CHAPTER 4

FINGER MOVEMENTS

This chapter defines the prosodic size of Mandarin finger-rhyme movements. Finger movements, one kind of physical recitation, are strongly correlated with metrical rhythm, but rarely noticed in poetic language. The well-formedness condition of FR movements is revealed in two perspectives. One is intonational phrasing (Halliday 1967; Selkirk 1978; Pierrehumbert and Liberman 1982); the other is the framework of the Optimality Theory (Prince and Smolensky 1993, 2004).

Finger rhymes are a newly-developed[26] style of child verses, where the versifications are not different in that the numbers of syllables and lines allow degrees of freedom. Rather, this genre is characteristic of the finger movements, which are not found in other nursery rhymes. In this chapter, the finger movements are closely examined in terms of the prosodic structure (metrical structure). The variations of finger movements return to the stage of

[26] Many thanks go to the comments on 14th Annual Conference of the International Association of Chinese Linguistics & 10th International Symposium on Chinese Languages and Linguistics Joint Meeting. One of the questions is what kind of the genre the finger rhymes belong to. In my personal communications, finger rhymes are different from general nursery rhymes. There are finger movements that are not randomly performed. Rather, the design of the performance takes into account the physiological reasons, namely the verbal and physical capacities. On the other hand, the performance strictly follows the rhythm. In any event, it is not any casual interactions as in the game.

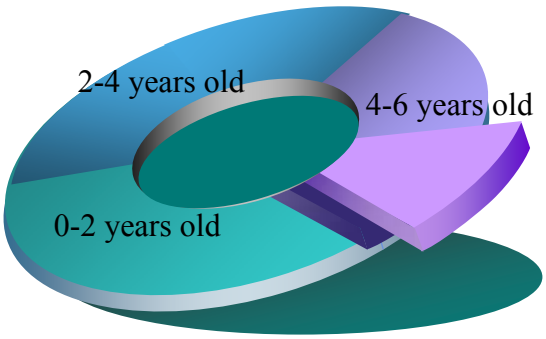
metrico-syntactic debate and wait for the compromise between two models.

In §4.1 I introduce some finger movements following the tempo. In §4.2 I present the frequency of the finger movements, and generalize the well-formed size of finger movements in §4.3 and §4.4. Finally in §4.5, I provide a new framework of OT to account for the inter- and intra-speaker variations.

4.1 Introduction of Finger-rhyme Movements

Finger rhymes are defined as preschooler-only nursery rhymes. The design takes age into account, 0-2 years old for the first stage, 2-4 for the second stage, and 4-6 for the third stage. The contents are concrete, and the metaphors are avoided. The words should be simple, and a great number of onomatopoetic words and reduplications are favored. Besides, the lines are relatively short. This makes it easier to recite a line and to complete a finger movement.

(1) Three Stages of Finger-rhyme Design



The three-demibeat lines are the most common in our corpus, as in (2)-(3). Rhythm-1 is the reading in favor of one-to-one mapping between syllables and demibeats. Rhythm-2 is the one that beat-sharing is triggered.

(2) Demibeat Numbers: Rhythm-1

Demibeats per Line	Total # of Lines	Percentage
1	58	1.39%
2	144	3.45%
3	1503	36.03%
4	349	8.37%
5	624	14.96%
6	166	3.98%
7	1250	29.96%
8	36	0.86%
9	26	0.62%
10	14	0.34%
11	1	0.02%
13	1	0.02%
TOTAL	**4172**	**100.00%**

(3) Demibeat Number: Rhythm-2

Demibeats per Line	Total # of Lines	Percentage
1	58	1.39%
2	144	3.45%
3	1503	36.03%
4	349	8.37%
5	625	14.98%
6	171	4.10%
7	1275	30.56%
8	26	0.62%

