic OT, the mechanism of ranking constraints proposed by Boersma and Hayes (1999) is bidirectional. For example, if there are two incorrectly ranked constraints in a learner's ranking, the higher ranked one is demoted and the lower ranked one is promoted slightly in the full hierarchy of constraints. After learning, the ranking is reranked and the two constraints are ranked closer, until the ranking is reversed finally.

In the present study, the classic OT model is adopted to analyze the data since the one directional mechanism of constraint ranking is simple and clear to observe which constraint is demoted in the full hierarchy. Besides, by using OT, we can explain the phonological development of children of Vietnamese and Indonesian mothers by the constraint rankings and investigate whether there is any similarity or difference with native children.

### ***2.1.2 Phenomena in Phonological Development***

In children's early speech, there is still some babble contained in their speech. Moreover, during the transition from prespeech to speech, children may produce words invented by them, defined as 'protowords.' Protowords may with or without adult models, but the appearance of protowords shows that children have begun to voluntarily control over their vocalizations.

Then, when children start out to learn to pronounce, several phenomena may appear in the process such as feature changing, cluster reduction, and assimilation. For children, they learn adult words through trial and error. And, by descriptive features, it would be more clearly for us to interpret children's changing of sounds during the process. So, the often seen patterns in early child phonology include all initial stops being voiced, using alveolar place of articulation for both alveolar and velar consonants, and nasal assimilation or assimilating the place of articulation.

Besides the patterns mentioned above, the accuracy of children's perception of sounds is also a key point for them to learn speech. For example, some children learning English may have problem distinguishing [f] from [θ] the two sounds are similar for audition, because which leads to late acquisition of [θ] (Velleman 1988). In addition, in the early period of phonological development, word pronunciation is affected by the length of the word and stress patterns. For example, children tend to omit the initial syllable of a multisyllabic word as the syllable is unstressed. So, we may hear 'posed' for 'supposed.' This phenomenon may be due to the fact that the weakly stressed syllables are harder to perceive so that children miss hearing the whole words.

During the process of learning speech sounds, we can see the differences in learning strategies among children. Some children would not use a word if they cannot produce the sounds accurately. But, other children may feel free to rearrange

adult words to fit them into their speech. So, some children may attempt one word at a time until the word is clear to them. On the other hand, some children may try a whole phrase at once. Nevertheless, as children begin to put words together and become precise in their articulation, the differences in learning strategies will disappear finally.

By three years of age, the basic features of the adult phonological system are present in children's pronunciation and most children can produce all the vowel sounds and nearly all the consonant sounds. However, the liquids /r/ and /l/ are still easy to be mistaken even until the age of four or five. Besides, in longer words such as *vacuum cleaner*, children may still mispronounce the /v/ sound although utter accurately in shorter word such as *vase*. Around the age of seven, children could pronounce all sounds accurately (Gleason 2012).

### ***2.1.3 Adult role in Phonological Development***

If parents correct children's pronunciation adequately, it would be helpful for children's learning speech. Studies of Malsheen (1980) and Bernstein Rater (1984) have shown that parents indeed clarify their articulation as speaking to their children at the one-word stage. Moreover, their findings indicated that parents' clarification of vowel production can be seen as a good model for children's learning to use (Gleason 2012). Consequently, parents or adults actually have effect on children's phonological development.

## **2.2 Phonology of Mandarin, Taiwan Southern Min, Vietnamese, and Indonesian**

Before discussing Mandarin phonological development, Mandarin phonology will be introduced first. In addition, Taiwan Southern Min, widely spoken language in Taiwan, a possible source of influence of the Mandarin in Taiwan, is also introduced. Moreover, since Mandarin is not a native language for those immigrant mothers, they may tend to be influenced by their first languages while learning Mandarin, which in turn affect their children's Mandarin phonological development. Immigrant mothers' native languages, Vietnamese and Indonesian, will be discussed. Thus, this section focuses on the comparison of phonological systems among the four different languages: Mandarin, Taiwan Southern Min, Vietnamese, and Indonesian.



2.2.1 Phonology of Mandarin

Mandarin has twenty-two consonants including three palatals, which were analyzed as consonant–glide combinations by some scholars (i.e., Cheng 1973; Duanmu 2000). I will follow the tradition in the acquisition literature treating them as single sound for the ease of transcription and discussion. Table 2.1 shows the twenty-two phonemes in phonetic symbols.

Mandarin has five vowel phonemes as shown in Table 2.2 (Duanmu 2000). Mandarin has three glides [j, w, ɥ], as in [ja] ‘tooth,’ [wa] ‘frog,’ and [ɥ] ‘moon,’ which correspond with vowels [i, u, y]. Since the two sets do not contrast with each other, the vowel symbols were used for transcription. A vowel in Mandarin can carry four tones with contrastive meanings. Some examples are given in Table 2.3 (Ladefoged and Johnson 2015). The pitch levels are represented by five numerals with one representing the lowest and five representing the highest.

A Mandarin syllable is made up of an optional onset limited to one consonant and an optional coda restricted to nasals. Since our focus is acquisition, we will not get into sophisticated phonological analysis.

Table 2.1 Mandarin consonants

Manner	Place					
	Bilabial	Labiodental	Dental	Retroflex	Palatal	Velar
Stop (vl.)	p, p <sup>h</sup>		t, t <sup>h</sup>			k, k <sup>h</sup>
Fricative (vl.)		f	s	ʂ	ç	x
(vd.)				ʐ		
Affricate (vl.)			ts, ts <sup>h</sup>	tʂ, tʂ <sup>h</sup>	tɕ, tɕ <sup>h</sup>	
Nasal (vd.)	m		n			ŋ
Liquid (vd.)			l			

Table 2.2 Mandarin vowel phonemes

	Front	Central	Back
High	i, y		u
Mid	ə		
Low	a		

Table 2.3 Mandarin tones

Name	Description	Tone value	Example
Tone 1	High level	55	ma ‘mother’
Tone 2	High rising	35	má ‘hemp’
Tone 3	Low falling rising	214	mǎ ‘horse’
Tone 4	High falling	53	mà ‘scold’

2.2.2 Phonology of Taiwan Southern Min

Taiwan Southern Min is a Min dialect of Chinese spoken in Taiwan. In the literature of linguistics, there is a variety of names of Taiwan Southern Min: South Min, Southern Min, Taiwanese, and Taiwanese Hokkien. Taiwan Southern Min is a tone language like Mandarin, but it has seven tones to distinguish lexical meanings. In the following, tones, consonants, and vowels of Taiwan Southern Min will be introduced.

2.2.2.1 Tones of Taiwan Southern Min

There are seven tones in Taiwan Southern Min including five long tones: Yinping, Yinshang, Yinqu, Yangping, and Yangqu and two short tones (entering tones): Yinru and Yangru. Every tone has two forms: juncture tone and sandhi tone. Because of the tone sandhi phenomenon in Taiwan Southern Min, every juncture tone has a matched sandhi tone which appears in context position. According to Cheng (1997), seven tones of Taiwan Southern Min are shown in Table 2.4.

Entering tones, Yinru and Yangru, only exist in checked syllables, i.e., a syllable ending with unaspirated stops: /p, t, k, ʔ/, for example, /hap<sup>5</sup>/ ‘close,’ /lak<sup>5</sup>/ ‘six,’ and /p<sup>h</sup>aʔ<sup>3</sup>/ ‘beat.’ The tone sandhi phenomenon in Taiwan Southern Min results in two tonal forms. For example, given the word ‘short,’ the juncture form is [te<sup>53</sup>] and the sandhi form is [te<sup>55</sup> te<sup>53</sup>]. Basically, tone sandhi is applied regressively (Chung 2002; Liu 2009). As the example shown, when the lexical item ‘short’ is alone, it is a juncture tone [te<sup>53</sup>] and tone value is high falling; when a lexical item is followed by another lexical item within a tone group, the tone sandhi rule is applied. Therefore, in [te<sup>55</sup> te<sup>53</sup>] ‘short,’ tone value of the first one [te] is realized as high-level tone. Examples of tone sandhi phenomenon of each tone are given in Table 2.5.

Table 2.4 Tones of Taiwan Southern Min (Cheng 1997)

Name	Juncture tone	Description	Sandhi tone	Description
Yinping	55	High level	33	Mid-level
Yinshang	53	High falling	55	High level
Yinqu	21	Low falling	53	High falling
Yinru	32	Mid-short	5	High short
Yangping	13	Low rising	33	Mid-level
Yangqu	33	Mid-level	11	Low level
Yangru	54	High short	3	Low short

**Table 2.5** Examples of Taiwan Southern Min tone sandhi (Cheng 1997)

Juncture tone	Gloss	Sandhi tone	Gloss
sa <sup>55</sup>	‘Cloth’	sa <sup>33</sup> k <sup>h</sup> o <sup>21</sup>	‘Cloth’
te <sup>53</sup>	‘Short’	te <sup>55</sup> te <sup>53</sup>	‘Short’
k <sup>h</sup> o <sup>21</sup>	‘Pants’	k <sup>h</sup> o <sup>53</sup> tua <sup>21</sup>	‘Waist belt’
k <sup>h</sup> uaʔ <sup>32</sup>	‘Broad’	k <sup>h</sup> uaʔ <sup>5</sup> k <sup>h</sup> uaʔ <sup>32</sup>	‘Broad’
laŋ <sup>13</sup>	‘People’	laŋ <sup>33</sup> laŋ <sup>13</sup>	‘Everyone’
p <sup>h</sup> i <sup>3</sup>	‘Nose’	p <sup>h</sup> i <sup>11</sup> bi <sup>33</sup>	‘Smell’
tit <sup>54</sup>	‘Straight’	tit <sup>3</sup> tit <sup>54</sup>	‘Straight’

2.2.2.2 Consonants of Taiwan Southern Min

Based on Cheng (1997), there are eighteen consonant phonemes in Taiwan Southern Min as shown in Table 2.6.

In Taiwan Southern Min, there are eighteen consonant phonemes including stops, nasals, fricatives, affricates, and glides. Stops are distinguished by voice, aspiration, and nasality. Oral stops are /p, t, k/, and /p<sup>h</sup>, t<sup>h</sup>, k<sup>h</sup>/ are distinguished by [+/- aspiration]. /b, l, g/ are the voiced counterparts of voiceless stops /p, t, k/. Nasal stops are /m, n, ŋ/, in which /m/ and /ŋ/ are also syllabic consonants, serving as the nucleus of a syllable.

2.2.2.3 Vowels of Taiwan Southern Min

There are six oral vowels and four nasal vowels in Taiwan Southern Min as given in Table 2.7.

Taiwan Southern Min has oral vowels including front vowels /i, e/, central vowels /ə, a/, and back vowels /u, ɔ/. Besides, different from Mandarin, Vietnamese, and Indonesian, Taiwan Southern Min has four nasal vowels /ĩ, ê, ɔ̃, â/, which can stand alone even they do not occur with nasal consonants as examples shown in Sect. 2.1 (Chung 2002).

**Table 2.6** Consonants of Taiwan Southern Min (Cheng 1997)

Manner			Place				
			Bilabial	Alveolar	Palatal	Velar	Glottal
Stop	vl.	unasp.	/p/	/t/		/k/	/ʔ/
		asp.	/p <sup>h</sup> /	/t <sup>h</sup> /		/k <sup>h</sup> /	
	vd.		/b/	/l/		/g/	
Nasal	vd.		/m/	/n/		/ŋ/	
Fricative	vl.			/s/			/h/
Affricate	vl.	unasp.		/ts/			
		asp.		/ts <sup>h</sup> /			
Glide	vd.			/j/			

Note ‘vl.’ is an abbreviation for the feature *voiceless*, ‘vd.’ *voiced*, ‘unasp.’ *unaspirated*, and ‘asp.’ *aspirated*

**Table 2.7** Vowels of Taiwan Southern Min

	Front		Central		Back	
	Oral	Nasal	Oral	Nasal	Oral	Nasal
High	/i/	/ĩ/			/u/	
Mid	/e/	/ẽ/	/ə/		/ɔ/	/õ/
Low			/a/	/ã/		

(2.1)	[ĩ <sup>33</sup> ]	‘yard’
	[pi <sup>53</sup> ]	‘flat’
	[ẽ <sup>55</sup> ]	‘child’
	[pe <sup>33</sup> ]	‘illness’
	[ta <sup>55</sup> ]	‘bear’
	[sa <sup>55</sup> ]	‘three’
	[ɔ <sup>55</sup> ]	‘infant sleeps’

2.2.3 Phonology of Vietnamese

Vietnamese has northern and southern dialects. The northern dialect does not have retroflex consonants, while the southern one does. Affricates are lacking in southern Vietnamese, while they exist in northern Vietnamese. The consonants of the two dialects are given in Table 2.8.

Vietnamese has ten vowels. Below is the vowel chart for the Hanoi variety, a northern dialect, and other dialects may have different vowel inventories (Vietnamese language 2007) (Table 2.9).

All vowels are unrounded except the back vowels. Therefore, the high front rounded vowel [y] in Mandarin is particular challenging for Vietnamese learners of Mandarin. On the other hand, like Mandarin, all vowels in Vietnamese carry an inherent tone. Vietnamese tones are not identical with Mandarin tones though. There are six tones in Vietnamese: high level, low falling, high rising, dipping-rising, breaking-rising, and low falling constricted. The tone value is listed in Table 2.10 (Vietnamese Language 2007; Lin 2005).

Table 2.8 Vietnamese consonants

Northern Vietnamese						
Manner	Place					
	Labial	Alveolar	Palatal	Velar	Glottal	
Stop (vl.)	p	t, t <sup>h</sup>	c	k		
Stop (vd.)	b	d				
Fricative (vl.)	ɸ	s		x	h	
(vd.)	v	z		ɣ		
Affricate (vl.)			tɕ			
Nasal (vd.)	m	n	ɲ	ŋ		
Approximant	w	l	j			
Southern dialect						
Manner	Place					
	Labial	Alveolar	Retroflex	Palatal	Velar	Glottal
Stop (vl.)	p	t	ɮ	c	k	
Stop (vd.)	b	d				
Fricative (vl.)	ɸ	s	ʂ		x	h
(vd.)			ʐ		ɣ	
Nasal (vd.)	m	n		ɲ	ŋ	
Approximant	w	l		j		

Table 2.9 Vietnamese vowels

	Front	Central	Back
High	i	ɨ	u
Upper mid	e	ə/ɐ:	o
Lower mid	ɛ		ɔ
Low		a	

Table 2.10 Vietnamese Tones

Name	Description	Tone value	Example
Ngang ‘level’	High level	33	<i>má</i> ‘ghost’
Huyền ‘hanging’	Low falling	21	<i>mà</i> ‘but’
sắc ‘sharp’	High rising	35	<i>má</i> ‘cheek, mother (southern)’
Hỏi ‘asking’	Dipping-rising	313	<i>mả</i> ‘tomb, grave’
Ngã ‘tumbling’	Breaking-rising	435	<i>mã</i> ‘horse (Sino-Vietnamese), code’
nặng ‘heavy’	Low falling constricted	3	<i>mạ</i> ‘rice seedling’

2.2.4 Phonology of Indonesian

Indonesian is not a tone language as Mandarin or Vietnamese; instead, Indonesian is an intonation language as English. Intonation, which means distinctive pitches in a phrase, conveys information about the syntactic components of the utterance. However, tone is distinctive pitches within a word, which may convey both lexical information about the meaning of the word and the grammatical function of the word. Speakers of intonation language often find it hard to consider the tone as an important, meaningful part of a word. Consequently, it is possible that speakers of Indonesian may make some mistakes in pronouncing Mandarin tones.

2.2.4.1 Indonesian Consonants

Indonesian has twenty-two consonants. Twelve of them can occur in both initial and final positions, and ten of them can only occur initially in the syllable. The twenty-two consonants are shown in Table 2.11.

As shown in Table 2.11, Indonesian has stops including voiceless–voiced pairs /p, b/, /t, d/, /k, g/ and one glottal stop /ʔ/, in which /p, t, k, ʔ/ can occur initially and finally in the syllable, but /b, d, g/ only occur in the initial position. Indonesian fricatives include /f, v/ and /s, z/ as two pairs of voiceless–voiced fricatives, one palatal fricative /ʃ/, one velar fricative /x/, and one glottal fricative /h/. /f, s, h/ occur both initially and finally in the syllable, but /v, z, ʃ, x/ occur only in the initial position of a syllable. Affricates include voiceless palatal /tʃ/ and the corresponding voiced palatal /dʒ/ and both of them only occur initially in the syllable. Besides, Indonesian has nasals /m, n, ɲ/, one alveolar trill /r/ and an alveolar lateral /l/. Palatal nasal /ɲ/ only occurs initially, but /m, n, ɲ, r, l/ occur both initially and finally in the syllable. In comparison with Vietnamese, the voiced velar stop /g/ and the

Table 2.11 Indonesian consonants (Macdonald and Darjowidjojo 2007)

Manner		Place					
		Bilabial	Labiodental	Alveolar	Palatal	Velar	Glottal
Stop	v.l.	/p/		/t/		/k/	/ʔ/
	vd.	/b/		/d/		/g/	
Nasal	vd.	/m/		/n/	/ɲ/	/ŋ/	
Fricative	v.l.		/f/	/s/	/ʃ/	/x/	/h/
	vd.		/v/	/z/			
Affricate	v.l.				/tʃ/		
	vd.				/dʒ/		
Trill	vd.			/r/			
Liquid	vd.			/l/			

Note ‘v.l.’ is an abbreviation for the feature *voiceless*, ‘vd.’ as *voiced*, ‘unasp.’ as *unaspirated*, and ‘asp.’ as *aspirated*

**Table 2.12** Indonesian vowels and semivowels (Macdonald and Darjowidjojo 2007: 6)

	Front	Central	Back
Semivowel	/j/		/w/
High	/i/		
Mid	/e/	/ʌ/	/o/
Low		/a/	

voiceless glottal stop /ʔ/ only exist in Indonesian but not in Vietnamese. However, Vietnamese has one voiceless aspirated alveolar stop /t<sup>h</sup>/ which also exists in Mandarin but not in Indonesian as well as a voiceless unaspirated palatal stop /c/. In terms of fricatives, Indonesian has palatal fricative /ʃ/, but Vietnamese does not; on the other hand, Vietnamese has velar fricative /ɣ/ which is absent in Indonesian. As for affricates, Indonesian has palatal affricates /tʃ/ and /dʒ/ distinguished by the feature [+/- voiced]. Mandarin has three pairs of affricates which are voiceless and distinguished by [+/- aspirated]: alveolar affricates /ts, ts<sup>h</sup>/, retroflex affricates /tʂ, tʂ<sup>h</sup>/, and palatal affricates /tɕ, tɕ<sup>h</sup>/. Vietnamese has no affricates. Both Vietnamese and Indonesian have four nasals /m, n, ɲ, ŋ/ and an alveolar lateral /l/, but alveolar trill /r/ exists only in Indonesian. In contrast to Mandarin, both Vietnamese and Indonesian lack retroflex sounds; moreover, the difference between Mandarin, Vietnamese, and Indonesian is that most of Mandarin consonants are distinguished by the feature [+/- aspirated], but both consonants of Vietnamese and Indonesian are distinguished by the feature [+/- voiced] (Macdonald and Darjowidjojo 2007).