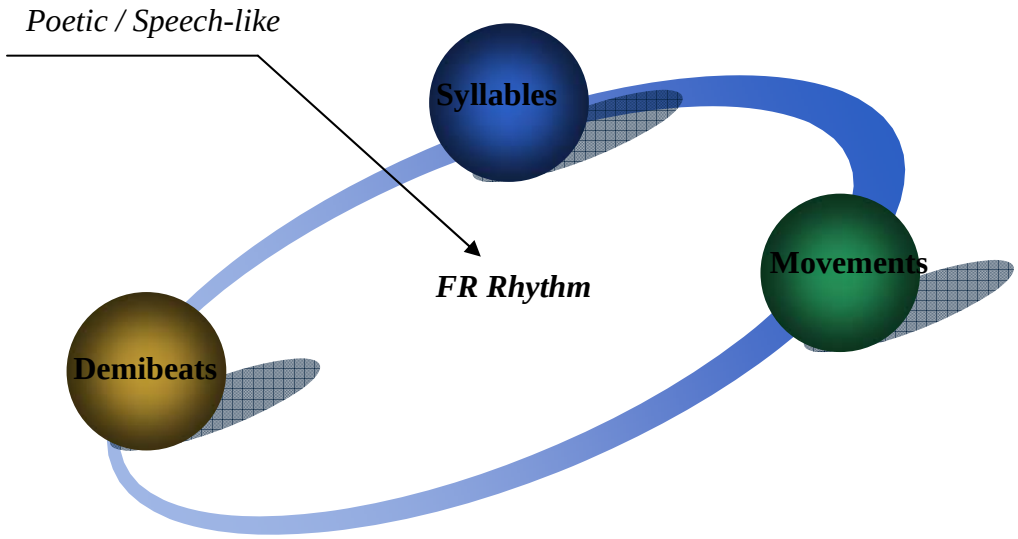
9	14	0.34%
10	7	0.17%
TOTAL	**4172**	**100.00%**

Both readings uncover the fact that the seven-demibeat lines are secondary frequent, only fewer than the three-demibeat lines, 29.96% in (2) and 30.56% in (3).

Age confines the distribution of rhythm types. The FR short lines, especially three-demibeat lines in our corpus, are the most desired length for the children under 6. The longer the FR line is, the more difficult the scansion is. That is, it is the elder kids that are more likely to read a long line. For other children, the scansion proceeds part by part.

As mentioned earlier, the finger movements are rhythmically performed. Three components, verbal recitation, finger movements and the prosody, form the core of the finger rhymes. This lifts the doubt why the prosody in the finger rhymes is more complicated than in the other child verses.

(4) Three Components of Finger Rhymes



The figure of (4) shows the interaction among these three components. Rhythm refers to as syllable-demibeat associations in way of clapping. This device has been known in other nursery rhymes, where downbeats represent strong demibeats and upbeats weak demibeats (Hsiao 1991, 2006). Two demibeats, S and W, form a trochaic foot, as in (5).

(5) S **W** S W S W S demibeats
[*zhi* ***yao*** ***ni*** *pigu* *liang* *jing-jing*]
only want 2SG hip bright shiny
'We only ask you to keep your hip clean.' (FR-619-5)

The foot is parsed from left to right. The syllables *yao* 'want' and *ni* 'you' shares a single demibeat.

On the other hand, finger movements display another type of rhythm. The presentation is in a wider range, from a demibeat, a foot, a phonological phrase, to an intonational phrase. The example is shown below.

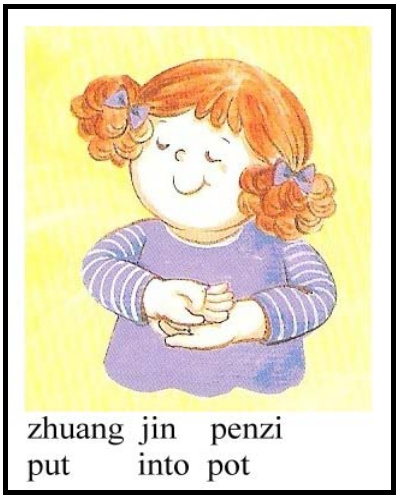
(6) *si ge da lun-zi* ‘four big tires’ (Ding 1997: 24-5)

a. ‘sands and sands’

b. ‘put them into bottles’

c. ‘bottles and bottles’

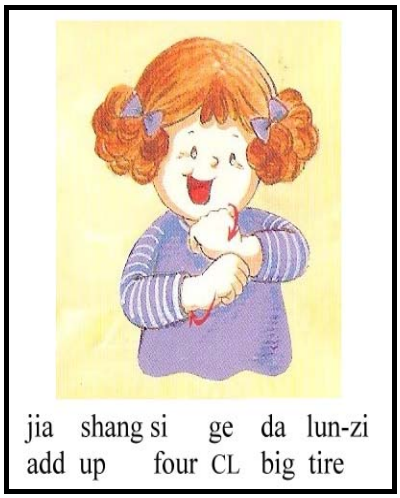
d. ‘put them into pot’



e. ‘pots and pots’

f. ‘they become cars’

g. ‘The cars are added with four big tires’



The recitation of each line of (6) is rhythmically followed by gestures. In presenting the finger form *sha-zi* ‘sand’ (6a), one stretches out our right palm in the first two demibeats, and then continues the remaining demibeats with our left palm. It takes a metrical foot to complete any of the movement *sha-zi* ‘sand’ (6a). The other form, a bottle (6b), starts with a strong metrical demibeat and ends in a weak metrical demibeat. Again, every finger

movement requires a prosodic unit, particularly a foot.

Finger movements are a good training for cognition. Anthropologists and educationalists claim that babies develop their preverbal knowledge by conducting a repertoire of baby-signs. Babies use their fingers to convey meaningful messages. To our amazement, they drop some abstract words, like conjunctions. In U.S. those who study baby signs contend that this sign language should be prosodically performed. For example, a given movement is completed in a timing of one foot. I present some of the baby-signs[27] used in U.S. families.

(7) Baby Sings

a. 'more'

b. 'rains'

c. 'a bird'

d. 'to brush the teeth'

[27] More information can be found in the website: http://www.babysigns.com.tw/.

In (7) these four movements are of meanings. Children use these signs as their verbal expressions.

4.2 The Prosodic Size of Finger-rhyme Movements

The movement is completed within the timing of any number of demibeats. The present corpus shows a given movement takes as few as one demibeat, or as many as seven demibeats. The line of the finger rhymes requires boundaries to parse one movement from another. In work by Chen (1979) and Boyce (1980), the syntactically-based domain is defined for the analysis of tone sandhi. In this research, I count the number of the demibeats in a movement. The size accounts for how many movements there are in a printed line.

4.2.1 The Number of Movements

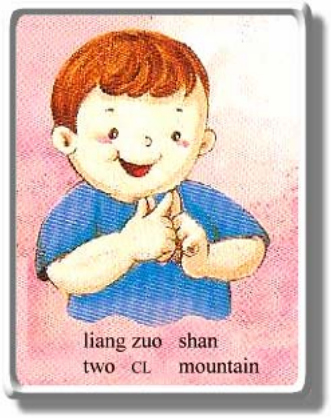
The three-demibeat lines are the most frequent in our FR corpus, as stated in §4.1. This is attributed to the fact that a lengthy line is a burden to the kids under six years old. A short line would be more proper in terms of ease of recitation. What centers our attention is the linguistic association between the size of the finger movement and the prosodic structure, i.e. as small as a foot or as large as an intonational phrase. I wonder if the size of the FR movements is sensitive to age, resulting in all types of the prosodic size. Before our discussion, two aspects should be carefully examined.

The first of the investigations is the number of the movements in a printed line[28]. Children perform the finger movements quite differently. Generally speaking, the touching of fingers belongs to a small movement; the exercise of a palm indicates a larger one. It is a result from the capacity of sports nerves. More elder the kids are, more easily they show a finger form. Consider now how many movements in a printed line, as in (8) through (10).