### 2.2.4.2 Indonesian Vowels

There are two semivowels and six vowel phonemes in Indonesian and they are presented in Table 2.12.

Indonesian has two semivowel phonemes /j/ and /w/ and both of them can occur initially and finally in the syllable. In comparison with Vietnamese, both Vietnamese and Indonesian have front vowels /i/ and /e/ and back rounded vowels /u/ and /o/. Indonesian has a mid-central unrounded vowel phoneme /ʌ/ which Vietnamese does not have. However, compared with Mandarin, both Vietnamese and Indonesian lack high front rounded vowel /y/, which is easily replaced by high front unrounded vowel /i/ if there is no such a sound in the native language.

## 2.3 Mandarin Phonological Development by Native Children

### 2.3.1 Development of Mandarin consonants

According to Hsu (1996), children's phonological development in Mandarin can be divided into five stages. The first stage is from twelve to twenty months (1; 0–1; 8). In this stage, children do not seem to have a productive sound system because they

are still in the period of exploration of sounds. However, they have acquired [p], [m], [h], and [t]. It seems that the bilabial sounds are acquired quite early, but [n] is still unstable and sometimes even deleted from pronunciation. Besides, a variety of substitution sounds are used by the age of twenty months. For example, [l] is often replaced by [t] and [n].

The second stage is from twenty to thirty months (1; 8–2; 6). In the stage, children begin the active process of acquisition of a complex set of linguistic rules, so the development becomes a major part of acquisition in this stage. In this period, [f], [t<sup>h</sup>], and [ts<sup>h</sup>] begin to appear but are still unstable. [f] is often substituted by [p]. And, at this time, [p<sup>h</sup>] and [t<sup>h</sup>] are substituted by their unaspirated counterparts although they have been acquired at the preceding stage. Likely, [t] and [n] are still the most often substitutions for [l]. Besides, all the affricates except [tɕ], the fricatives, and the retroflex sounds are difficult for children. So, [ɕ] is replaced by [t], [k], or [tɕ]. Both [ts] and [s] are substituted by [t] or [tɕ]. As for [z], [l] is the most often substituted sound for it. [tɕ] and [tɕ<sup>h</sup>] are often replaced by [tɕ] and sometimes by [t]. [ʂ] has many variants such as [t], [k], and [tɕ] and English interdental fricative [θ].

The third stage is from thirty-one to thirty-eight months (2; 7–3; 2). During this stage, children progress from putting two words together with the well-formed simple sentences. Moreover, children still continue to add new sounds to his/her language. In this period, the mutual substitution between [l] and [n] is observed. Besides, all affricates and fricatives have emerged but are not very stable. The retroflex sounds are substituted by different ways including the corresponding affricates or fricatives and some sound approximations.

The fourth stage is from forty to forty-eight months (3; 4–4; 0). In this period, aspirated stops such as [t<sup>h</sup>] and [p<sup>h</sup>] can be pronounced, and the substitution of sounds such as [l], [tɕ<sup>h</sup>], and [ɕ] is dramatically narrowed down. As to the retroflex sounds and [ts], [ts<sup>h</sup>], and [s], they do not make any significant progress in this period.

The final stage is from fifty-two to seventy-two (4; 4–6; 0). In this stage, phonological development progresses considerably in that children begin to develop his/her perceptual abilities and acquire a number of phonemic contrasts in speech production. The number of substitution for the retroflex sounds seems to decrease gradually. But, sometimes [ts] is still used for [tɕ], and [ts] or [ts<sup>h</sup>] is used for [tɕ<sup>h</sup>]. The factors for the delay in acquiring the retroflexes might be the influence of Taiwanese (Hsu 1996). In fact, deretroflexion is quite common among adult Mandarin speakers in Taiwan (Rau and Li 1994).

### 2.3.2 *Development and Acquisition of Vowels and Final Nasals*

Since vowel production involves more invisible articulators, children may need to adopt trial and error in order to find proper positions of articulators. By the age of twelve months, children produce [a] first and followed by [i]. Then, by the age of



thirteen and fourteen months, children are able to pronounce [u] sound. By the age of eighteen months, children have good control over all the single vowels except [y]. That is, they can produce vowels such as [a], [i], [u], [ə], and [o]. Moreover, from thirteen months to eighteen months, children appear to pronounce the diphthongs such as [ai], [au], [ua], [ie], [ui], and [ia] although these diphthongs are not so stable in this period. Besides, they may be used to substitute for other sounds which are not acquired. By the age of six, children might still have problem with [ei] and [ou]. For example, [ei] may lose its glide and pronounced as [e]; [ou] may be pronounced as [o]. [y] may not be accurately pronounced by children till the age of six; otherwise, it is substituted by [i] or [ə].

Triphthongs are most difficult for children. Some children even cannot produce them accurately by the age of six. The first emergent triphthong is [iau] at around 2.6 and followed by [iou] at around 3.2; occasionally, [uai] would appear as early as one year of age. As for [uei], it is observed very late in language development and is often replaced by [ue].

Observations show that Chinese final nasals are very often used to substitute diphthongs without nasal ending. Sometimes the final nasals were dropped. The first final nasal that appeared was [uan] but was not so stable. It sometimes was replaced by [an] and [ua]. At around 3.2, [uan] was finally stabilized. [uang] had three alternatives for the period from 1.8 to 3.2. They are [ua], [ang], and [uang]. [yen] is replaced by [ien]. [uen] emerged around the age of 2.6 and was the only one used accurately (Hsu 1996).

### 2.3.3 *Development and Acquisition of Tones and Syllables*

In the early stage of language development, children may rely on the prosodic features such as stress and intonation. The declarative utterances rise gradually and then fall in fundamental frequency. The imperative utterances rise sharply and then fall. The questions have fundamental frequency contours which rise sharply at the end of the utterance. Usually, the declarative and imperative intonations are acquired at the beginning of one-word stage. The question intonation appears around the twentieth month. Besides, stress patterns are also made by children to show their emphasis on the intonation.

According to the literature, around one year of age, children appear to use the level tone and falling tone though not stable. But, before the age of one year, all rising and falling rising tones are substituted by the level or falling tones. The rising tone begins to appear shortly after 1.0. The falling rising tone does not emerge till the age of 1.6. By the age of 2.6, children have acquired the four tones, but they are sometimes confused between the rising and falling rising tones.

The development of syllable structures can be divided into the following four stages, beginning with simple structure to more complex one. In the first stage, the syllable structures appear to be CV, V, VV, and CVC, and CV is the dominant one in this period. In the second stage, the CVC pattern becomes stabilized and CVV

structure is new to appear in the period. Then, the CVV structure is a common one in this period; there appeared to be nasal syllabic consonants. In the final stage, the most complex structures appeared are VVV, CVVC, and CVVV.

There is some relationship between syllable structures and tones in children's development of speech. In early stage, children deal with simple structures such as V, CV, and VV and the level, falling, and rising tones are used. The falling rising tone begins to appear when children construct more complex syllables such as CVV and VVV. So, it seems that the dipping tone begins to appear after acquiring complex syllable structures (Hsu 1996).

## **2.4 Mandarin Phonological Development by Children of Vietnamese**

Since adult input has effects on children's phonology acquisition, it is important to know the characteristics of input they received. Just like most adult second language learners, Vietnamese mothers' Mandarin is influenced by the first language Vietnamese.

### ***2.4.1 Mandarin Phonological Errors of Vietnamese Mothers***

Vietnamese immigrants in Taiwan have some common Mandarin phonological errors. First, they are confused about the four tones. The mix of Tone 3 (rising falling) and Tone 2 (rising) and Tone 1 (high level) and Tone 4 (falling) occurs most frequently. The most difficult consonants are fricatives and affricates. They tend to be confused about aspirated affricates and voiceless fricatives. They are also confused about nasals and laterals and have difficulty distinguishing final alveolar and velar nasal. The most frequently observed vowel error lies in the high front rounded vowel /y/ and the dropping of glides in diphthongs (Lin 2005).

### ***2.4.2 Mandarin Phonological Development by Children of Vietnamese Mothers***

Children of Vietnamese mothers did not delay in phonological development as claimed in the previous literature. Despite pronunciation problems, most of them were also observed in the children of Taiwanese mothers such as retroflexes, nasals, and affricates. They both substituted retroflex obstruents with alveolar ones just like adult Mandarin speakers in Taiwan. While younger children tended to delete nasals

in coda, older children tended to alter the place of articulation. Children of Vietnamese mothers simplified affricates to fricatives, while children of Taiwanese mothers changed them to stops. Children in both groups were accurate in tones, regardless of the Vietnamese mothers' tone errors.

The common difficult place of articulation is retroflex. Both children of Vietnamese mothers and Taiwanese mothers across all ages have problems with retroflex obstruents. They tend to replace retroflex obstruents with alveolar obstruents. This phenomenon is also observed in the adult speakers of both Vietnamese and Taiwanese (Lin 2005). Replacing retroflex obstruents with alveolar obstruents is actually a characteristic of Mandarin spoken in Taiwan (Rau and Li 1994). It is the target adult form that children are achieving, which may not be considered as an error.

In addition, children in both groups have difficulty with nasals. The four-year-old child of a Vietnamese mother replaced an alveolar nasal [n] with an alveolar lateral liquid [l]. The same error was found in the speech of the two-year-old child of a Taiwanese mother, but was not observed in older children. The opposite process—change of [l] to [n]—was found in the Vietnamese two-year-old and the Taiwanese four-year-old as a result of nasal assimilation as in /nali/ 'where' → [nani]. Nasals in codas are most difficult for children. The four-year-old Vietnamese and Taiwanese tend to drop nasals in codas, which are the only coda allowed in Mandarin. The five- and six-year-old Vietnamese and six-year-old Taiwanese changed the place of articulation of nasals in codas. The five-year-old Vietnamese replaced a velar nasal with an alveolar nasal just like the six-year-old Taiwanese. The six-year-old Vietnamese did the opposite, who replaced an alveolar nasal with a velar nasal. The errors in nasals were not found in adults, neither Vietnamese nor Taiwanese. They are due to children's difficulty in velum control.

The common difficult manner of articulation is affricate. Affricates are composed of stops followed by fricatives. Children younger than five-year-olds in both groups were found to simplify this complex phonological process. While two- and four-year-old children of Vietnamese mothers changed affricates to fricatives, the three- and four-year-old children of Taiwanese mothers changed affricates to stops. Aspiration seems to confuse children, too. The two-year-old child of a Vietnamese mother tended to pronounce aspirated stops without aspiration. The three-year-old child of a Taiwanese mother pronounced aspirated stops as affricates. The problems with affricates were also observed in Vietnamese mothers but not in Taiwanese adults.

Some errors were unique to children of Vietnamese mothers such as pronouncing high front rounded vowels without lip rounding and replacing a labiodental fricative with a velar fricative followed by a labiovelar glide. The errors in lip rounding were observed in the two-year-olds and six-year-olds of Vietnamese mothers. The replacement of labiodental fricatives was found in the three- and four-year-olds of Vietnamese mothers. Such errors were also found in their mothers. They are also quite common in adult Mandarin speakers in Taiwan due to

Taiwanese interference. However, our children of Taiwanese groups in the study did not show difficulty in these two sounds.

As for the suprasegmental aspect, children seem to acquire well. Although Vietnamese mothers showed errors in tones, they did not influence the children's speech. No tone errors were found in children's speech. This confirms the literature that suprasegmental is the first thing first language children acquire while is the most difficult part for adult second language learners.

Children of Vietnamese mothers are not necessary slower language learners. Many of the difficulties they faced are also faced by the children of Taiwanese mothers. They can be due to innate biological constraints or poverty of input (Kuo 2008).

## 2.5 Mandarin Phonological Development by Children of Indonesian Mothers

Due to great individual differences, we conducted case studies of nineteen children aged from 2 to 6, a boy and a girl in each age-group except that the two-year-old Indonesian boy was missing. It is a primarily cross-sectional and secondarily longitudinal study so that we can see the developmental trend within reasonable time frame without missing the insight of individual differences. We followed the children for three years. We visited children at their homes, interviewed parents, and recorded their spontaneous conversation with children. All the data were transcribed in CHAT format with Chinese characters, international phonetic alphabet, English gloss, and translation. In the following, we described their phonological development and compared with children of Mandarin-speaking parents. Finally, some samples were illustrated in OT.

### 2.5.1 *The Two-Year-Old Indonesian Girl*

#### 2.5.1.1 Phonological Development in the First Year

The two-year-old Indonesian girl has not acquired most of the phonemes. She has problems with fricatives, affricates, retroflexes, and the high front rounded vowel /y/. She sometimes substituted labiodental fricative /f/ with high back vowel /u/. For example, she pronounced /fàn tsuàn/ 'sail' as [uàn tsuàn]. She also sometimes deleted the velar fricative /x/. For example, she pronounced /xua/ 'flower' as [ua]. She changed fricatives to affricates as /sān/ 'three' was pronounced as [tsān]. The child had problems with the aspirated alveopalatal affricate /tɕʰ/ and sometimes changed it to the unaspirated one [tɕ], as /tɕʰin tsʰái/ 'vegetable' was pronounced as [tɕin tsʰái] or the alveolar one [ts] as /fān tɕʰie/ 'tomato' was pronounced as

[fān ts<sup>h</sup>ie]. The alveopalatal fricative was changed to affricates at the same place of articulation. For example, /tiau cia te<sup>h</sup>y/ ‘fall’ was pronounced as [tiau teia te<sup>h</sup>y]. She replaced retroflexes with alveolars like her mother and many adults in Taiwan. For example, /tɕū/ ‘cook’ was pronounced as [tsū], /tɕ<sup>h</sup>/ ‘eat’ was pronounced as [ts<sup>h</sup>], and /ɕ/ ‘ten’ was pronounced as [ʃ]. The high front rounded vowel /y/ was replaced with the unrounded one [i] half of the time; for example, /te<sup>h</sup>y/ ‘go’ was pronounced as [te<sup>h</sup>i].

### 2.5.1.2 Phonological Development in the Second Year

In the second year, aspiration was acquired. All the aspirated stops were pronounced correctly. The unaspirated bilabial stop /p/ was omitted sometimes, e.g., /pù/ ‘no’ → [øù].

The child had acquired alveopalatal affricates. The problems with the labiodental and retroflex still remained. She continued pronouncing the labiodental fricative /f/ as a voiceless velar fricative [x] and replacing retroflex affricates with alveolars, e.g., /tɕuō tɕ/ ‘table’ → [tsuō tɕ]. She was able to produce the voiced retroflex fricative correctly, but not the voiceless one. The child showed regression in the aspirated alveolar affricate, which was pronounced correctly in the first year.

### 2.5.1.3 Phonological Development in the Third Year

In the third year, the child still deleted /x/ and deaspirated the aspirated alveopalatal affricate /tɕ<sup>h</sup>/ occasionally. All the retroflex consonants were still replaced by alveolars, and the retroflex schwa was pronounced without retroflex. Final velar nasals were sometimes changed to alveolar nasals or dropped like the final alveolar nasal sometimes. /u/ was deleted in /uo/ sequence occasionally.

The phonological development of the two-year-old child of an Indonesian mother is summarized in Table 2.13. The first column lists the target phonemes. The second column shows the phonetic representations and frequency of occurrences in the first year, two-year-old; the third column indicates those in the second year, three-year-old; the last column presents those in the third year, four-year-old. The frequency was omitted when there were no phonetic variations.

Let me give an example in OT framework. The Indonesian two-year-old girl ranked \*Retroflex constraint quite high and so replaced the retroflex fricative with alveolar fricative for three years as shown in Tableau 2.2.

**Table 2.13** Acquisition and substitutions of the sounds from the Indonesian girl: 2, 2 + 1, and 2 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p, ø	p: 96.87 %, ø: 3.13 %		p
p <sup>h</sup>	p <sup>h</sup>	100 %	p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f, u	u: 20 %	f		f	
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n		m		n	
l	l		l		l, n	l: 11/12 = 91.67 %, n: 1/12 = 8.33 %
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x, ø, u	ø: 4 %, u: 2 %	x		x, ø	x: 8/10 = 80 %, ø 2/10 = 20 %
te	te		te		te	
te <sup>h</sup>	te <sup>h</sup> , te, ts <sup>h</sup>	te: 2 %, ts <sup>h</sup> : 2 %	te <sup>h</sup> , te, ø	te <sup>h</sup> : 81.82 %, te: 9.09 %, ø: 9.09 %	te <sup>h</sup> , te	te <sup>h</sup> : 4/5 = 80 %, te: 1/5 = 20 %
ɕ	ɕ, te, te <sup>h</sup>	te: 52 %, te <sup>h</sup> : 9 %	ɕ, te	ɕ: 40 %, te: 60 %	ɕ	
tɕ	ts	100 %	ts	100 %	ts	100 %
tɕ <sup>h</sup>	ts <sup>h</sup>	100 %	ts <sup>h</sup>	100 %	ts <sup>h</sup>	100 %
ʃ	s, ts	s: 96 %, ts: 4 %	s	100 %	ʃ, s, ts	ʃ: 1/17 = 5.89 %, s: 15/17 = 88.22 %, ts: 1/17 = 5.89 %
ʒ	ʒ		s	100 %		ʃ: 1/17 = 5.89 %, s: 15/17 = 88.22 % ts: 1/17 = 5.89 %
ʒ	ʒ		ʒ		l	1/1 = 100 %
ts	ts		ts, ts <sup>h</sup>	ts: 95 %, ts <sup>h</sup> : 5 %	ts	

(continued)

Table 2.13 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>	
s	s, ts	ts: 33 %	s, ts	s: 75.86 %, ts: 24.14 %	s	
ɲ	ɲ		ɲ		ɲ	
i	i		i, ø	i: 96.77 %, ø: 3.23 %	i	
u	u		u, ø, y	u: 81.82 %, ø: 13.64 %, y: 4.55 %	u	
y	y, i	i: 50 %	y, i	y: 90.91 %, i: 9.09 %	y	
a	a		a, ai	a: 80 %, ai: 20 %	a	
o	o		o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai, a	a: 5 %	ai		ai	
e	e		e		e	
au	au		au		au	
ou	ou		ou		ou	
an	an, a, aŋ, uan	a: 7 %, aŋ: 7 %, uan: 2 %	an		an	
ən	ən		ən		ən	
aŋ	aŋ		aŋ, a, an, en	aŋ: 80 %, a: 4 %, an: 4 %, en: 12 %	aŋ, an	aŋ: 10/12 = 83.33 %, an: 2/12 = 16.67 %
əŋ	əŋ		əŋ		əŋ	
ə	ə		ə	100 %	ə	100 %
ia	ia		ia		ia	

(continued)

Table 2.13 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ua	ua		ua		ua	
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
ie	ie		ie		ie	
ye	ye		ye		ye	
uai	uai		uai		uai	
uei	uei		uei		uei	
iau	iau		iau		iau	
iou	iou		iou		iou	
ien	ien		ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in		in		in, i	in: 5/6 = 83.33 %, i: 1/6 = 16.67 %
uən	uən		uən		uən	
yn	yn		yn		yn	
iaŋ	iaŋ		iaŋ		iaŋ	
uaŋ	uaŋ		uaŋ		ua	ua: 1/1 = 100 %
in	in		in, in		in	
jɔŋ	jɔŋ		jɔŋ		jɔŋ	
uo	uo		uo		uo, o	uo: 6/7 = 85.71 %, o: 1/7 = 14.29 %



**Tableau 2.2** OT tableau for the Indonesian girl: 2, 2 + 1, and 2 + 2 years of age

§	Ident (αstrident)	*Retroflex	*Affricate	*(+cont)	*(+anterior)
ɬ				*	*
ʃ		*!		*	
ts			*!		*
tʃ		*!	*		

## 2.5.2 The Three-Year-Old Indonesian Boy

### 2.5.2.1 Phonological Development in the First Year

The three-year-old boy of an Indonesian mother has problems with aspiration, fricatives, laterals, nasals, retroflexes, and complex vowels. He sometimes aspirated and unaspirated stops and affricates as /pín/ ‘sick’ was pronounced as [p<sup>h</sup>ín] and /tɛi tɛ<sup>h</sup>izɛn/ ‘robot’ was pronounced as [tɛ<sup>h</sup>i tɛ<sup>h</sup>i lɛn]. He pronounced the labiodental fricative /f/ as aspirated or unaspirated voiceless bilabial stops as /fɛi tɛi/ ‘plane’ was pronounced as [pɛi tɛi] and /fán/ ‘put’ was pronounced as [p<sup>h</sup>án]. The alveolar lateral was used interchangeably with the alveolar nasal. For example, /pú nɛŋ/ ‘can’t’ was pronounced as [pú lɛŋ] and /luán tɛiǎŋ xúa/ ‘speak nonsense’ was pronounced as [núan tɛiǎŋ uá]. The velar fricative was omitted as in the above example, and also, /xóu mién/ ‘back’ was pronounced as [óu mén]. The alveopalatal fricative was replaced by the palatal one, as /tɔŋ ɛi/ ‘thing’ was pronounced as [tɔŋ ɛi]. The alveolar affricate was replaced by the alveopalatal one, for example, /tɛi tɛi/ ‘self’ as [tɛi tɛi]. The retroflex obstruents were replaced by their alveolar counterparts, for example, /tɕó/ ‘this’ as [tsó], /tɕ<sup>h</sup>ɔ ts/ ‘car’ as [ts<sup>h</sup>ɔ ts], /ʃ/ ‘is’ as [s], and /zɛn/ ‘person’ as [lɛn]. The high front rounded vowel was pronounced without lip rounding, for example, /uàn tɛy/ ‘toy’ as [uàn tɛi]. The child had a constraint against vowel sequences, so complex vowels were simplified, for example, /t<sup>h</sup>ɛ tɕ/ ‘sticker’ as [t<sup>h</sup>ɛ tɕ], /tuán tiáu/ ‘break’ as [tán tiáu], /tɛ<sup>h</sup>i kuái/ ‘strange’ as [tɛ<sup>h</sup>i kuá], and /p<sup>h</sup>ǎu tsǔu/ ‘run away’ as [p<sup>h</sup>ǎ tsǔu]. He seemed to do better in the vowels in syllable final. However, he tended to drop the final nasal; for example, /ɛiǎu ɛín/ ‘careful’ was pronounced as [ɛiǎu ɛi] and /uàn/ ‘play’ was pronounced as [uá].

Some of errors were also observed in the mother. The mother also replaced retroflex obstruents with alveolars just like most Mandarin-speaking adults in Taiwan. She simplified vowel sequence but not as productive as the child. She only omitted /i/ in /ie/ and /iou/ sequence, for example, /t<sup>h</sup>iɛ/ ‘paste’ as [t<sup>h</sup>ɛ] and /tɛiúu xú tɕ<sup>h</sup>ɔ/ ‘ambulance’ as [tɛiú xú tɕ<sup>h</sup>ɔ]. She was also observed to change alveolar affricate to alveopalatal, for example, /tɛi tɛi/ ‘self’ as [tɛi tɛi] like her child. She did not drop final nasals like her child, but changed the place of articulation, for example, /pú ɛiŋ/ ‘may not’ as [pú ɛin].

### 2.5.2.2 Phonological Development in the Second Year

In the second year, the voiceless labiodental fricative [f] has been acquired and pronounced accurately. However, he continued replacing retroflex obstruents with alveolar obstruents, i.e., /ʃuěi kuǒ/ ‘fruit’ → [suěi kuǒ]. There were also variants of stops. For example, the unaspirated voiceless bilabial stop /p/ was sometimes replaced as the aspirated one [p<sup>h</sup>] as in /tɕ<sup>h</sup>iàŋ pí/ ‘wall,’ or the alveolar one [t] as in /pǎn tɕ/ ‘board.’ The aspirated voiceless velar stop /k<sup>h</sup>/ was sometimes replaced with the alveolar one [t<sup>h</sup>], e.g., /k<sup>h</sup>ǎ p<sup>h</sup>ién/ ‘card’ → [t<sup>h</sup>ǎ p<sup>h</sup>ién]. Some errors in the vowels occurred in the second year. A coda [n] was added to the vowel /a/, e.g., /tǎ teiá/ ‘fight’ → [tǎ teián] or replaced the velar nasal coda, i.e., /tɕ<sup>h</sup>uàn/ ‘bed’ → [tɕ<sup>h</sup>uàn].

### 2.5.2.3 Phonological Development in the Third Year

In the third year, the child was already six years of age. He had acquired most phonemes, but still had problems with retroflexes and pronounced them as alveolars just like most adult Mandarin speakers in Taiwan. For example, retroflex affricate /tɕ/ was still replaced by alveolar affricate [ts] as in /tɕǒ/ ‘this’; retroflex obstruent /ʃ/ was still replaced by alveolar obstruent [s] as in /ʃí/ ‘be.’ The other problem is replacing the vowel /u/ with [ou], e.g., /p<sup>h</sup>iŋ kuǒ/ ‘apple’ → [p<sup>h</sup>iŋ kou]. The phonological development of the three-year-old boy of an Indonesian mother is summarized in Table 2.14.

Let me illustrate the phonological development of the three-year-old Indonesian boy in the OT framework. The three-year-old Indonesian boy ranked the markedness constraints \*(+s.g), \*(+cont), and \*Stop over the faithfulness constraint, so the labiodental fricative became the unaspirated voiceless bilabial stop as shown in Tableau 2.3. In the second and the third year, \*(+s.g) and \*(+cont) were demoted and thus ended with the correct target [f] as in Tableau 2.4.

## 2.5.3 The Three-Year-Old Indonesian Girl

### 2.5.3.1 Phonological Development in the First Year

The three-year-old girl of an Indonesian mother has acquired all the stops and had mistakes only occasionally. She had some typical Taiwan Mandarin pronunciation. She replaced labiodental fricative /f/ with the velar one [x], for example, /fǒŋ lì/ ‘pineapple’ as [xǒŋ lì]. She also replaced retroflexes with alveolar counterparts, for example, /tɕǒ kǎ/ ‘this one’ as [tsǒ kǎ], /tɕ<sup>h</sup>/ ‘eat’ as [tɕ<sup>h</sup>], /ʃ/ ‘is’ as [s], and /zǎn/ ‘person’ as [lǎn]. The child has acquired all the vowels except sometimes they replaced the rounded high front vowel /y/ with the unrounded one [i]. For example, /y mǐ/ ‘corn’ was pronounced as [i mǐ].

**Table 2.14** Acquisition and substitutions of the sounds from the Indonesian boy: 3, 3 + 1, and 3 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p, p <sup>h</sup>	p (93.59 %), p <sup>h</sup> (6.41 %)	p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup> , m once	
m	m		m		m	
f	f, p, p <sup>h</sup> , x	f (21.74 %), p (69.57 %), p <sup>h</sup> (4.35 %), x (4.35 %)	f		f	
t	t, k, l	t (87.18 %), k (1.71 %), l (11.11 %)	t		t	
t <sup>h</sup>	t <sup>h</sup> , x, ø	t <sup>h</sup> (70 %), x (1.15 %), ø (1.12 %)	t <sup>h</sup>		t <sup>h</sup>	
n	n, l	n (94.95 %), l (5.05 %)	m		n	
l	l, n, k, ø	l (97.21 %), n (0.56 %), k (1.12 %), ø (1.12 %)	l		l	
k	k, k <sup>h</sup>	k (99.04 %), k <sup>h</sup> (0.96 %)	k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x, ø	x (96.94 %), ø (3.06 %)	x		x	
te	te, te <sup>h</sup> , ts, t <sup>h</sup>	te (77.27 %), te <sup>h</sup> (19.09 %), ts (2.73 %), t <sup>h</sup> (0.91 %)	te, ø, t	te (81.82 %), ø (4.54 %), t (13.64 %)	te	
te <sup>h</sup>	te <sup>h</sup>		te <sup>h</sup>		te <sup>h</sup>	
ɛ	ɛ, ɛ, s, k <sup>h</sup> , te	ɛ (88.68 %), ɛ (1.89 %), s (1.89 %), k <sup>h</sup> (1.89 %), te (5.66 %)	ɛ, te	ɛ (81.82 %), te (18.18 %)	ɛ	
tʂ	ts, te	ts (99.34 %), te (0.66 %)	tʂ, ts, te, t <sup>h</sup> , t	tʂ (4.08 %), ts (85.72 %), te (4.08 %), t <sup>h</sup> (4.08 %), t (2.04 %)	ts	100 %
tʂ <sup>h</sup>	ts <sup>h</sup> , te <sup>h</sup>	ts <sup>h</sup> (97.18 %), te <sup>h</sup> (2.82 %)	tʂ <sup>h</sup> , ts <sup>h</sup>	tʂ <sup>h</sup> (9.09 %), ts <sup>h</sup> (90.91 %)	ts <sup>h</sup>	100 %
ʂ	s, ɛ	s (97.26 %), ɛ (2.74 %)	s	100 %	s, ɛ	

(continued)

Table 2.14 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ʒ	l	100 %	ʒ		l	100 %
ts	ts, tɕ	ts (4.74 %), tɕ (5.26 %)	ts, k	ts (87.5 %), tɕ (8.33 %), k (4.17 %)	ts	
tɕ <sup>h</sup>	tɕ <sup>h</sup>		tɕ <sup>h</sup>		tɕ <sup>h</sup> , ø	tɕ <sup>h</sup> (92.59 %), ø (7.41 %)
s	s		s		s	
ɲ	ɲ		ɲ		ɲ	
i	i		i		i	
u	u		u		u	
y	y, i	y (59.1 %), i (40.91 %)	y		y	
a	a, ia, au	a (96.97 %), ia (1.82 %), au (1.21 %)	a		a	
o	o		o		o	
ə	ə, i, ei, o	ə (99.25 %), i (0.30 %), ei (0.15 %), o (0.30 %)	ə		ə	
ei	ei, ie	ei (93.65 %), ie (6.35 %)	ei		ei	
ai	ai, a, ia	ai (68.18 %), a (29.09 %), ia (2.73 %)	ai, a	ai (66.67 %), a (33.33 %)	ai	
e	e		e		e	
au	au, a, iau	au (71.95 %), a (26.83 %), iau (1.22 %)	au		au	
ou	ou		ou		ou	
an	an, a	an (90 %), a (10 %)	an		an, uan once	

(continued)

Table 2.14 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ən	ən		ən, in	ən (77.78 %), in (22.22 %)	ən	
aŋ	aŋ		aŋ		aŋ	
əŋ	əŋ, an	əŋ (93.33 %), an (6.67 %)	ən	100 %	əŋ	
ə	ə		ə	100 %	ə	100 %
ia	ia		ia		ia	
ua	ua		ua		ua	
əŋ	əŋ		əŋ		əŋ	
ie	ie, e, i, ei, iau	ie (24 %), e (40 %), i (12 %), ei (20 %), iau (4 %)	ie, e	ie (56.25 %), e (43.75 %)	ie	
ye	ye		ye		ye	
uai	uai, ua	uai (88.64 %), ua (11.36 %)	uai		uai	
uei	uei, u	uei (97.87 %), u (2.13 %)	uei		uei	
iau	iau, ia	iau (86.13 %), ia (13.87 %)	iau		iau	
iou	iou, ə, ou, iɔ	iou (90.82 %), ə (2.04 %), ou (3.06 %), iɔ (4.08 %)	iou		iou	
ien	ien, en, iŋ, ei, i	ien (65.08 %), en (25.40 %), iŋ (3.17 %), ei (4.76 %), i (1.59 %)	ien, en	ien (73.68 %), en (26.32 %)	ien	
uan	uan, an, ua, uaŋ, əŋ	uan (73.44 %), an (1.56 %), ua (12.5 %), uaŋ (4.69 %), əŋ (7.81 %)	uan		uan	
yen	yen		yen		yen	
in	in, i	in (92 %), i (8 %)	in		in	
uən	uən		uən		uən	
yn	yn		yn		yn	

(continued)

Table 2.14 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
iaŋ	iaŋ		iaŋ		iaŋ	
uaŋ	uaŋ, ɔŋ	uaŋ (42.86 %), ɔŋ (57.14 %)	uaŋ		uaŋ, ɔŋ	uaŋ (86.67 %), ɔŋ (13.33 %)
iŋ	iŋ		iŋ, in	iŋ (28.57 %), in (71.43 %)	iŋ	
jɔŋ	jɔŋ		jɔŋ		jɔŋ	
uo	uo, o, ou	uo (71.31 %), o (26.23 %), ou (2.46 %)	uo, o, u	uo (80 %), o (14.29 %), u (5.71 %)	uo, o	uo (98.91 %), o (1.09 %)

**Tableau 2.3** OT tableau for the Indonesian boy: 3 years of age

/f/	Ident ( $\alpha$ anterior)	*(+s.g)	*(+cont)	*Stop	Ident ( $\alpha$ strident)
f		*!	*		
$\text{ᶱᶮ}$ p				*	*
p <sup>h</sup>		*!		*	*
x	*!		*		*

**Tableau 2.4** OT tableau for the Indonesian boy: 3 + 1 and 3 + 2 years of age

/f/	Ident ( $\alpha$ anterior)	*Stop	*(+s.g)	*(+cont)	Ident ( $\alpha$ strident)
$\text{ᶱᶮ}$ f			*	*	
p		*!			*
p <sup>h</sup>		*!	*		*
x	*!			*	*

### 2.5.3.2 Phonological Development in the Second Year

In the second year, the phonetic variations decreased in both types and tokens. The replacement of labiodental fricative /f/ with the velar one [x] has disappeared. The replacement of retroflexes with alveolars still happens occasionally. The alveopalatal fricative was still pronounced as affricates most of the time. The alveolar fricative was also pronounced as affricates sometimes. The vowel /u/ was dropped occasionally. She still replaced the rounded high front vowel /y/ with the unrounded one [i] occasionally. /a/ was replaced with [ai] occasionally. She dropped nasals in codas or changed the place of articulation occasionally, which was not observed in the first year.

### 2.5.3.3 Phonological Development in the Third Year

In the third year, the only problems remained were retroflexes and nasals in coda. Retroflexes were replaced with alveolars most of the time. The velar nasals in codas were still replaced with alveolar nasals when following /i/ but not other vowels sometimes. The frequency is lower than that in the second year. The phonetic representations of the three-year-old girl are summarized in Table 2.15.

**Table 2.15** Acquisition and substitutions of the sounds from the Indonesian girl: 3, 3 + 1, and 3 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup> , x, f, t <sup>h</sup>	x: 8 %, f: 8 %, t <sup>h</sup> : 8 %	p <sup>h</sup> , p	p <sup>h</sup> : 77.78 %, p: 22.22 %	p <sup>h</sup>	
m	m		m, l	m: 87.5 %, l: 12.5 %	m	
f	f, x	x: 33 %	f		f	
t	t, p, k, ts	p: 4 %, k: 2 %, ts: 2 %	t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n		m		n	
l	l		l, n	l: 98 %, n: 2 %	l	
k	k		k		k, ø	ø: once once
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
tɛ	tɛ, t	t: 2 %	tɛ		tɛ	
tɛ <sup>h</sup>	tɛ <sup>h</sup> , ɛ	ɛ: 6 %	tɛ <sup>h</sup>		tɛ <sup>h</sup>	
ɛ	ɛ		ɛ		ɛ	
tɕ	tɕ, ts	ts: 94 %	ts, tɛ	ts: 93.33 %, tɛ: 6.67 %	ts	53/53 = 100 %
tɕ <sup>h</sup>	tɕ <sup>h</sup> , ts <sup>h</sup> , k <sup>h</sup>	ts <sup>h</sup> : 81 %, k <sup>h</sup> : 2 %	ts <sup>h</sup>	100 %	ts <sup>h</sup>	8/8 = 100 %
ɕ	ɕ, s, ts <sup>h</sup> , k <sup>h</sup> , x, k, t <sup>h</sup>	s: 66 %, ts <sup>h</sup> : 2 %, k <sup>h</sup> : 18 %, x: 5 %, k: 5 %, t <sup>h</sup> : 2 %	ɕ, s	ɕ: 25 %, s: 75 %	s	43/43 = 100 %
ʒ	l	100 %	ʒ		ʒ	ʒ: 2/4 = 50 %, l: 2/4 = 50 %

(continued)



Table 2.15 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency	year	Frequency		Frequency
ts	ts, k, tʂ	k: 10 %, tʂ: 10 %	ts, tʂ	ts: 90.91 %, tʂ: 9.09 %	ts, tʂ, tɕ	tʂ once tɕ once
ts <sup>h</sup>	ts <sup>h</sup> , k <sup>h</sup>	k <sup>h</sup> : 6 %	ts <sup>h</sup>		ts <sup>h</sup>	
s	s, ʂ, k <sup>h</sup>	ʂ: 9 %, k <sup>h</sup> : 27 %	s, ʂ	s: 97.92 %, ʂ: 2.08 %	s, ʂ	ʂ twice
ɲ	ɲ		ɲ		ɲ	
i	i		i		i	
u	u		u, ø	u: 94.34 %, ø: 5.66 %	u	
y	y, i	i: 48 %	y		y	
a	a, au	au: 3 %	a		a	
o	o		o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai		ai		ai	
e	e		e		e	
au	au		au		au, iau	iau twice
ou	ou		ou		ou	
an	an, ən, uan	ən: 10 %, uan: 15 %	an		an	
ən	ən		ien	100 %	ən	
aŋ	aŋ, an	an: 9 %	aŋ, an	aŋ: 81.25 %, an: 18.75 %	aŋ	
əŋ	əŋ		əŋ		əŋ	
əʊ	əʊ		ə	100 %	əʊ	
ia	ia		ia		ia	

(continued)

Table 2.15 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency	year	Frequency		Frequency
ua	ua		ua		ua	
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
ie	ie		ie		ie	
ye	ye		ye		ye	
uai	uai		uai		uai	
uei	uei		uei		uei	
iau	iau		iau		iau	
iou	iou		iou		iou	
ien	ien		ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in		in		in	
uən	uən		uən		uən	
yn	yn		yn		yn	
iaŋ	iaŋ		iaŋ		iaŋ	
uaŋ	uaŋ		uaŋ		uaŋ	
ɪŋ	ɪŋ		ɪŋ, in	ɪŋ: 69.23 %, in: 30.77 %	ɪŋ, in, in	ɪŋ: 5/8 = 62.5 %, in: 2/8 = 25 %, i: 1/8 = 12.5 %
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
uo	uo		uo		uo	

## 2.5.4 *The Four-Year-Old Indonesian Boy*

### 2.5.4.1 Phonological Development in the First Year

The Indonesian four-year-old boy had problems with stops, fricatives, laterals, nasals, alveopalatals, and retroflexes. The child replaced the unaspirated voiceless bilabial stop /p/ with the voiceless labiodental fricative [f] as /pán fǎ/ ‘solution’ was pronounced as [fán fǎ]. On the other hand, he also changed fricatives to stops. For example, /xēi sǎ/ ‘black’ was pronounced as [xēi tá] and /sǒŋ şǔ/ ‘squirrel’ was pronounced as [tǒŋ tú]. The aspirated voiceless alveolar stop /tʰ/ was replaced by alveolar affricates [tsʰ]. For example, /tʰú/ ‘throw up’ was pronounced as [tsʰú]. The alveolar lateral /l/ and alveolar nasal /n/ were used interchangeably as /nàn şǒŋ/ ‘male’ was pronounced as [làn tǒŋ] and /làn teʰiòu/ ‘basketball’ was pronounced as [nàn teʰiòu]. Alveolar nasals and velar nasals in codas were mixed. For example, /kuán teŋ/ ‘champion’ was pronounced as [kuán teŋ] and /tsʰòŋ kōŋ/ ‘succeed’ was pronounced as [tʂʰən kōŋ]. The alveopalatal fricative /ç/ was changed to the palatal fricative [ç] or alveolar fricative [s]. For example, /çiǎŋ táu/ ‘think of’ was pronounced as [çiǎŋ táu] and /tʂʰòŋ ěi/ ‘restart’ was pronounced as [tsʰòŋ sĭ]. The retroflexes were replaced by their alveolar counterparts. For example, /kʰǎ tʂú/ ‘stuck’ was pronounced as [kʰǎ tsú], /tʂʰuán/ ‘wear’ was pronounced as [tsʰuán], and /şǎ y/ ‘shark’ was pronounced as [sǎ y]. The voiced retroflex fricative was replaced by the alveolar lateral [l] all the time as /zən teiā/ ‘I’ was pronounced as [lən teiā]. The child sometimes changed alveolar affricates to retroflex or alveopalatal ones. For example, /tʰú ts/ ‘rabbit’ was pronounced as [tʰú tʂ] and /tʂ/ ‘rabbit’ was pronounced as [teʰi]. The child did not really have problems with any manner or place of articulation, but was confused about when to use which one. All the vowels were correct. His mother also replaced retroflexes and final velar nasals with alveolars as she pronounced /tʂǎu/ ‘find’ as [tsǎu] and /nàn şǒŋ/ ‘male’ as [nàn sən]. The mother’s errors were more systematic.