(8) One Movement per Line

a. *yi* *zuo* *shan*
one CL mountain
'a mountain' (FR-011-1)

b. *liang* *zuo* *shan*
two CL mountain
'two mountains' (FR-011-2)



(9) Two Movements per Line

a. *sha-zi* *sha-zi*
sand sand
'sands' (FR-014-1)

b. *nie* *ge* *bao-zi* / *song* *ye-ye*
pinch CL dumpling / send grandfather
'make a dumpling, and send it to my grandfather' (FR-088-2)

[28] The count of the movement number is based on a printed line. That is, the line is printed in the published books. Since our corpus is built up according to a variety of sources. They consist of published books, broadcastings, the manuscripts of the kindergartens, and so on. The design of a finger movement in the same line can be more than one style. To avoid the complexity, we focus the study of the finger movements on a set of the books by H.Y. Ding (1997a, 1997b, 1997c), *Baobei Shouzhi Yao* [Baby Finger Plays].

■ Left: (9a) / Right: (9b)

(10) Three Movements per Line

yuan *gu-gu*
circle full
'very circle' (FR-077-2)

There are respectively one, two, and three movements in one line, as seen above. Obviously, the timing of one movement is not consistent. In (8), the movement is completed within three demibeats, and ends with one movement. The movement size in (10) is much smaller, so there are three one-demibeat movements in a printed line. Each movement is operated within one demibeat. A fist turns left when one reads *yuan* 'circle', turns right when one reads the second syllable *gu* 'full,' and returns to the left on the third syllable. It is not

necessary for one line to carry the movements which are with the consistent timing. In (9b) there are two movements in one line, the former of which proceeds in four demibeats while the latter advances in three demibeats.

This corpus[29] of finger movements is constituted by three sub-corpora, with a total of 319 lines, for the kids aged of 0-2, 2-4, and 4-6 years old. The frequencies of these corpora are given as follows.

(11) The Number of Movements in a Printed FR Line (0-2 Years Old)

Movements per Line	**Total # of Lines**	**Percentage**
1	37	50.68%
2	5	6.85%
3	23	31.51%
4	1	1.37%
5	4	5.48%
6	1	1.37%
7	2	2.74%
TOTAL	**73**	**100.00%**

(12) The Number of Movements in a Printed FR Line (2-4 Years Old)

Movements per Line	**Total # of Lines**	**Percentage**
1	51	49.04%
2	17	16.35%

[29] Ding (1997a, 1997b, 1997c) suggests that the design of the finger rhymes be age-sensitive. The present corpus is mature from all sorts of media, including published books, broadcasting, the manuscripts of the kindergartens, and more like that. A finger movement of the same line is probably more than one form in view of different designers. To remove the complexity, we center the investigation of the finger movements on a set of the books by H.Y. Ding (1997a, 1997b, 1997c), *Baobei Shouzhi Yao* [Baby Finger Plays]. The form of a finger movement has a standard version. Personal judgments and the redundant movements are rejected.

3	21	20.19%
4	1	0.96%
5	8	7.69%
7	6	5.77%
TOTAL	**104**	**100.00%**

(13) The Number of Movements in a Printed FR Line (4-6 Years Old)

Movements per Line	**Total # of Lines**	**Percentage**
1	80	56.34%
2	31	21.83%
3	11	7.75%
4	11	7.75%
5	5	3.52%
6	1	0.70%
7	3	2.11%
TOTAL	**142**	**100.00%**