### 2.5.4.2 Phonological Development in the Second Year

In the second year, the child produced the labiodental fricative /f/ correctly, but still have problems with the voiceless retroflex fricative, which was replaced with an alveolar one [s], e.g., /şǔ/ ‘book’ → [sǔ]. The other problem was the dropping of velar nasal coda, i.e., /ɔŋ/ → [ɔ] as in /xòŋ lò puo/ ‘carrot.’ Moreover, the child still replaced retroflex affricate /tʂ/ with alveolar affricate /ts/ as in /tʂuō tʂ/ ‘table.’

### 2.5.4.3 Phonological Development in the Third Year

In the third year, the child was already seven years of age. He had acquired all the phonemes and pronounced them almost correctly. But, sometimes, the child may replace the unaspirated voiceless alveolar stop /t/ with the aspirated one [t<sup>h</sup>], e.g., /tɔŋ ú/ ‘animal’ → [t<sup>h</sup>ɔŋ ú]. Besides, the retroflex affricate /tʂ/ was sometimes replaced with alveolar affricate /ts/, i.e., /tʂɔ́ kə/ ‘this’ → [tsɔ́ kə]. The phonological development of the four-year-old boy of an Indonesian mother is summarized in Table 2.16.

Let me illustrate with an example of the four-year-old boy’s phonological development in the OT framework. \*(+cont) was high-ranked in the first year, so the voiceless bilabial stop was changed to voiceless labiodental fricative as in Tableau 2.5.

In the second and the third year, \*(+cont) was demoted and ended with the target [p] as in Tableau 2.6.

### 2.5.5 The Four-Year-Old Indonesian Girl

#### 2.5.5.1 Phonological Development in the First Year

The Indonesian four-year-old girl has acquired most of the phonemes and just had problems with retroflexes and high front rounded vowels like many Mandarin-speaking adults in Taiwan. She replaced retroflexes with alveolars. For example, /tʂũ/ ‘cook’ was pronounced as [tsũ]. /tʂ<sup>h</sup>ũ/ ‘out’ was pronounced as [ts<sup>h</sup>ũ]. /ʃ̥/ ‘teacher’ was pronounced as [ʃ̥]. /zàn/ was pronounced as [làn]. The high front rounded vowel was pronounced without lip rounding, as /tɕ<sup>h</sup>ý/ ‘go’ was pronounced as [tɕ<sup>h</sup>i] occasionally.

**Table 2.16** Acquisition and substitutions of the sounds from the Indonesian boy: 4, 4 + 1, and 4 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p, f	p: 2/6 = 33.3 %, f: 4/6 = 66.6 %	p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m, l	m: 5/6 = 83.33 %, l: 1/6 = 16.67 %	m	
f	f		f		f, p	p: once
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup> , ts <sup>h</sup> , tʃ	t <sup>h</sup> : 5/12 = 41.6 %, ts <sup>h</sup> : 6/12 = 50 %, tʃ: 1/12 = 8.3 %	t <sup>h</sup> , ts <sup>h</sup>	t <sup>h</sup> : 6/7 = 85.71 %, ts <sup>h</sup> : 1/7 = 14.29 %	t <sup>h</sup>	
n	n, l	n: 1/2 = 50 %	m		n	
		l: 1/2 = 50 %				
l	n, l	l: 11/13 = 84.6 % n: 2/13 = 15.3 %	l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
te	te		te		te, k	k twice
te <sup>h</sup>	te <sup>h</sup>		te <sup>h</sup>		te <sup>h</sup>	
ɕ	ɕ, s, ts	ɕ: 4/8 = 50 %, s: 3/8 = 37.5 %, ts: 1/8 = 12.5 %	ɕ		ɕ, k	k once
tʂ	ts, t	ts: 14/17 = 82.3 %, t: 3/17 = 17.7 %	tʂ, t, ts	tʂ: 1/4 = 25 %, t: 2/4 = 50 %, ts: 1/4 = 25 %	tʂ, ts, te	tʂ: 4/144 = 2.78 %, ts: 139/144 = 96.53 %, te: 1/144 = 0.69 %
tʂ <sup>h</sup>	tʂ <sup>h</sup> , ts <sup>h</sup>	tʂ <sup>h</sup> : 4/23 = 17.3 %, ts <sup>h</sup> : 19/23 = 82.6 %	tʂ <sup>h</sup> , t, h	tʂ <sup>h</sup> : 3/4 = 75 %, t+: 1/4 = 25 %	tʂ <sup>h</sup> , ts <sup>h</sup>	tʂ <sup>h</sup> : 3/30 = 10 % ts <sup>h</sup> : 27/30 = 90 %

(continued)

Table 2.16 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ʒ	s, ts, ts <sup>h</sup> , t, ɛ	s: 3/31 = 9.6 %, ts: 1/31 = 3.2 %, ts <sup>h</sup> : 23/31 = 74.1 %, t: 3/31 = 9.6 %, ɛ: 1/31 = 3.2 %	ʒ, s	ʒ: 3/4 = 75 %, s: 1/4 = 25 %	ʒ, s	s: 7/78 = 8.97 %, s: 71/78 = 91.03 %
ʒ	l	1/1 = 100 %	ʒ		l, n	l: 16/17 = 94.12 %, n: 1/17 = 5.88 %
ts	ts, ts, t	ts: 1/3 = 33.3 %, ts: 1/3 = 33.3 %, t: 1/3 = 33.3 %	ts	7/7 = 100 %	ts, ts	l: 35/38 = 92.11 %, n: 3/38 = 7.89 %
ts <sup>h</sup>	ts <sup>h</sup> , ts <sup>h</sup>	ts <sup>h</sup> : 1/2 = 50 %, ts <sup>h</sup> : 1/2 = 50 %	ts <sup>h</sup> , ts <sup>h</sup>	ts <sup>h</sup> : 4/5 = 80 %, ts <sup>h</sup> : 1/5 = 20 %	ts <sup>h</sup> , ts <sup>h</sup>	ts <sup>h</sup> : 8/9 = 88.89 %, ts <sup>h</sup> : 1/9 = 11.11 %
s	s, t, ɛ	s: 4/19 = 21.05 %, t: 13/19 = 68.42 %, ɛ: 2/19 = 10.52 %	s, ʒ	s: 7/12 = 58.33 %, ʒ: 5/12 = 41.67 %	s, ʒ	s: 28/30 = 93.33 %, ʒ: 2/30 = 6.67 %
ɪ	ɪ		ɪ		ɪ	
i	i		i		i	
u	u		u		u	
y	y		y		y	
a	a		a		a	
o	o		o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai		ai		ai	
e	e		e		e	
au	au		au		au	
ou	ou		ou		ou	
an	an, aɪ	an: 3/11 = 27.27 %, aɪ: 8/11 = 72.72 %	an		an	
ən	ən		ən		ən	

(continued)

Table 2.16 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year	Phonetic representations, third year	
		Frequency		Frequency	Frequency
aŋ	aŋ		aŋ	aŋ	
əŋ	əŋ, ən	əŋ: 3/6 = 50 %, ən: 3/6 = 50 %	əŋ	əŋ, ən	əŋ: 2/7 = 28.57 %, ən: 5/7 = 71.43 %
ə~	ə~		ə~	ə~	19/19 = 100 %
ia	ia		ia	ia	
ua	ua		ua	ua	
əŋ	əŋ		əŋ	əŋ	
ie	ie		ie	ie	
ye	ye		ye	ye	
uai	uai		uai	uai	
uei	uei		uei	uei	
iau	iau		iau	iau	
iou	iou		iou	iou	
ien	ien		ien	ien	
uan	uan		uan	uan	
yen	yen		yen	yen	
in	in		in	in	
uən	uən		uən	uən	
yn	yn		yn	yn	
iaŋ	iaŋ		iaŋ	iaŋ	
uaŋ	uaŋ		uaŋ	uaŋ	

(continued)

Table 2.16 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
iŋ	in	3/3 = 100 %	iŋ		iŋ	
jɔŋ	jɔŋ		jɔŋ		jɔŋ	
uo	uo		uo		uo	



**Tableau 2.5** OT tableau for the Indonesian boy: 4 years of age

p	Ident ( $\alpha$ anterior)	*Stop	* (+cont)	* (+strident)
p		*!		
$\text{u}\text{a}\text{f}$			*	*

**Tableau 2.6** OT tableau for the Indonesian boy: 4 + 1 and 4 + 2 years of age

p	Ident ( $\alpha$ anterior)	* (+cont)	* (+strident)	*Stop
$\text{u}\text{a}\text{p}$				*
f		*!	*	

Her mother also replaced retroflexes with alveolars and pronounced the high front rounded vowel without lip rounding. In addition, she replaced alveolar nasals with alveolar laterals, changed the place of articulation of final nasals, simplified complex vowels, and pronounced the first tone as the fourth tone. For example, the mother pronounced /nién/ ‘read’ as [lién]. She changed the final alveolar nasal to a velar one, as /uón/ ‘ask’ was pronounced as [uón]. She tended to drop the first vowel in a sequence; for example, /tɛ<sup>h</sup>ién mién/ ‘front’ was pronounced as [tɛ<sup>h</sup>ién mén] and /xǔo tɛién/ ‘rocket’ was pronounced as [xǔ tɛién]. She pronounced the first tone as the fourth tone as /xiǎŋ kū/ ‘mushroom’ was pronounced as [xiǎŋ kū]. These errors were not observed in the child.

### 2.5.5.2 Phonological Development in the Second Year

In the second year, the girl still replaced retroflexes with alveolars all the time. In addition, she had problems with place of articulation of nasals in codas. She tended to replace velar nasals with alveolar nasals next to /i/, which could be caused by assimilation. Nasals following other vowels were pronounced correctly.

### 2.5.5.3 Phonological Development in the Third Year

In the third year, retroflexes were still replaced with alveolars over 90 % of the time. Velar nasals were replaced with alveolar nasals next to /i/ with even higher frequency than in the second year. The acquisition and substitutions of the sounds of the four-year-old girl are summarized in Table 2.17.

**Table 2.17** Acquisition and substitutions of the sounds from the Indonesian girl: 4, 4 + 1, and 4 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f		f		f, xw	f: 13/16 = 81.25 %, xw: 3/16 = 18.75 %
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n, m	n: 98.24 %, m: 1.75 %	m		n	
l	l		l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
tɕ	tɕ		tɕ		tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup>		tɕ <sup>h</sup>		tɕ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tʂ	tʂ	100 %	tʂ	100 %	tʂ, ts	tʂ: 8/134 = 5.97 %, ts: 126/134 = 94.03 %
tʂ <sup>h</sup>	tʂ <sup>h</sup>	100 %	tʂ <sup>h</sup>	100 %	tʂ <sup>h</sup> , ts <sup>h</sup>	tʂ <sup>h</sup> : 2/31 = 6.45 %, ts <sup>h</sup> : 29/31 = 93.55 %
ʂ	s	100 %	s	100 %	ʂ, s	ʂ: 22/341 = 6.45 %, s: 319/341 = 93.55 %
ʐ	l	100 %	ʐ		ʐ, l	ʐ: 24/52 = 46.15 %, l: 28/52 = 53.85 %
ts	ts		ts		ts	
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>	
s	s		s		s	

(continued)

Table 2.17 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ŋ	ŋ		ŋ		ŋ	
i	i		i		i	
u	u		u		u	
y	y, i	y: 93.75 %, i: 6.25 %	y		y	
a	a		a		a	
o	o		o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai		ai		ai	
e	e		e		e	
au	au, aŋ	au: 98.33 %, aŋ: 1.66 %	au		au	
ou	ou		ou		ou	
an	an, aŋ	an: 96.77 %, aŋ: 3.22 %	an		an	
ən	ən		ən		ən	
aŋ	aŋ		aŋ		aŋ	
əŋ	əŋ		əŋ		əŋ	
ə	ə	100 %	ə		ə, ə	ə: 3/24 = 12.5 %, ə: 21/24 = 87.5 %
ia	ia		ia		ia	
ua	ua		ua		ua	
əŋ, au,	əŋ, au,	əŋ: 88.88 %, au: 5.55 %, ə: 5.55 %	əŋ		əŋ	

(continued)

Table 2.17 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ie	ie		ie		ie	
ye	ye		ye		ye	
uai			uai		uai	
uei			uei		uei	
iau	iau, teiau	iau: 96.87 %, teiau: 3.12 %	iau		iau	
iou	iou		iou		iou	
ien	ien		ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in		in		in	
uən	uən		uən		uən	
yn	yn		yn		yn	
iaŋ	iaŋ		iaŋ		iaŋ	
uaŋ	uaŋ		uaŋ		uaŋ	
iŋ	iŋ		iŋ, in	in: 57.14 %, in: 42.86 %	iŋ, in	in: 14/50 = 28 %, in: 36/50 = 72 %
jəŋ	jəŋ		jəŋ		jəŋ	
uo	uo, o	uo: 99.31 %, o: 0.68 %	uo		uo	

### 2.5.6 *The Five-Year-Old Indonesian Boy*

#### 2.5.6.1 Phonological Development in the First Year

The Indonesian five-year-old boy had problems with labiodental fricatives, retroflexes, final nasals, and complex vowels. He replaced the labiodental fricative /f/ with [xu]; for example, [fēi tēi] ‘airplane’ was pronounced as [xuēi tēi]. He replaced all the retroflexes with alveolars as /tṣó ián/ ‘this way’ as [tsó ián], /tṣʰ ‘eat’ as [tṣʰ], /ʃ/ ‘is’ as [ʃ], and /zən/ ‘person’ as [lən]. One of the vowels in a sequence was omitted sometimes. For example, /kǒu/ ‘dog’ was pronounced as [kǒ], /mién/ ‘noodles’ as [mén], /tṣʰuān/ ‘bed’ as [tṣʰān], and /uǒ/ ‘I’ as [ǒ]. The velar nasal /ŋ following /i/ was changed to the alveolar nasal [n] as /tɛʰiŋ/ ‘clean’ was pronounced as [tɛʰin]. Many of these errors were also observed in the mother (Table 2.21).

His mother also replaced retroflexes with alveolars, changed the place of articulation of final nasals, pronounced the high front rounded vowel without lip rounding, and simplified complex vowels. In addition, she replaced the alveolar nasal with the alveolar lateral, the first tone with the fourth tone. For example, the mother pronounced /nién/ ‘read’ as [lién]. She changed the final alveolar nasal to a velar one, as /uǎn/ ‘ask’ was pronounced as [uǎŋ]. She tended to drop the first vowel in a sequence; for example, /tɛʰièn mién/ ‘front’ was pronounced as [tɛʰièn mén] and /xǔo tién/ ‘rocket’ as [xǒ tién]. She pronounced the first tone as the fourth tone as /xiǎn kū/ ‘mushroom’ was pronounced as [xiǎn kū] like the stress in a stress language like her L1, Indonesian. The tone errors were not observed in the child.

#### 2.5.6.2 Phonological Development in the Second Year

In the second year, the alveolar variants [s, ts, tsʰ] of retroflex obstruents /ʃ, t ʃ, tṣʰ/ coexisted with retroflexes [ʃ, tṣ, tṣʰ] and alveopalatals [ç, tç] except the voiceless aspirated retroflex affricate /tṣʰ/ and the voiced retroflex fricative /ʒ/ were consistently replaced by the alveolars [tsʰ] and [z].

#### 2.5.6.3 Phonological Development in the Third Year

In the third year, almost all the phonemes were acquired except that the aspirated voiceless retroflex affricate /tṣʰ/ was still replaced by the unaspirated one [tṣ], e.g., /tṣʰi/ ‘eat’ → [tṣi]. The phonological development of the five-year-old boy of an Indonesian mother is summarized in Table 2.18.

**Table 2.18** Acquisition and substitutions of the sounds from the Indonesian boy: 5, 5 + 1, and 5 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f, x	f: 91.66 % x: 8.33 %	f		f	
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n		m		n	
l	l		l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
te	te		te		te	
te <sup>h</sup>	te <sup>h</sup>		te <sup>h</sup>		te <sup>h</sup>	
ɛ	ɛ		ɛ		ɛ, te	ɛ: 96.77 %, te: 3.23 %
tʂ	tʂ	100 %	tʂ, ts	tʂ: 25 %, ts: 75 %	tʂ, ts	tʂ: 26.53 %, ts: 73.47 %
tʂ <sup>h</sup>	tʂ <sup>h</sup>	100 %	tʂ <sup>h</sup>	100 %	tʂ <sup>h</sup> , tʂ <sup>h</sup>	tʂ <sup>h</sup> : 25.81 %, ts <sup>h</sup> : 74.19 %
ʂ	s	100 %	s	100 %	ʂ, s	ʂ: 16.38 %, s: 83.62 %
ʐ	l	100 %	ʐ		ʐ, l	ʐ: 36.36 %, l: 63.64 %
ts	ts		ts		ts	
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>	
s	s		s		s	

(continued)

Table 2.18 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ŋ	ŋ		ŋ		ŋ	
i	i		i		i	
u	u, ə	u: 96.96 %, ə: 3.03 %	u		u	
y	y		y		y	
a	a		a		a	
o	o		o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai		ai		ai	
e	e		e		e	
au	au		au, a	au: 75 %, a: 25 %	au	
ou	ou, o	ou: 93.54 %, o: 6.45 %	ou		ou	
an	an		an		an	
ən	ən		ən		ən	
aŋ	aŋ		aŋ		aŋ	
əŋ	əŋ		əŋ		əŋ	
ə	ə	100 %	ə		ə, ə	ə: 5.26 %, ə: 94.74 %
ia	ia		ia		ia	
ua	ua		ua		ua	
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
ie	ie		ie		ie	
ye	ye		ye		ye	

(continued)

Table 2.18 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
uai	uai		uai		uai	
uei	uei		uei		uei	
iau	iau		iau		iau	
iou	iou		iou		iou	
ien	ien, en	ien: 97.43 %, en: 2.56 %	ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in		in		in	
uan	uan		uan		uan	
yn	yn		yn		yn	
ian	ian		ian		ian	
uan	uan, an	uan: 83.33 %, an: 16.66 %	uan		uan	
ij	ij	100 %	ij		ij, in	ij: 27.5 %, in: 72.5 %
jɔŋ	jɔŋ		jɔŋ		jɔŋ	
uo	uo, o	uo: 95.23 %, o: 4.76 %	uo		uo	



## 2.5.7 *The Five-Year-Old Indonesian Girl*

### 2.5.7.1 Phonological Development in the First Year

The Indonesian five-year-old girl had problems with alveolar laterals, retroflexes, final nasals, and high front rounded vowels. She changed the alveolar lateral /l/ to nasal [n]; for example, /lǎŋ/ ‘cold’ was pronounced as [nǎŋ]. All the retroflexes were replaced by their alveolar counterparts. For example, she pronounced /kōŋ šǔ/ ‘princess’ was pronounced as [kōŋ tsǔ], [ṣ<sup>h</sup>ū lài] ‘come out’ as [ts<sup>h</sup>ū lài], and /suéi teiáu/ ‘sleep’ as [suéi teiáu]. There were also aspiration and palatal assimilation. She pronounced the unaspirated voiceless alveopalatal affricate as the aspirated one as /teín te<sup>h</sup>ý/ ‘enter’ was pronounced as [te<sup>h</sup>ín te<sup>h</sup>ý]. The final nasals tended to be dropped; for example, the child pronounced /eiǎu/ ‘small’ as [eiǎ], /uǎŋ teí/ ‘forget’ as [uǎ teí], /p<sup>h</sup>ǎŋ/ ‘fat’ as [p<sup>h</sup>ǎ], /k<sup>h</sup>áu teín/ ‘get close’ as [k<sup>h</sup>áu teí], and /pì kǒŋ/ ‘nose hole’ as [pì kǒ]. The high front rounded vowels were sometimes pronounced without lip rounding; for example, /te<sup>h</sup>ý/ ‘go’ was pronounced as [teí].

### 2.5.7.2 Phonological Development in the Second Year

In the second year, the alveolar lateral /l/ was pronounced correctly. The retroflexes were still replaced by alveolars with lower frequency. She had no more problems with aspiration and palatal assimilation. The velar final nasals were sometimes changed to alveolar nasals.

### 2.5.7.3 Phonological Development in the Third Year

In the third year, the girl has acquired all the phonemes except that retroflexes were consistently replaced by alveolars. The retroflex mid-central lax vowel was also pronounced without retroflex (Table 2.19).

Let us put /tʂ/ in the OT framework. The five-year-old Indonesian girl high-ranked \*Retroflex and so turned it to an alveolar affricate and remained for three years as shown in Tableau 2.7.

**Table 2.19** Acquisition and substitutions of the sounds from the Indonesian girl: 5, 5 + 1, and 5 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f		f		f	
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n		n		n	
l	l, n	l: 81.82 %, n: 18.18 %	l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
te	te, te <sup>h</sup>	te: 77.27 %, te <sup>h</sup> : 22.73 %	te		te, ts	te: 70.83 %, ts: 29.17 %
te <sup>h</sup>	te <sup>h</sup>		te <sup>h</sup>		te <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tʂ	ts	100 %	tʂ, ts	tʂ: 13.64 %, ts: 86.36 %	ts	100 %
tʂ <sup>h</sup>	ts <sup>h</sup>	100 %	ts <sup>h</sup>	100 %	ts <sup>h</sup>	100 %
ʂ	s	100 %	s	100 %	s	100 %
ʐ	l	100 %	ʐ		l	100 %
ts	ts		ts		ts	
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>	
s	s		s		s	
ɲ	ɲ		ɲ		ɲ	
i	i		i		i	

(continued)

Table 2.19 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
u	u		u		u	
y	y, i	y: 88.89 %, i: 11.11 %	y		y	
a	a		a		a	
o	o		o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai		ai		ai	
e	e		e		e	
au	au		au		au	
ou	ou		ou		ou	
an	an		an, a	an: 95 %, a: 5 %	an	
ən	ən		ən	ən	ən	
aŋ	aŋ, an, a	aŋ: 36.36 %, an: 45.45 %, a: 18.18 %	aŋ		aŋ	
əŋ	əŋ	100 %	əŋ		əŋ	
ə	ə		ə	100 %	ə	100 %
ia	ia		ia		ia	
ua	ua		ua		ua	
ie	ie		ie		ie	
ye	ye		ye		ye	
uai	uai		uai		uai	
uei	uei		uei		uei	
iau	iau		iau		iau	
iou	iou		iou		iou, ɔ	iou: 91.86 %, ɔ: 8.14 %

(continued)

Table 2.19 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ien	ien		ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in		in		in	
uan	uan		uan		uan	
yn	yn		yn		yn	
ianj	ianj		ianj		ianj	
uanj	uanj		uanj		uanj	
ij	ij, in	inj: 20 %, in: 80 %	ij, in	inj: 54.55 %, in: 45.45 %	ij	
ɔj	ɔj, ɔ	ɔ once	ɔj		ɔj	
jɔj	jɔj		jɔj		jɔj	
uo	uo		uo		uo	

**Tableau 2.7** OT tableau for the Indonesian girl: 5; 5 + 1, and 5 + 2 years of age

tʂ	*(+cont)	*Retroflex	*(+anterior)
ʈʂ ts			*
tʂ		*!	

## 2.5.8 The Six-Year-Old Indonesian Boy

### 2.5.8.1 Phonological Development in the First Year

The six-year-old Indonesian boy still had phonetic errors in aspirations, fricatives, retroflexes, and final nasals. He occasionally deaspirated the aspirated velar stops and alveopalatal affricates. He replaced the aspirated voiceless velar stop with the unaspirated one; for example, /k<sup>h</sup>ǎu/ ‘test’ was pronounced as [kǎu] and /tɕ<sup>h</sup>io iǎn/ ‘earthworm’ was pronounced as [tɕio iǎn]. He replaced the alveopalatal fricative with an affricate or an alveolar stop. For example, /ɛi pīan/ ‘riverbank’ was pronounced as [tɕi pīan], /ɛie ɛie/ ‘thank’ as [tɕ<sup>h</sup>ie tɕ<sup>h</sup>ie], and /ɛǎu kǒ/ ‘dog’ as [tíau kǒ]. The retroflexes were replaced by their alveolar counterparts. For example, /tʂ táu/ ‘know’ was pronounced as [tʂ táu], /tʂ<sup>h</sup>ǎŋ tɛín lú/ ‘giraffe’ as [ts<sup>h</sup>ǎŋ tɛín lu], /ʂ t<sup>h</sup>ò/ ‘stone’ as [ʂ t<sup>h</sup>ò], and /zɛ̀n/ ‘person’ as [lǎn]. He mixed the place of articulation of final nasals; for example, /sán kǎi/ ‘spread’ was pronounced as [sǎŋ kǎi] and /t<sup>h</sup>ǎŋ ʂǎŋ/ ‘burn’ was pronounced as [t<sup>h</sup>ǎŋ ʂǎŋ]. The substitution of retroflexes with alveolars was also observed in his mother, but not other errors.

### 2.5.8.2 Phonological Development in the Second Year

In the second year, the child continued to replace retroflex affricates with alveolar affricates and replaced a labiodental fricative with a velar fricative followed by a labiovelar glide. For example, /f/ was replaced by [xu] as in /fǎn tɕ<sup>h</sup>iè/ ‘tomato.’ The voiced retroflex fricative was pronounced correctly, but the voiceless one /ɕ/ was still replaced by an alveolar one [s], e.g., /ɕueǐ kuǒ/ ‘fruit’ → [sueǐ kuǒ]. In addition, the child replaced the voiced bilabial nasal stop /m/ with the lateral liquid [l], e.g., [mién peǐ] ‘quilt’ → [lién peǐ]. All the vowels and finals have been acquired except the rounded high front vowel was still pronounced without lip rounding.

### 2.5.8.3 Phonological Development in the Third Year

In the third year, when the child was eight years of age, all the phonemes were pronounced correctly, except the vowel /u/ was dropped in /uo/ sequence, e.g., /p<sup>h</sup>iŋ kuǒ/ ‘apple’ → [p<sup>h</sup>iŋ kǒ]. It was correct in the first two years. The phonological development of the six-year-old child of an Indonesian mother is summarized in Table 2.20.

**Table 2.20** Acquisition and substitutions of the sounds from the Indonesian boy: 6, 6 + 1, and 6 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year
		Frequency		Frequency	
p	p		p		p
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>
m	m		m		m
f	f		f		f
t	t		t, t <sup>h</sup>	t (88.89 %), t <sup>h</sup> (11.11 %)	t
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>
n	n		m		n
l	l		l		l
k	k		k		k
k <sup>h</sup>	k <sup>h</sup> , k	k (16 %)	k <sup>h</sup>		k <sup>h</sup>
x	x		x		x
tɕ	tɕ		tɕ		tɕ
tɕ <sup>h</sup>	tɕ <sup>h</sup> , tɕ	tɕ (10 %)	tɕ <sup>h</sup>		tɕ <sup>h</sup>
ɕ	ɕ, tɕ, t	tɕ (50 %), t (10 %)	ɕ		ɕ
tʂ	tʂ	100 %	tʂ	100 %	ts
tʂ <sup>h</sup>	tʂ <sup>h</sup> , s	tʂ <sup>h</sup> (96 %), s (4 %)	tʂ <sup>h</sup> , ts <sup>h</sup>	ts <sup>h</sup> (80 %)	ts <sup>h</sup>
ʂ	s, ts, ts <sup>h</sup>	s (50 %), ts (40 %), ts <sup>h</sup> (10 %)	s	100 %	s
ʐ	l	100 %	ʐ, l	ʐ (33.33), l (66.67 %)	l, z
ts	ts		ts		ts
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>
s	s		s		s
ɲ	ɲ		ɲ		ɲ

(continued)

Table 2.20 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year
		Frequency		Frequency	
i	i, ei	ei (6 %)	i, ø, y	i (82.61 %), ø (15.22 %), y (2.17 %)	i
u	u		u, ø	u (68.18 %), ø (31.82 %)	u
y	y		y		y
a	a		a		a
o	o		o		o
ə	ə		ə		ə
ei	ei		ei		ei
ai	ai		ai		ai
e	e		e		e
au	au		au		au
ou	ou		ou		ou
an	an, aŋ	aŋ (18 %)	an		an
ən	ən		ən		ən
aŋ	aŋ, an	an (7 %)	aŋ		aŋ
əŋ	əŋ		əŋ, ən	əŋ (66.67 %), ən (33.33 %)	əŋ
ə-	ə-		ə-		ə-
ia	ia		ia		ia
ua	ua		ua		ua
ɔŋ	ɔŋ		ɔŋ		ɔŋ
ie	ie		ie		ie
ye	ye		ye		ye
uai	uai		uai		uai

(continued)

Table 2.20 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency	year	Frequency
uei	uei		uei		uei	
iau	iau		iau		iau	
iou	iou		iou		iou	
ien	ien		ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in		in		in	
uən	uən		uən		uən	
yn	yn		yn		yn	
iaŋ	iaŋ		iaŋ		iaŋ	
uaŋ	uaŋ		uaŋ		uaŋ	
iŋ	iŋ		iŋ, in	iŋ (85.71 %), in (14.29 %)	iŋ	
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
joŋ	joŋ		joŋ		joŋ	
uo	uo		uo		uo	



## 2.5.9 *The Six-Year-Old Indonesian Girl*

### 2.5.9.1 Phonological development in the first year

The six-year-old Indonesian girl has acquired most phonemes in Mandarin except alveopalatals, retroflexes, and final nasals. The child sometimes changed alveopalatal affricates to alveolar ones; for example, /tɕ<sup>h</sup>ʔan pú/ ‘whole’ was pronounced as [ts<sup>h</sup>ʔŋ pú]. She mixed retroflexes and alveolars. She replaced retroflexes with alveolars most of the time. For example, /tɕ<sup>h</sup> táu/ ‘know’ was pronounced as [tɕ táu], /pían tɕ<sup>h</sup>ʔŋ/ ‘become’ was pronounced as [pían ts<sup>h</sup>ʔŋ], /nían sū/ ‘study’ was pronounced as [nían su], and /zə̃n/ ‘person’ was pronounced as [lən]. At other times, alveolars were replaced by retroflexes. For example, /tɕ<sup>h</sup> tɕí/ ‘self’ was pronounced as [tɕ<sup>h</sup> tɕí] and /làn só/ ‘blue’ was pronounced as [làn só]. She occasionally changed the place of final nasals or even dropped it. For example, /tɕ<sup>h</sup>ʔan pú/ ‘whole’ was pronounced as [ts<sup>h</sup>ʔŋ pú], /xuə̃j só/ ‘yellow’ was pronounced as [xuə̃j só], and /sə̃n lin/ ‘forest’ was pronounced as [sə̃n li]. The child did not seem to have difficulty with particular place articulation, but was confused about when to use which one. Only the replacement of retroflexes with alveolars was observed in the mother.

### 2.5.9.2 Phonological development in the second year

In the second year, the mistakes with low frequency in the first year disappeared but some new errors were observed. There were substitutions of the bilabial nasal /m/ with the high back vowel /u/ and the substitution of the alveolar lateral /l/ with the alveolar nasal [n]. The final velar nasal /ŋ/ was replaced by the alveolar nasal [n] with higher frequency (30 %). The final alveolar nasal, which was dropped occasionally in the first year, was pronounced correctly most of the time while replaced by the velar nasal 25 % of the time. The retroflex mid central vowel /ɤ̃/ was pronounced without retroflexation. She replaced aspirated retroflex affricates and fricatives with alveolars 100 % of the time. The unaspirated retroflex affricates /tɕ/ co-exist with the alveolar and alveopalatal variants.

### 2.5.9.3 Phonological development in the third year

In the third year, the girl has acquired all the phonemes except replacing retroflexes with alveolars consistently. The aspirated voiceless retroflex affricates /tɕ<sup>h</sup>/ were pronounced correctly 75 % of the time though. The acquisition and substitutions of the sounds by the six-year-old Indonesian girl for three years were summarized in Table 2.21.

The six-year-old Indonesian boy and girl both high-ranked \*Retroflex and changed the retroflex fricative to the alveolar fricative throughout the three years as shown in Tableau 2.8.

**Table 2.21** Acquisition and substitutions of the sounds from the Indonesian girl: 6, 6 + 1, and 6 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p, f	f (2 %)	p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m, u	m (87.5 %), u (12.5 %)	m	
f	f		f	f	f	
t	t, ø	ø (2 %)	t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n, l	l (5 %)	m		n	
l	l		l, n	l (67.74 %), n (32.26 %)	l	
k	k, t	t (8 %)	k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x, f	f (3 %)	x		x	
tɕ	tɕ, ɕ	ɕ (3 %)	tɕ		tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup> , ts <sup>h</sup>	ts <sup>h</sup> (13 %)	tɕ <sup>h</sup>		tɕ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tɕ	tɕ, ts	ts (63 %)	tɕ, ts, tɕ	tɕ (8.33 %), ts (79.17 %), tɕ (12.5 %)	ts	100 %
tɕ <sup>h</sup>	tɕ <sup>h</sup> , ts <sup>h</sup>	ts <sup>h</sup> (45 %)	ts <sup>h</sup>	100 %	ts <sup>h</sup> , ts	tɕ <sup>h</sup> (75 %), ts (25 %)
ʂ	ʂ, s	s (87 %)	s	100 %	s	100 %
ʐ	ʐ, l	l (80 %)	n	100 %	l	100 %
ts	ts, tɕ	tɕ (16 %)	ts		ts	
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>	
s	s, ʂ	ʂ (15 %)	s, ʂ, ts	s (88.24 %), ʂ (5.88 %), ts (5.88 %)	s, ʂ	ʂ once
ŋ	ŋ		ŋ		ŋ	

(continued)

Table 2.21 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
i	i, y, ø	y (4 %), ø (2 %)	i		i	
u	u		u		u	
y	y		y		y	
a	a		a		a	
o	o		o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai		ai, ei	ai (96.3 %), ei (3.7 %)	ai	
e	e		e		e	
au	au		au, a	au (94.44 %), a (5.56 %)	au	
ou	ou		ou		ou	
an	an, ɔŋ	ɔŋ (4 %)	an		an	
ən	ən		ən		ən	
aŋ	aŋ, an	an (3 %)	aŋ, an	aŋ (70 %), an (30 %)	aŋ	
əŋ	əŋ		əŋ		əŋ	
ə-	ə-		ə	100 %	ə-	
ia	ia		ia		ia	
ua	ua		ua		ua	
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
ie	ie		ie		ie	
ye	ye		ye		ye	
uai	uai		uai		uai	

(continued)

Table 2.21 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
uei	uei		uei		uei	
iau	iau		iau		iau	
iou	iou		iou		iou	
ien	ien		ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in, i	i (11 %)	in, inj	in (75 %), inj (25 %)	in	
uən	uən		uən		uən	
yn	yn		yn		yn	
iaŋ	iaŋ		iaŋ		iaŋ	
uaŋ	uaŋ		uaŋ		uaŋ	
inj	inj		inj, in	inj (83.33 %), in (16.67 %)	inj	
jəŋ	jəŋ		jəŋ		jəŋ	
uo	uo		uo		uo	

**Tableau 2.8** OT tableau for the Indonesian children: 6, 6 + 1, and 6 + 2 years of age

ξ	Ident (αstrident)	*Retroflex	*Affricate	*(+cont)	*(+anterior)
ㄙ S				*	*
ξ		*!		*	

### 2.5.10 *The Two-Year-Old Taiwanese Boy*

#### 2.5.10.1 Phonological Development in the First Year

The Taiwanese two-year-old boy has acquired most of the phonemes and just had mistakes occasionally (under 10 %). The only frequent error is the replacement of retroflexes with alveolars. For example, he pronounced /tʃáu eíáŋ teĩ/ ‘camera’ as [tʃáu eíáŋ tei], /tʃʰuàn/ ‘boat’ as [tsʰuàn], /ʃũ/ ‘book’ as [sũ], and /teĩ teʰí zʒèn/ ‘robot’ as [teĩ teʰí lèn]. He also deretroflexed the retroflex vowel; for example, /ʃé/ ‘twelve’ was pronounced as [ʃé]. He dropped final nasals or changed the place of articulation occasionally. He also simplified vowel sequence occasionally, but it was not systematic in terms of which one was dropped. For example, /kũo tʃ̥/ ‘juice’ was pronounced as [kõ tʃ̥] and /nà kúo lài/ ‘bring’ was pronounced as [nà kú lài].

The mother also replaced retroflexes with alveolars and deretroflexed retroflex vowels. She also changed the final velar nasal following /i/ to the alveolar nasal.

#### 2.5.10.2 Phonological Development in the Second Year

In the second year, the boy has improved a lot in pronunciation. The only problem remained was retroflex and final nasal. He still replaced retroflexes with alveolars and deretroflexed the retroflex vowel. In addition, he changed the final velar nasal following /i/ to the alveolar nasal.

#### 2.5.10.3 Phonological Development in the Third Year

The third year is similar to the second year. The errors in retroflex and final nasal seemed to have fossilized. He still replaced retroflexes with alveolars and deretroflexed the retroflex vowel and still changed the final velar nasal following /i/ to the alveolar nasal. The phonological development of the two-year-old Taiwanese boy is summarized in Table 2.22.

**Table 2.22** Acquisition and substitutions of the sounds from the Taiwanese boy: 2; 2 + 1, and 2 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p, f, m	p (94.25 %), f (4.59 %), m (1.14 %)	p		p	
p <sup>h</sup>	p <sup>h</sup> , p	p <sup>h</sup> (88.88 %), p (11.11 %)	p <sup>h</sup>		p <sup>h</sup>	
m	m, p	m (98.87 %), p (1.12 %)	m		m	
f	f		f		f	
t	t, l	t (99.1 %), l (0.89 %)	t		t, ø	ø once
t <sup>h</sup>	t <sup>h</sup> , tɛ <sup>h</sup>	t <sup>h</sup> (97.91 %), tɛ <sup>h</sup> (2.08 %)	t <sup>h</sup>		t <sup>h</sup> , ø	ø once
n	n, l	n (97.61 %), l (2.38 %)	m		n, l	n (97.18 %) l (2.82 %)
l	l, ʌ	l (97.29 %), ʌ (2.7 %)	l		l, ø	ø once
k	k, ø	k (99.15 %), ø (0.84 %)	k		k	
k <sup>h</sup>	k <sup>h</sup> , x	k <sup>h</sup> (97.5 %), x (2.5 %)	k <sup>h</sup>		k <sup>h</sup>	
x	x, ø	x (99.23 %) ø (0.76 %)	x		x, ø	ø once
tɛ	tɛ		tɛ		tɛ	
tɛ <sup>h</sup>	tɛ <sup>h</sup>		tɛ <sup>h</sup>		tɛ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tɕ	tɕ, ts	tɕ (41.98 %) ts (58.01 %)	tɕ, ts		tɕ, ts	tɕ (50.43 %), ts (49.57 %)
tɕ <sup>h</sup>	tɕ <sup>h</sup> , ts <sup>h</sup>	tɕ <sup>h</sup> (35.71 %), ts <sup>h</sup> (64.28 %)	tɕ <sup>h</sup> , ts <sup>h</sup> ts <sup>h</sup>		tɕ <sup>h</sup> , ts <sup>h</sup> , ts	tɕ <sup>h</sup> (66.66 %), ts <sup>h</sup> (16.67 %), ts (16.67 %)

(continued)

Table 2.22 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ɕ	ɕ, s, ts, ɕ	ɕ (63.46 %), s (35.25 %), ts (0.64 %), ɕ (0.64 %)	s	100 %	ɕ, s	ɕ (55.38 %), s (44.62 %)
ʈ	ʈ, l	ʈ (21.05 %), l (78.94 %)	l	100 %	ʈ, l	ʈ (88.89 %), l (11.11 %)
ts	ts		ts		ts	
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>	
s	s, f	s (97.95 %), f (2.04 %)	s		s, ɕ	ɕ once
ɲ	ɲ		ɲ		ɲ	
i	i		i		i	
u	u, ø	u (98.43 %), ø (1.56 %)	u		u	
y	y		y		y	
a	a		a		a	
o	o		o		o	
ə	ə, o, əŋ	ə (96.41 %), o (3.4 %), əŋ (0.3 %)	ə, o	ə (95 %), o (5 %)	ə	
ei	ei, i	ei (96.96 %), i (3.03 %)	ei		ei	
ai	ai		ai		ai	
e	e		e		e	
au	au		au		au	
ou	ou		ou		ou	
an	an, a	an (98.41 %), a (1.58 %)	an		an	
ən	ən, ə, əŋ	ən (89.47 %) ə (5.26 %) əŋ (5.26 %)	ən		ən	

(continued)

Table 2.22 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency	year	Frequency		Frequency
aŋ	aŋ, a, an	aŋ (90.9 %), a (6.06 %), an (3.03 %)	aŋ		aŋ	
əŋ	əŋ		əŋ		əŋ	
ə-	ə-, ə	ə- (84.21 %), ə (15.78 %)	ə-, ə	ə- (83.33 %), ə (16.67 %)	ə-, ə	ə- (15.38 %), ə (84.62 %)
ia	ia		ia		ia	
ua	ua		ua		ua	
ŋ	ŋ		ŋ		ŋ	
ie	ie		ie		ie	
ye	ye		ye		ye	
uai	uai		uai		uai	
uei	uei		uei		uei	
iau	iau		iau		iau	
iou	iou		iou		iou	
ien	ien, ie	ien (96.29 %), ie (3.7 %)	ien		ien	
uan	uan, ua	uan (98.03 %), ua (1.96 %)	uan		uan	
yen	yen		yen		yen	
in	in		in		in	
uən	uən		uən		uən	
yn	yn		yn		yn	

(continued)



Table 2.22 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
iaŋ	iaŋ		iaŋ		iaŋ	
uaŋ	uaŋ		uaŋ		uaŋ	
iŋ	iŋ, in	iŋ (2.56 %), in (97.43 %)	iŋ, in	iŋ (40 %), in (60 %)	iŋ, in	iŋ (41.67 %), in (58.33 %)
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
jɔŋ	jɔŋ		jɔŋ		jɔŋ	
uo	uo, o, u	uo (97.95 %), o (1.02 %), u (1.02 %)	uo		uo	

### 2.5.11 *The Two-Year-Old Taiwanese Girl*

#### 2.5.11.1 Phonological Development in the First Year

In the first year, the child has acquired most phonemes in Mandarin while having problems in producing alveolar nasals, alveopalatal fricatives, and retroflex affricates. She tended to replace an alveolar nasal /n/ with an alveolar lateral [l] and replace an alveopalatal fricative /ɕ/ with an unaspirated alveopalatal affricate [tɕ]. She pronounced retroflex affricates as alveolar affricates, which were also observed in her parents' speech. The father even pronounced the retroflex fricative /ʂ/ as an alveolar fricative [s], e.g., /ʂí/ 'is' → [sí]. The child had problems with vowel /o/ and /u/. She pronounced /o/ as [ej] and /u/ as [u], [ej] [i], or [ou] inconsistently, e.g., /tʂə́ kə́/ 'this' → [tsei kə], /kʰə́i/ 'can' → [kʰouĩ]. Adults did not have vowel problems.

#### 2.5.11.2 Phonological Development in the Second Year

In the second year, the alveolar nasal /n/ and an alveopalatal fricative /ɕ/ have been acquired. However, the retroflex fricative /ʂ/ was still replaced by an alveolar fricative [s], for example, /mǎ liŋ ʂǔ/ 'potato' → [mǎ liŋ sǔ]. Retroflex affricates were not observed in the data of the second year. A new error has been observed, that is, the replacement of aspirated alveopalatal affricates with unaspirated ones sometimes, e.g., /tɕʰiɛn pǐ/ 'pencil' → [tɕiɛn pǐ]. All the vowels have been acquired. The child has acquired most of the phonemes except the retroflexes, whose correct forms were not available in the input.

#### 2.5.11.3 Phonological Development in the Third Year

The child did not make any further progress in the third year. All the errors have seemed to be fossilized. The retroflexes, fricatives, and affricates were replaced with alveolar ones for example, /ʂán mián/ 'on the top' → [sán mián]. Aspirated alveopalatal affricates were still replaced by unaspirated ones sometimes.

The phonological development from two-year-old Taiwanese girl for three years is summarized in Table 2.23.

Putting in OT framework, like the Indonesian two-year-old girl, the Taiwanese two-year-old boy also high-ranked \*retroflex and so changed the retroflex affricate to alveolar affricate in the first two years as shown in Tableau 2.9. In the third year, the alveolar (49.57 %) and retroflex affricates (50.43 %) coexist. Those two kinds of rankings coexist as shown in Tableau 2.9 and 2.10.

**Table 2.23** Acquisition and substitutions of the sounds from the Taiwanese girl: 2; 2 + 1, and 2 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f (50 %), x, u	x (25 %), u (25 %)	f		f	
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup> , ɛ		t <sup>h</sup>		t <sup>h</sup>	
n	l		n		n	
l	l, ø	ø (9 %)	l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x, t	t (8 %)	x		c	
tɕ	tɕ		tɕ		tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup>		tɕ <sup>h</sup> , tɕ	tɕ (67 %)	tɕ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tʂ	ts, tɕ	ts (14 %)	ts	ts (14 %)	tʂ, ts	ts (54 %)
tʂ <sup>h</sup>	tʂ <sup>h</sup>					
ʂ	ʂ		s	s (100 %)	ʂ, s	s (76 %)
z	z					
ts	ts		ts, tɕ	tɕ (50 %)	ts	
ts <sup>h</sup>	ts <sup>h</sup>					
s	s		s, ɕ	ɕ (73 %)	s	
i	i, u	u (13 %)	i		i	
u	u		u		u	
y	y				y	
a	a		a		a	
o	ei		o		o	
ɤ	ɤ, ei, i, ou, a	ei (6 %), ou (6 %), a (6 %)	ɤ		ɤ	
ɛ	ɛ					
ai	ai		ai		ai	
ei	ei		ei		ei	
au	au		au		au	
ou	ou, əŋ					

(continued)

Table 2.23 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
an	aŋ	aŋ (100 %)	an		an	
ən	ən		ən		ən	
aŋ	aŋ		aŋ		aŋ	
əŋ	aŋ		əŋ		əŋ	
ɣ ɪ	ɣ ɪ		ɣ ɪ		ɣ ɪ	

Tableau 2.9 OT tableau for the Taiwanese male: 2, 2 + 1 years of age

tʂ	*(+cont)	*Retroflex	*(+anterior)
ᵐᵗs			*
tʂ		*!	

Tableau 2.10 OT tableau for the Taiwanese male: 2 + 2 years of age

tʂ	*(+cont)	*(+anterior)	*Retroflex
ts		*!	
ᵐᵗʂ			*

2.5.12 The Three-Year-Old Taiwanese Boy

2.5.12.1 Phonological Development in the First Year

The three-year-old Taiwanese boy had acquired all the vowels and finals in Mandarin while had problems with some initial consonants. He had problems with manner of articulations. Aspiration and frication seem to confuse him. He turned aspirated voiceless alveolar stops /tʰ/ to aspirated voiceless alveolar affricates /tsʰ/ while turned an unaspirated voiceless alveolar affricate /ts/ to an unaspirated voiceless alveolar stop [t], for example, /tsái lài/ ‘again’ as [tái lài]. He replaced an alveopalatal fricative /ɕ/ with an unaspirated alveopalatal affricate [tɕ], for example, /ɕí/ ‘happy’ → [tɕí]. He pronounced the retroflex fricatives as alveolar fricatives or stops and retroflex affricates as alveopalatal affricates, for example, /ʂí/ ‘copula BE’ as [ɕí], /ʂou táu/ ‘receive’ as [tou táu], /tʂuēi tʂə/ ‘chase’ as [tsuēi tsə], and /tʂən tʂən/ ‘really’ as [tən tən]. His mother replaced retroflexes with alveolars. No other errors were observed in his mother’s speech.

2.5.12.2 Phonological Development in the Second Year

In the second year, the child got rid of problems in aspiration and frication. He pronounced aspirated stops and unaspirated affricates correctly. The alveopalatal fricative /ɕ/ was also pronounced correctly. However, he still had problems with retroflexes. Alveolar affricates coexist with the correct forms. The voiceless retroflex fricative /ʂ/ was consistently replaced by the alveolar one [s], e.g., /ʂu/ ‘book’ → [sū], while the voiced one /ʐ/ was replaced by the lateral liquid [l], for example, /ʐʰ kǒu/ ‘hot dog’ → [lʰ kǒu].

2.5.12.3 Phonological Development in the Third Year

In the third year, the child had acquired most phonemes except the typical Taiwan Mandarin problems. They are retroflexes and the rounded high front vowel. He still replaced the voiceless retroflex affricate /tʂ/ with voiceless alveolar affricate [ts] and replaced the voiceless retroflex fricative /ʂ/ with the alveolar fricative [s], for example, /ʂi/ ‘is’ as [si]. The rounded high front vowel /y/ was pronounced correctly in the first two years, but was replaced with the unrounded one [i] in the third year, e.g., /ɕiǎu ɕyòŋ/ ‘baby bear’ → [ɕiǎu ɕiòŋ]. The target forms that the child acquired seem to be Taiwanese-interfered Mandarin. A summary of the child’s phonemes and phonetic variants in three years is given in Table 2.24.

**Table 2.24** Acquisition and substitutions of the sounds from the Taiwanese boy: 3, 3 + 1, and 3 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f		f		f	
t	t		t		t	
t <sup>h</sup>	ts <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n		n		n	
l	n		l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x, f		x	
tɕ	tɕ		tɕ		tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup>		tɕ <sup>h</sup>		tɕ <sup>h</sup>	
ɕ	ɕ, tɕ, ʂ	ʂ (29 %)	ɕ		ɕ	
tʂ	tʂ, tɕ, t, ts	tʂ (23 %), tɕ (3 %), t (31 %), ts (43 %)	tʂ, ts, s	ts (97 %), s (2 %)	tʂ (50 %), ts (50 %)	

(continued)

**Table 2.24** (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
tɕ <sup>h</sup>	tɕ <sup>h</sup> , tɕ <sup>h</sup> , t <sup>h</sup> , ts	t <sup>h</sup> (17 %), ts (25 %)	tɕ <sup>h</sup> ts <sup>h</sup> , ts	tɕ <sup>h</sup> (40 %), ts (60 %)	tɕ <sup>h</sup>	
ɕ	ɕ, s, t, ɕ	s (79 %), t (4 %), ɕ (4 %)	s (100 %)		s (100 %)	
z	l	l (100 %)	l	l (100 %)		
ts	ts, t	ts, t (11 %)	ts	ts	ts	ts
ts <sup>h</sup>	ts	ts (100 %)	ts <sup>h</sup>	ts <sup>h</sup>	ts <sup>h</sup>	ts <sup>h</sup>
s	ɕ	ɕ	s	s	s	s
i	i	i	i	i	i	i
u	u, i	u, i (9 %)	u	u	u	u
y	y	y	y	y	i (100 %)	i (100 %)
a	a	a	a	a	a	a
o	o	o	o	o	o	o
ɤ	ɤ	ɤ	ɤ	ɤ		
ɛ	a	a	ɛ	ɛ	ɛ	ɛ
ai	ai	ai	ai	ai	ai	ai
ei	ei	ei	ei	ei	ei	ei
au	au	au	au	au	au	au
ou	ou	ou	ou	ou	ou	ou
an	an, aŋ	an, aŋ (5 %)	an	an	an	an
ən	ən	ən	ən	ən	ən	ən
aŋ	aŋ	aŋ	aŋ	aŋ	aŋ	aŋ
əŋ	əŋ	əŋ	əŋ	əŋ	əŋ	əŋ
ɤ.ɪ	ɤ.ɪ	ɤ.ɪ	ɤ.ɪ	ɤ.ɪ		
in	in	in				

### 2.5.13 The Three-Year-Old Taiwanese Girl

#### 2.5.13.1 Phonological Development in the First Year

The three-year-old Taiwanese girl's major problem is retroflexes with occasional errors in bilabial stops and vowel sequences. She replaced retroflexes with alveolars; for example, /tɕũ/ 'cook' was pronounced as [tsũ], /tɕ<sup>h</sup>ũ fəŋ/ 'kitchen' as [ts<sup>h</sup>ũ fəŋ], /ɕũ/ 'lose' as [sũ], /zəŋ/ 'person' as [lən], and /zəŋ xúa/ 'melt' as [nəŋ xúa]. Occasionally, she replaced a bilabial stop with a velar stop; for example, p<sup>h</sup>ú k<sup>h</sup>ə p<sup>h</sup>ai/ 'poker' was pronounced as [k<sup>h</sup>ú k<sup>h</sup>ə p<sup>h</sup>ai]. She occasionally omits the /u/ in /uo/ sequence, for example, /tsũo í tsũo/ 'rub' as [ts\_ũo í ts\_ũo]. The mother also replaced retroflexes with alveolars, which is a typical phonetic feature of Taiwan Mandarin.

### 2.5.13.2 Phonological Development in the Second Year

In the second year, the only problems left were retroflexes and omission of /u/ in /uo/ sequence. As in the first year, she still replaced retroflexes with alveolars. Other errors have disappeared.

### 2.5.13.3 Phonological Development in the Third Year

In the third year, the girl consistently replaced retroflexes with alveolars. They seem to have fossilized. The aspirated retroflex affricate /tɕʰ/ was pronounced as alveolar affricate with or without aspiration. The phonemes and phonetic variations of the Taiwanese three-year-old girl for three years are summarized in Table 2.25.

Both Taiwanese three-year-old boy and girl high-ranked \*Retroflex and thus pronounced retroflex fricative as alveolar fricative throughout three years as in Tableau 2.11.

## 2.5.14 *The Four-Year-Old Taiwanese Boy*

### 2.5.14.1 Phonological Development in the First Year

The four-year-old Taiwanese boy's pronunciation was not clear. He replaced a retroflex affricate with an aspirated alveolar stop and dropped the final nasal. The dropping of final nasal was also observed in /tʰiŋdaw/ 'hear' → [tʰi daw]. In addition, he replaced a retroflex fricative [ɕ] with an alveolar fricative [s]. He deleted the voiceless velar fricative before back vowels, e.g., /xau/ 'ok' → [au]. We also noticed cross-segmental nasal assimilation, e.g., /nali/ 'where' → [nani].

### 2.5.14.2 Phonological Development in the Second Year

In the second year, the omission of final nasals and voiceless velar fricatives was no longer observed. Neither was nasal assimilation. The voiced retroflex fricative /ʒ/ was acquired. The only problem left was the replacement of voiceless retroflex fricatives and affricates—/ɕ/, /tɕ/, and /tɕʰ/ with alveolar ones—[s], [ts], and [tsʰ], e.g., /ɕā fā/ 'sofa' → [sā fā], /tɕi/ 'paper' → [tsi], and /tɕʰi/ 'ruler' → [tsʰi].

**Table 2.25** Acquisition and substitutions of the sounds from the Taiwanese girl: 3, 3 + 1, and 3 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup> , k <sup>h</sup>	k <sup>h</sup> (10 %)	p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f		f		f	
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup> , x	x (5 %)	t <sup>h</sup>		t <sup>h</sup>	
n	n		m		n	
l	l		l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
tɕ	tɕ		tɕ		tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup>		tɕ <sup>h</sup>		tɕ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tʂ	ts	100 %	ts	100 %	ts	100 %
tʂ <sup>h</sup>	ts <sup>h</sup>	100 %	tʂ <sup>h</sup> , ts <sup>h</sup>	tʂ <sup>h</sup> (20 %) ts <sup>h</sup> (80 %)	tʂ <sup>h</sup> , ts <sup>h</sup>	ts <sup>h</sup> (57.14 %), ts (42.86 %)
ʂ	s	100 %	s	100 %	s	100 %
ʐ	l, n	l (85 %), n (25 %)	ʐ, l	ʐ (33.33 %), l (66.67 %)	l	100 %
ts	ts		ts		ts	
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>	
s	s		s		s	
ɲ	ɲ		ɲ		ɲ	
i	i, u, ian	u (5 %), ian (5 %)	i		i	

(continued)



Table 2.25 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
u	u, ø	ø (10 %)	u, ø	u (69.23 %), ø (30.77 %)	u	
y	y		y		y	
a	a		a		a	
o	o, ɔŋ	ɔŋ (2 %)	o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai, an	an (6 %)	ai		ai	
e	e		e		e	
au	au		au		au	
ou	ou		ou		ou	
an	an, ai	ai (3 %)	an		an	
ən	ən		ən		ən	
aŋ	aŋ		aŋ		aŋ	
əŋ	əŋ		əŋ		əŋ	
ə-	ə-		ə	100 %	ə-	
ia	ia		ia		ia	
ua	ua		ua		ua	
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
ie	ie		ie		ie	
ye	ye		ye		ye	
uai	uai		uai		uai	
uei	uei		uei		uei	
iau	iau		iau		iau	

(continued)

Table 2.25 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
iou	iou		iou		iou	
ien	ien		ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in		in		in	
uən	uən		uən		uən	
yn	yn		yn		yn	
ianɿ	ianɿ		ianɿ		ianɿ	
uaŋ	uaŋ		uaŋ		uaŋ	
iŋ	iŋ		iŋ		iŋ	
jəŋ	jəŋ		jəŋ		jəŋ	
uo	uo		uo		uo	

**Tableau 2.11** OT tableau for the Taiwanese children: 3, 3 + 1, and 3 + 2 years of age

ξ	*Retroflex	*(+anterior)	*(+strident)
ㄝㄢˊ s		*	*
ξ	*!		*

2.5.14.3 Phonological Development in the Third Year

In the third year, the child acquired the aspirated retroflex affricate /tʂʰ/, but still replaced unaspirated voiceless retroflex affricates—/tʂ/ and the voiceless retroflex fricative /ʂ/ with alveolar ones—[ts] and [s], e.g., /tʂó tʂāŋ/ ‘this piece’ as [tsó tsān] and /ʂí/ ‘is’ as [sí]. A new error was observed. That is the replacement of final velar nasal by alveolar nasal. The child’s phonological development for three years is summarized in Table 2.26.

**Table 2.26** Acquisition and substitutions of the sounds from the Taiwanese boy: 4, 4 + 1, and 4 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p, p <sup>h</sup>	p (86 %) p <sup>h</sup> (14 %)	p		p	
p <sup>h</sup>	p <sup>h</sup> , tɕ <sup>h</sup>	p <sup>h</sup> (89 %) tɕ <sup>h</sup> (11 %)	p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f		f		f	
t	t, ts		t		t	
t <sup>h</sup>	t <sup>h</sup> , k <sup>h</sup> , p <sup>h</sup> , t	t <sup>h</sup> (56 %) k <sup>h</sup> (27 %) p <sup>h</sup> (9 %) t (9 %)	t <sup>h</sup>		t <sup>h</sup>	
n	ŋ		n		n	
l	l, n	l (87 %) n (13 %)	l		l	
k	k, t <sup>h</sup>	t <sup>h</sup> (9 %)	k		k	
k <sup>h</sup>	k <sup>h</sup> , t <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x, ø	x (73 %) ø (27 %)	x		x	
tɕ	tɕ, ɕ	tɕ (92 %) ɕ (8 %)	tɕ		tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup> , tɕ, ts	tɕ (25 %) ts (13 %)	tɕ <sup>h</sup>		tɕ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tʂ	tʂ, ts, t, t <sup>h</sup> , ʂ	tʂ (71 %), ts (12 %), t (12 %), t <sup>h</sup> (2 %), ʂ (2 %)	ts (100 %)		tʂ, ts	tʂ (52 %), ts (48 %)

(continued)

**Table 2.26** (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
tɕ <sup>h</sup>	tɕ <sup>h</sup> , ts <sup>h</sup> , t, t <sup>h</sup> , k <sup>h</sup>	tɕ <sup>h</sup> (6 %), ts <sup>h</sup> (59 %), t (18 %), t <sup>h</sup> (18 %), k <sup>h</sup>	tɕ <sup>h</sup> (100 %)		tɕ <sup>h</sup>	
ɕ	ɕ, s, ɛ, ts	ɕ (14 %), s (79 %), ɛ (5 %), ts (2 %)	s (100 %)		ɕ, s	ɕ (50 %), s (50 %)
ʐ	z		ʐ		ʐ	
ts	ts, tɕ, t, k <sup>h</sup>	ts (62 %), s (15 %), ɛ (8 %), ts (15 %)	ts		ts	
ts <sup>h</sup>	ts <sup>h</sup> , k <sup>h</sup>	ts <sup>h</sup> , k <sup>h</sup> (75 %)	ts <sup>h</sup>			
s	s		s		s	
i	i		i		i	
u	i		u		u	
y	j, w		y		y	
a	a		a		a	
o	ɲ		o		o	
ɣ	ɣ, ei	ei (13 %)	ɣ			
ɛ	ɛ	ɛ	ɛ		ɛ	
ai	ai, a	a (15 %)	ai		ai	
ei	ei		ei		ei	
au	au		au		au	
ou	ou		ou		ou	
an	a	a (100 %)	an		an	
ən	əɲ	əɲ (100 %)	ən		ən	
aɲ	a	a (100 %)	aɲ		aɲ	
əɲ	əɲ		əɲ		əɲ	
ɣ.I	ɣ.I		ɣ.I			

### 2.5.15 The Four-Year-Old Taiwanese Girl

#### 2.5.15.1 Phonological Development in the First Year

The Taiwanese four-year-old girl has acquired most of the phonemes in Mandarin and just replaced retroflexes with alveolars and changed final velar nasals to alveolar nasals. She replaced retroflexes with alveolars as /tɕó kə/ ‘this one’ was pronounced as [tsó kə], [tɕ<sup>h</sup>] ‘eat’ as [tɕ<sup>h</sup>], and /ɕ/ ‘is’ as [ɕ]. He changed the velar nasal following high front vowel to the alveolar nasal; for example, /lɿ̃ ɕiɲ/ ‘travel’ was pronounced as [lɿ̃ ɕin]. The same errors were observed in the mother.

**Tableau 2.12** OT tableau for the Taiwanese children: 4, 4 + 1, and 4 + 2 years of age

ξ	Ident (αstrident)	*Retroflex	*(+anterior)	Ident (αanterior)
ξ		*!		
ᵐᶜʰ s			*	*

### 2.5.15.2 Phonological Development in the Second Year

Phonological development was stabilized in the second year. She consistently replaced retroflexes with alveolars. /tʂ/ was realized as [ts], /tʂʰ/ as [tsʰ], /ʂ/ as [s], and /ʐ/ as [l] 100 % of time. She changed final velar nasals to alveolar nasals next to /i/ sometimes.

### 2.5.15.3 Phonological Development in the Third Year

In the third year, the correct target of retroflex coexisted with alveolar variations with low frequency. The retroflex mid-central lax vowel /ə-/ was consistently pronounced without retroflex [ə], which was pronounced correctly in the last two years. Final velar nasal next to /i/ was replaced by alveolar nasal with higher frequency 62.96 % (Table 2.27). The child's phonological development for three years is summarized in Table 2.27.

The Taiwanese four-year-old boy and girl also high-ranked \* retroflex and so changed the retroflex fricative to alveolar fricative as shown in Tableau 2.12. The high ranking of \*retroflex by both Indonesian and Taiwanese children proves it to be a universal constraint.

## 2.5.16 The Five-Year-Old Taiwanese Boy

### 2.5.16.1 Phonological Development in the First Year

The five-year-old Taiwanese boy had difficulties with some places of articulation. He mixed alveolars and retroflexes, changed alveolar nasal to lateral, and changed final velar nasal to alveolar. He used retroflexes and alveolars interchangeably. He could pronounce both, but was not clear when to use which one. Retroflexes were changed to alveolars in the following examples. /tʂó lí/ 'here' was pronounced as [tsó lí]. /sái tʂʰǎ/ 'racing car' was pronounced as [sái tsǎ]. /ʂüei kǔo/ 'fruit' was pronounced as [süei kǔo], and /zə̀n/ 'person' was pronounced as [lən]. On the other hand, alveolars were changed to retroflexes in the following examples. /tsʰə̀ŋ/ 'level' was pronounced as [tʂʰə̀ŋ], /tʂó/ 'purple' as [tʂó], and /sān/ 'three' as [ʂān]. He changed the alveolar nasal to a lateral as /nàn/ 'difficult' was pronounced as [lən]. Velar nasals in coda were changed to alveolar nasals; for example, /tʰɪŋ/ 'listen' was pronounced as [tʰɪn] and /tɛɪŋ tʂ/ 'mirror' was pronounced as [tɛɪn tʂ].

**Table 2.27** Acquisition and substitutions of the sounds from the Taiwanese girl: 4, 4 + 1, and 4 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m, p, ø	m (99.20 %), p (0.39 %), ø (0.39 %)	m		m	
f	f, x	f (90 %), x (10 %)	f		f	
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup> , ø	t <sup>h</sup> (96.77 %), ø (3.22 %)	t <sup>h</sup>		t <sup>h</sup>	
n	n		m		n, l	l once
l	l		l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
tɕ	tɕ, ø	tɕ (98.24 %), ø (1.75 %)	tɕ		tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup>		tɕ <sup>h</sup>		tɕ <sup>h</sup>	
ɕ	ɕ, tɕ <sup>h</sup>	ɕ (98.93 %), tɕ <sup>h</sup> (1.06 %)	ɕ		ɕ	
tʂ	tʂ, ts, tɕ	tʂ (18.23 %), ts (80.50 %), tɕ (1.25 %)	ts	100 %	tʂ, ts	tʂ (6.85 %), ts (93.15 %)
tʂ <sup>h</sup>	tʂ <sup>h</sup> , ts <sup>h</sup> , x	tʂ <sup>h</sup> (15.38 %), ts <sup>h</sup> (80.76 %), x (3.84 %)	ts <sup>h</sup>	100 %	tʂ <sup>h</sup> , ts <sup>h</sup>	tʂ <sup>h</sup> (7.14 %), ts <sup>h</sup> (92.86 %)
ʂ	ʂ, s, ɕ	ʂ (21.66 %), s (77.22 %), ɕ (1.11 %)	s	100 %	ʂ, s	ʂ (3.1 %), s (96.90 %)
ʐ	ʐ, l	ʐ (33.33 %), l (66.66 %)	l	100 %	ʐ, l	ʐ (15.38 %), l (84.62 %)
ts	ts		ts		ts	
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>	
s	s		s		s	

(continued)

Table 2.27 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year	Phonetic representations, third year	
		Frequency	year	Frequency	Frequency
ŋ	ŋ		ŋ	ŋ	
i	i		i	i	
u	u, iau, ien	u (97.72 %), iau (1.13 %), ien (1.13 %)	u	u	
y	y		y	y	
a	a		a	a	
o	o		o	o	
ə	ə		ə	ə	
ei	ei		ei	ei	
ai	ai, uei	ai (97.05 %), uei (2.94 %)	ai	ai	
e	e		e	e	
au	au		au	au	
ou	ou		ou	ou	
an	an, ian	an (97.61 %), ian (2.38 %)	an	an	
ən	ən		ən	ən	
aŋ	aŋ		aŋ	aŋ	
əŋ	əŋ		əŋ	əŋ	
ə	ə		ə	ə	100 %
ia	ia		ia	ia	
ua	ua		ua	ua	
ɔŋ	ɔŋ		ɔŋ	ɔŋ	
ie	ie		ie	ie	

(continued)

Table 2.27 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year	Phonetic representations, third year	
		Frequency			Frequency
ye	ye		ye	ye	
uai	uai		uai	uai	
uei	uei		uei	uei	
iau	iau		iau	iau	
iou	iou		iou	iou	
ien	ien		ien	ien	
uan	uan		uan	uan	
yen	yen		yen	yen	
in	in		in	in	
uən	uən		uən	uən	
yn	yn		yn	yn	
ianɿ	ianɿ		ianɿ	ianɿ	
uaŋ	uaŋ		uaŋ	uaŋ	
inɿ	inɿ, in	inɿ (3.22 %), in (96.77 %)	inɿ, in	inɿ, in	inɿ (37.04 %), in (62.96 %)
joŋ	joŋ		joŋ	joŋ	
uo	uo, o	uo (99.15 %), o (0.84 %)	uo	uo	



His mother also replaced retroflexes with alveolars, but not the other way around. For example, /tɕən tə/ ‘real’ was pronounced as [tsən tə]. The change of velar nasals in coda to alveolar nasals was also observed in the mother. For example, /ɛ̃en ɕəŋ/ ‘husband’ was pronounced as [ɛ̃en ɕən].

2.5.16.2 Phonological Development in the Second Year

In the second year, the aspirated voiceless bilabial stop was pronounced without aspiration. The frequency of the replacement of retroflexes with alveolars decreased. The voiced retroflex fricative /ʐ/ was pronounced correctly. The retroflex mid-central vowel was pronounced without retroflex all the time. Final velar nasals were changed to alveolar nasals sometimes.

2.5.16.3 Phonological Development in the Third Year

In the third year, the aspiration problem disappeared. The only problem left is retroflex. Retroflex affricates and fricatives were replaced with alveolar counterparts. Voiced retroflex fricative /ʐ/ was replaced by [l] again as in the first year most of the time. The phonetic variations of the Taiwanese five-year-old boy for three years are summarized in Table 2.28.

**Table 2.28** Acquisition and substitutions of the sounds from the Taiwanese boy: 5, 5 + 1, and 5 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p	100 %	p <sup>h</sup>	
m	m		m		m	
f	f		f		f	
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n		n		n	
l	l		l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
tɕ	tɕ		tɕ		tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup>		tɕ <sup>h</sup>		tɕ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	

(continued)

**Table 2.28** (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
tʂ	ts	100 %	tʂ, ts	tʂ (30.77 %) ts (69.23 %)	ts	100 %
tʂ <sup>h</sup>	tʂ <sup>h</sup>	100 %	tʂ <sup>h</sup> , ts <sup>h</sup>	tʂ <sup>h</sup> (20 %) ts <sup>h</sup> (80 %)	ts <sup>h</sup>	100 %
ʂ	s	100 %	s	100 %	ʂ, s	ʂ (1.11 %), s (98.89 %)
ʐ	ʐ, l, n, z	ʐ (4.76 %), l (88.1 %), n (4.76 %), z (2.38 %)	ʐ		ʐ, l, z	ʐ (6.67 %), l (86.66 %), z (6.67 %)
ts	ts, tʂ	tʂ once	ts		ts	
ts <sup>h</sup>	ts <sup>h</sup> , tʂ <sup>h</sup>	tʂ <sup>h</sup> once	ts <sup>h</sup>		ts <sup>h</sup>	
s	s		s		s	
ŋ	ŋ		ŋ		ŋ	
i	i		i		i	
u	u		u		u	
y	y, i	y (95.24 %), i (4.76 %)	y		y	
a	a		a		a	
o	o		o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai		ai		ai	
e	e		e		e	
au	au		au		au	
ou	ou		ou		ou	
an	an		an		an	
ən	ən		ən		ən	
aŋ	aŋ		aŋ		aŋ	
əŋ	ən	100 %	əŋ, ən	əŋ (50 %), ən (50 %)	əŋ	
ə̃	ə̃, ə	ə̃ (28.57 %), ə (71.43 %)	ə	100 %	ə	100 %
ia	ia		ia		ia	
ua	ua		ua		ua	
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
ie	ie		ie		ie	

(continued)

Table 2.28 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ye	ye		ye		ye	
uai	uai		uai		uai	
uei	uei		uei		uei	
iau	iau		iau		iau	
iou	iou		iou		iou	
ien	ien		ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in		in		in	
uən	uən		uən		uən	
yn	yn		yn		yn	
iaŋ	iaŋ		iaŋ		iaŋ	
uaŋ	uaŋ		uaŋ		uaŋ	
iŋ	iŋ, in	iŋ (26.09 %), in (73.91 %)	iŋ, in	iŋ (81.82 %), in (18.18 %)	iŋ, in	iŋ (70 %), in (30 %)
jɔŋ	jɔŋ		jɔŋ		jɔŋ	
uo	uo		uo		uo	

2.5.17 The Five-Year-Old Taiwanese Girl

2.5.17.1 Phonological Development in the First Year

The child can pronounce all the phonemes in Mandarin quite accurately except retroflexes, which were sometimes replaced by alveolar counterparts. Voiced retroflex fricatives /ʐ/ were also replaced by the lateral [l] sometimes, e.g., /xúai zən/ ‘bad person’ as [xúai lən]. The mother also replaced retroflexes with alveolars, but never changed the manner of articulation.

2.5.17.2 Phonological Development in the Second Year

In the second year, the child continued to replace retroflexes with alveolars. The voiceless retroflex fricative /ʂ/ was consistently replaced with the voiceless alveolar fricative [s]; for example, /ʂŭei kŭo/ ‘fruit’ was pronounced as [sŭei kŭo] and the voiced retroflex fricative /ʐ/ was consistently replaced by the alveolar lateral [l], e.g., /zən/ ‘human being’ → [lən]. In addition to the aspirated voiceless alveolar affricate [ts] used to replace the aspirated voiceless retroflex affricate /tʂʰ/ in the first

year, two other phonetic variants—/tɕ<sup>h</sup>/ and /t<sup>h</sup>/—showed up in the second year, e.g., /tɕ<sup>h</sup>uɔŋ/ ‘bed’ as [ts<sup>h</sup>uɔŋ]. The child might have noticed his inaccurate pronunciation and was trying other variants to approach the target.

### 2.5.17.3 Phonological Development in the Third Year

All the phonemes were acquired in the third year except the unaspirated retroflex affricate /tɕ/, which was replaced with the alveolar affricate [ts] sometimes. The child’s phonological development for three years is summarized in Table 2.29.

Let us put /tɕ/ in OT framework. The five-year-old Taiwanese children high-ranked \* Retroflex and so changed retroflex affricate to alveolar affricates throughout three years as in Tableau 2.13.

**Table 2.29** Acquisition and substitutions of the sounds from the Taiwanese girl: 5; 5 + 1, and 5 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f		f		f	
t	t, t <sup>h</sup>	t (80 %), t <sup>h</sup> (20 %)	t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n		n		n	
l	l		l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
tɕ	tɕ		tɕ		tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup>		tɕ <sup>h</sup>		tɕ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tɕʂ	ts, s	ts (86 %), s (14 %)	tɕʂ, ts, tɕ	ts (93 %)	tɕʂ, ts	tɕʂ (46 %), ts (54 %)
tɕʂ <sup>h</sup>	ts <sup>h</sup>	ts <sup>h</sup> (100 %)	ts <sup>h</sup> , t <sup>h</sup>	ts <sup>h</sup> (50 %), t <sup>h</sup> (50 %)	tɕʂ <sup>h</sup>	
ʂ	ʂ, s	ʂ (2 %), s (98 %)	ʂ, ɕ	s (100 %)		
z	l	l (100 %)	l	l (100 %)		
ts	ts, tɕ	ts (10 %), tɕ (90 %)	ts, tɕʂ		ts	
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>			
s	s		s, ʂ		s	

(continued)

Table 2.29 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
i	i		i		i	
u	u		u		u	
y	y		y		y	
a	a		a		a	
o	o		o		o	
ɤ	ɤ		ɤ			
ɛ	ɛ		ɛ		ɛ	
ai	ai		ai		ai	
ei	ei		ei		ei	
au	au		au		au	
ou	uo		ou		ou	
an	an		an		an	
ən	ən		ən		ən	
aŋ	aŋ		aŋ		aŋ	
əŋ	əŋ		əŋ		əŋ	
ɤ.ɪ	ɤ.ɪ		ɤ.ɪ			

Tableau 2.13 OT tableau for the Taiwanese children: 5, 5 + 1, 5 + 2, and 5 + 3 years of age

tʂ	*(+cont)	*Retroflex	*(+anterior)
ts			*
tʂ		*!	

2.5.18 The Six-Year-Old Taiwanese Boy

2.5.18.1 Phonological Development in the First Year

The child has acquired all the phonemes in Mandarin. The only errors sometimes occurred were in retroflex consonants and final velar nasals. He sometimes pronounced retroflex consonants as alveolar consonants just like his mother, e.g., /lǎu ʂi/ ‘teacher’ as [lǎu si]. This is actually quite common in Mandarin in Taiwan. Also, he replaced the final velar nasal with an alveolar nasal, e.g., /tʰaŋ/ ‘soup’ → [tʰan].

2.5.18.2 Phonological Development in the Second Year

In the second year, the child pronounced the aspirated retroflex affricate /tʂʰ/ and voiced retroflex fricative /z/ correctly, but still replaced unaspirated retroflex affricate /tʂ/ and voiceless retroflex fricative /ʂ/ with their alveolar counterparts—[ts] and [s] sometimes, e.g., /tʂi/ ‘paper’ as [tsi] and /xai ʂi/ ‘still’ as [xai si]. The final velar nasal was produced accurately.

### 2.5.18.3 Phonological Development in the Third Year

No progress was made in the third year. The child consistently replaced the unaspirated retroflex affricate /tʂ/ with the alveolar affricate [ts]. As for the voiceless retroflex fricative /ʂ/, the correct phonetic representation coexisted with the alveolar counterparts—[s]. A summary of the acquisition of sounds by the six-year-old boy is presented in Table 2.30.

**Table 2.30** Acquisition and substitutions of the sounds from the Taiwanese boy: 6; 6 + 1, and 6 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f		f		f	
t	t, t <sup>h</sup>	t <sup>h</sup> (20 %)	t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n, l	l (95 %)	b		b	
l	l		l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
tʂ	tʂ		tʂ		tʂ	
tʂ <sup>h</sup>	tʂ <sup>h</sup>		tʂ <sup>h</sup>		tʂ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tʂ	tʂ, ts	ts (94 %)	tʂ, ts	ts (88 %)	tʂ, ts	ts (41 %)
tʂ <sup>h</sup>	tʂ <sup>h</sup> , ts <sup>h</sup> , tʂ <sup>h</sup>	ts <sup>h</sup> (68 %), tʂ <sup>h</sup> (18 %)	tʂ <sup>h</sup> , ts	ts (20 %)	tʂ <sup>h</sup>	
ʂ	ʂ, s	s (97 %)	ʂ, s	s (33 %)	ʂ, s	s (50 %)
z	z, z	z (81 %)	z			
ts	ts		ts		ts	
ts <sup>h</sup>	tʂ <sup>h</sup>	tʂ <sup>h</sup> (100 %)	ts <sup>h</sup>			
s	s		s		s	
i	i		i		i	
u	u		u		u	
y	y		y		y	
a	a, ai	ai (25 %)	a		a	
o	o		o		o	
ɤ	ɤ		ɤ			

(continued)

Table 2.30 (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ɛ	ɛ		ɛ		ɛ	
ai	ai		ai		ai	
ei	ei		ei		ei	
au	au		au		au	
ou	ou		ou		ou	
an	an		an		an	
ən	ən		ən		ən	
aŋ	an	an (20 %)	aŋ		aŋ	
əŋ	əŋ		əŋ		əŋ	
ɣ.ɪ	ɣ.ɪ		ɣ.ɪ			

2.5.19 The Six-Year-Old Taiwanese Girl

2.5.19.1 Phonological Development in the First Year

The Taiwanese six-year-old girl mixed alveolar laterals with alveolar nasals, replaced retroflexes with alveolars, changed velar nasals in coda to alveolars, and simplified vowel sequence. The child used alveolar laterals and nasals interchangeably. For example, /lǎn túo/ ‘lazy’ was pronounced as [nǎn túo] and /niòu nǎi/ ‘milk’ was pronounced as [liòu nǎi]. She replaced retroflexes with alveolars. For example, she pronounced /tʂ/ ‘paper’ as [tʃ], /xǔo tʂ<sup>h</sup>ə/ ‘train’ as [xǔo ts<sup>h</sup>ə], /ʃū/ ‘book’ as [sū], and /zən/ ‘person’ as [lən]. The velar nasal was changed to an alveolar nasal as /mìŋ t<sup>h</sup>iēn/ ‘tomorrow’ was pronounced as [mìn t<sup>h</sup>iēn]. The /i/ in /ie/ sequence was dropped sometimes as /ná piēn/ ‘there’ was pronounced as [ná pēn].

Most of the child’s errors were also observed in the mother such as mixing alveolar laterals with nasals, replacing retroflexes with alveolars, and changing velar nasals to alveolar nasals. In addition, the mother sometimes pronounced the voiceless labiodental fricative as a velar fricative. For example, /fù/ ‘clothes’ was pronounced as [f̥ xù].

2.5.19.2 Phonological Development in the Second Year

In the second year, the exchange of laterals and nasals disappeared. However, she still replaced retroflexes with alveolars with lower frequency. The velar nasal was changed to an alveolar nasal when followed by /i/ with lower frequency.

### 2.5.19.3 Phonological Development in the Third Year

In the third year, the retroflexes were replaced by alveolars consistently. The mid-central retroflex vowel was pronounced without retroflex all the time. The problems with final nasals disappeared. The phonological development seems to have stabilized. The acquisition and phonetic variations of the Taiwanese six-year-old girl are summarized in Table 2.31.

Let us see the acquisition of retroflex in the OT framework. The six-year-old Taiwanese girl high-ranked the faithfulness constraint *ident* ( $\alpha$ retroflex) and changed alveolar affricate to retroflex affricate. That could be due to overcorrection when acquiring retroflexes. She demoted it and reached the target in the following two years as shown in Tableau 2.14 and 2.15.

**Table 2.31** Acquisition and substitutions of the sounds from the Taiwanese girl: 6, 6 + 1, and 6 + 2 years of age

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
p	p		p		p	
p <sup>h</sup>	p <sup>h</sup>		p <sup>h</sup>		p <sup>h</sup>	
m	m		m		m	
f	f		f		f	
t	t		t		t	
t <sup>h</sup>	t <sup>h</sup>		t <sup>h</sup>		t <sup>h</sup>	
n	n, l	n (98 %), l (2 %)	m		n	
l	l, n	l (99 %), n (1 %)	l		l	
k	k		k		k	
k <sup>h</sup>	k <sup>h</sup>		k <sup>h</sup>		k <sup>h</sup>	
x	x		x		x	
tɕ	tɕ		tɕ, tɕ <sup>h</sup>	tɕ (92.86 %), tɕ <sup>h</sup> (7.14 %)	tɕ	
tɕ <sup>h</sup>	tɕ <sup>h</sup>		tɕ <sup>h</sup>		tɕ <sup>h</sup>	
ɕ	ɕ		ɕ		ɕ	
tʂ	tʂ, ts	tʂ (3 %), ts (97 %)	tʂ, ts	tʂ (22.22 %), ts (77.78 %)	ts	100 %
tʂ <sup>h</sup>	tʂ <sup>h</sup> , ts <sup>h</sup>	tʂ <sup>h</sup> (8 %), ts <sup>h</sup> (92 %)	tʂ <sup>h</sup> , ts <sup>h</sup>	tʂ <sup>h</sup> (66.67 %), ts <sup>h</sup> (33.33 %)	ts <sup>h</sup>	100 %
ʂ	ʂ, s	ʂ (1.1 %), s (98.9 %)	ʂ, s	ʂ (50 %), s (50 %)	s	100 %
ʐ	l, n	ʐ (6.4 %), l (35.4 %), n (41.9 %), z (16.1 %)	ʐ		l, n	l (91.49 %), n (8.51 %)

(continued)



**Table 2.31** (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
ts	ts, tʂ	ts (99 %), tʂ (1 %)	ts		ts	
ts <sup>h</sup>	ts <sup>h</sup>		ts <sup>h</sup>		ts <sup>h</sup>	
s	s		s		s	
ɲ	ɲ		ɲ		ɲ	
i	i		i		i	
u	u		u		u	
y	y		y		y	
a	a		a		a	
o	o		o		o	
ə	ə		ə		ə	
ei	ei		ei		ei	
ai	ai		ai		ai	
e	e		e		e	
au	au		au		au	
ou	ou		ou		ou	
an	an		an		an	
ən	ən		ən		ən	
aŋ	aŋ		aŋ		aŋ	
əŋ	əŋ, ən	əŋ (11.1 %), ən (88.9 %)	əŋ		əŋ	
ə	ə		ə		ə	100 %
ia	ia		ia		ia	
ua	ua		ua		ua	
ɔŋ	ɔŋ		ɔŋ		ɔŋ	
ie	ie		ie		ie	
ye	ye		ye		ye	
uai	uai		uai		uai	
uei	uei		uei		uei	
iau	iau		iau		iau	
iou	iou		iou		iou	
ien	ien, en	ien (96.8 %), en (3.2 %)	ien		ien	
uan	uan		uan		uan	
yen	yen		yen		yen	
in	in		in		in	
uən	uən		uən		uən	
yn	yn		yn		yn	
iaŋ	iaŋ		iaŋ		iaŋ	

(continued)

**Table 2.31** (continued)

Phoneme	Phonetic representations, first year		Phonetic representations, second year		Phonetic representations, third year	
		Frequency		Frequency		Frequency
uaŋ	uaŋ		uaŋ		uaŋ	
iŋ	iŋ, in	iŋ (20.4 %), in (79.6 %)	iŋ, in	iŋ (72.73 %), in (27.27 %)	iŋ	
jɔŋ	jɔŋ		jɔŋ		jɔŋ	
uo	uo		uo		uo	

**Tableau 2.14** OT tableau for the Taiwanese children: 6 + 1 years of age

ts <sup>h</sup>	*(+anterior)	Ident (ɔretroflex)	*(+strident)
ts <sup>h</sup>	*!		*
ᵐᵒ ts <sup>h</sup>		*	*

**Tableau 2.15** OT tableau for the Taiwanese children: 6 and 6 + 2 years of age

ts <sup>h</sup>	Ident (ɔs.g)	Ident (ɔretroflex)	*(+anterior)
ts <sup>h</sup>			*
ᵐᵒ ts <sup>h</sup>		*!	

2.6 Discussion and Summary

Children of Indonesian immigrants have unique and common difficulties with the children of Vietnamese or Taiwanese mothers. The phonetic variants of children of Indonesian and Taiwanese mothers are summarized in Table 2.32. The first column lists the target phonemes in Mandarin. The phonetic variants observed in the children of Indonesian were listed in the second column and those produced by the children of Taiwanese were listed in the last column. Omission is indicated by Ø.

Like the children of Vietnamese and Taiwanese, the children of Indonesian have difficulties in retroflexes, aspirations, and nasals. They tended to replace retroflexes with alveolars just like many adult Mandarin speakers in Taiwan. For example, the three-year-old Indonesian boy pronounced /tʂʂ/ ‘this’ as [tsʂ], which is also observed in Huang (2011) and Hsu (1996). \*Retroflex outranked ident (ɔretroflex). This could be due to the universal markedness of retroflex or the children’s input. Retroflexes usually do not preserve in adult Mandarin in Taiwan. That could just be their target rather than an error.

Children of Indonesian mothers failed to discriminate aspiration. For example, unaspirated bilabial stop /p/ and unaspirated velar stop /k/ were replaced by their aspirated counterparts. Deaspirations were also observed. Fuzzy discrimination of aspiration was also found in the children of Taiwanese mothers. Hsu (1996) also found the substitutions of aspirated stops with unaspirated stops in the children of Taiwanese parents.

**Table 2.32** Comparison of phonetic variation between children of Indonesian and Taiwanese mothers

Phoneme	Phonetic variations	
	Indonesian	Taiwanese
p	p, p <sup>h</sup> , f, ø, m	p, p <sup>h</sup> , f, m
p <sup>h</sup>	p <sup>h</sup> , p, x, f, t <sup>h</sup>	p <sup>h</sup> , p, k <sup>h</sup> , tɕ <sup>h</sup>
m	m, l, u	m, p, ø
f	f, u, p, p <sup>h</sup> , w, x	f, u, x
t	t, k, l, t <sup>h</sup> , ø	t, l, t <sup>h</sup> ø, ts
t <sup>h</sup>	t <sup>h</sup> , x, ø, ts <sup>h</sup> , tʃ	t <sup>h</sup> , tɕ <sup>h</sup> , ø, ɕ, x, k <sup>h</sup> , p <sup>h</sup> , t
n	n, l, m	n, l, ŋ
l	l, n, k	n, l, ŋ
k	k, k <sup>h</sup> , ø, t	k, ø, t <sup>h</sup>
k <sup>h</sup>	k <sup>h</sup>	k <sup>h</sup> , x, t <sup>h</sup>
x	x, ø, u, f	x, ø, t
tɕ	tɕ, tɕ <sup>h</sup> , t, ɕ, ts, t <sup>h</sup> , ø	tɕ, ɕ, ø, tɕ <sup>h</sup>
tɕ <sup>h</sup>	tɕ <sup>h</sup> , tɕ, ts <sup>h</sup> , ɕ, ø	tɕ <sup>h</sup> , tɕ, ts
ɕ	ɕ, tɕ, tɕ <sup>h</sup> , ɕ, s, k <sup>h</sup> , ts, k, t	ɕ, ts, ʂ, tɕ <sup>h</sup>
tʂ	ts, tɕ, t	tʂ, ts, tɕ, t, t <sup>h</sup> , t, x
tʂ <sup>h</sup>	tʂ <sup>h</sup> , ts <sup>h</sup> , tɕ <sup>h</sup> , k <sup>h</sup> , t <sup>h</sup> , s	tʂ <sup>h</sup> , ts <sup>h</sup> , tɕ <sup>h</sup> , k <sup>h</sup> , ts, t <sup>h</sup> , t, x
ʂ	ʂ, s, ts, ɕs, ts <sup>h</sup> , k <sup>h</sup> , x, k, t <sup>h</sup> , tʂ, t, ɕ	ʂ, s, ts, ɕ, t
ʐ	ʐ, l	ʐ, l, n, z
ts	ts, tɕ, k, tʂ, t	ts, tʂ, tɕ, t, k <sup>h</sup>
ts <sup>h</sup>	ts <sup>h</sup> , k <sup>h</sup> , tɕ <sup>h</sup> , tʂ <sup>h</sup> , tʂ, k, ø	ts <sup>h</sup> , tʂ <sup>h</sup> , k <sup>h</sup>
s	s, ts, ʂ, k <sup>h</sup> , t, ɕ	s, f, ʂ, ɕ
ŋ	ŋ	ŋ

All the children have problems with nasals. Younger children tended to drop nasals in coda, while older children changed the place of articulation. The two-year-old Indonesian girl pronounced /tan/ ‘egg’ as [ta]. The four-year-old Indonesian boy pronounced /ts<sup>h</sup>uān/ ‘wear’ as [ts<sup>h</sup>uāŋ] ‘window.’ The six-year-old Indonesian boy pronounced /ʂān/ ‘hurt’ as [san] ‘three.’ Changing the place of final nasals was also observed in Indonesian mothers. Children of Indonesian were often confused by aspiration like their mothers. For example, the three-year-old Indonesian boy said /tɕin/ ‘enter’ as [tɕ<sup>h</sup>in]. Children in both groups were accurate in tones, regardless of the Indonesian mothers’ tone errors. The Indonesian mother of the four-year-old girl and five-year-old boy pronounced the high-level tone as the falling tone, for example, /ɕiān kū/ ‘mushroom’ as [ɕiāŋ kū].

The unique problems observed in the children of Indonesian include simplification of complex vowels and preference for affricates and palatals. Younger children of Indonesian mothers tended to simplify complex vowels, which have not been observed in the children of Taiwanese or Vietnamese mothers. For example, the Indonesian two-year-old girl pronounced /tiau/ ‘lose’ as [ta]. Only one vowel

was left in the three-vowel sequence. The Indonesian boy pronounced /tuan/ 'broken' as [tan]. Only one vowel was left in the two-vowel sequence. /a/ tended to the vowel preserved.

The challenging alveopalatal affricates for the children of Vietnamese and Taiwanese mothers (Kuo 2008) do not seem to be a problem for the children of Indonesian mothers. They preferred affricates to fricatives. The two-year-old Indonesian girl pronounced the alveolar fricative /s/ as the alveolar affricate [ts], for example, /sə/ 'color' as [tsə]. The six-year-old Indonesian boy pronounced the alveopalatal fricative /ɕ/ as alveopalatal affricate [tɕ]; for example, /ɕei/ 'river' was pronounced as [tɕi].

Children of Indonesian mothers changed alveopalatals to palatals, which were not observed in the children of Taiwanese or Vietnamese mothers. The three-year-old and four-year-old Indonesian boys changed alveopalatal fricatives to palatal fricatives. For example, the three-year-old Indonesian boy pronounced /tɕiŋ ɕi/ 'thing' as [tɕiŋ ɕi]. The four-year-old Indonesian boy pronounced /ɕiaŋ tau/ 'think' as [ɕiaŋ tau]. These kinds of errors were also observed in their Indonesian mothers. For example, the mother of Indonesian three-year-old boy pronounced /tɕi/ 'self' as [tɕi tɕi].

The results of the present study show that the Mandarin phonological development by the children of immigrant mothers might be influenced by their mothers' Mandarin (L2), because they made similar errors. Since the same errors were observed among the children of mothers of different nationalities, they cannot be attributed to the mothers' L1 alone. Despite the similar exposure to Taiwan Mandarin as native children, children of immigrants made unique errors. This indicates the importance of primary interlocutors, their mothers. Children of immigrants have received input mediated by some universal constraints, whose rankings are dynamic in the process of development. Innatism and interactionism may not be mutually exclusive as the proposal for 'innately guided learning' (Gould and Marler 1987; Jusczyk and Bertoncini 1988; Marler 1991).

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