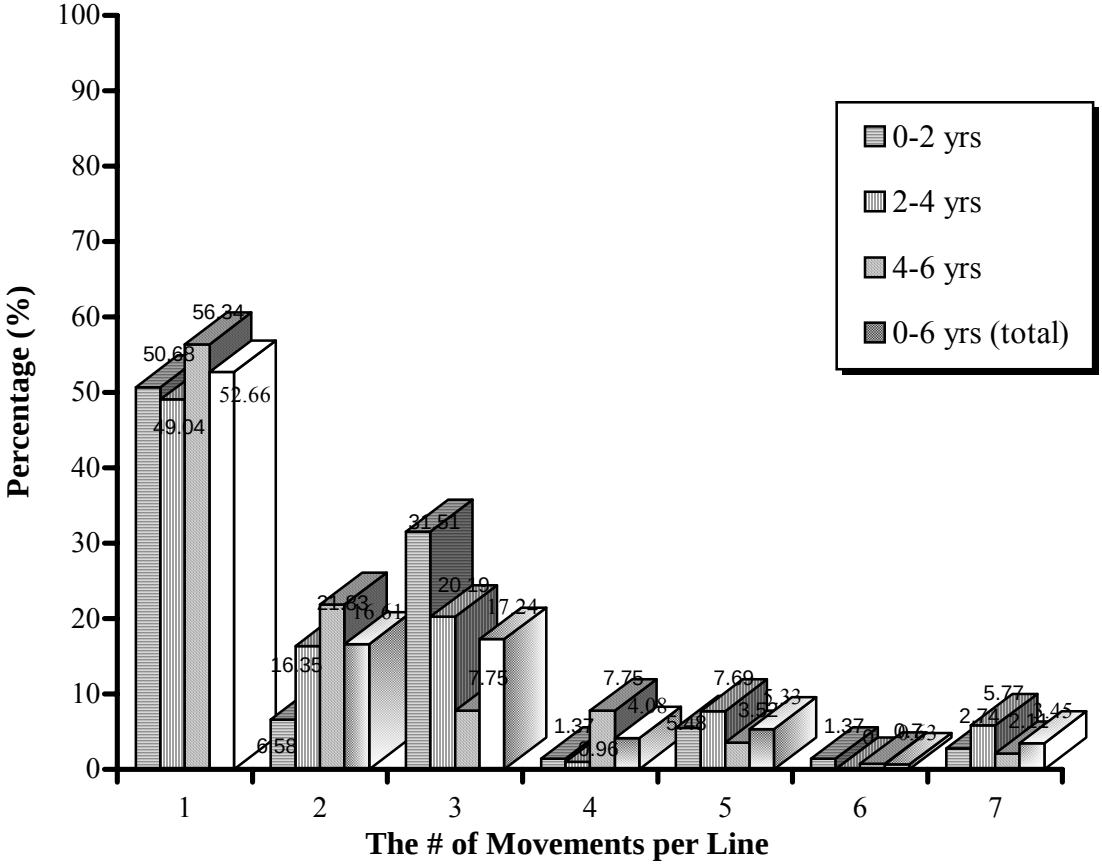
(14) The Number of Movements in a Printed FR Line (TOTAL: 0-6 Years Old)

Movements per Line	**Total # of Lines**	**Percentage**
1	168	52.66%
2	53	16.61%
3	55	17.24%
4	13	4.08%
5	17	5.33%
6	2	0.63%
7	11	3.45%
TOTAL	**319**	**100.00%**

There are 73 lines in the group of 0-2 years old, 104 in that of 2-4 years old, and 142 in that of 4-6 years old. The elder kids are able to scan more lines in a finger rhymes than those

who are younger. With respect to the number of finger movement in a line, we see in tables (11)-(14) that one FR line chiefly includes a single movement. The frequency of these three sub-corpora is close to 50%. The second and third frequent cases are the lines with two or three movements. This statistic tendency is presented in figure (15).

(15) The Number of FR Movements in a Line



The rare case is one line with more than three demibeats. In that event, these three sub-corpora are quite consistent in terms of the number of movements in a line.

4.2.2 The Size of Movements

A likely guess is that the prosodic size is inversely proportioned to the number of a movement. Otherwise there would be lines that are too long (e.g. a nine-demibeat line= 3 demibeats*3 movements), or too short (e.g. a one-demibeat line=1 demibeat*1 movement). See the following examples.

(16) One Demibeat per FR Movement

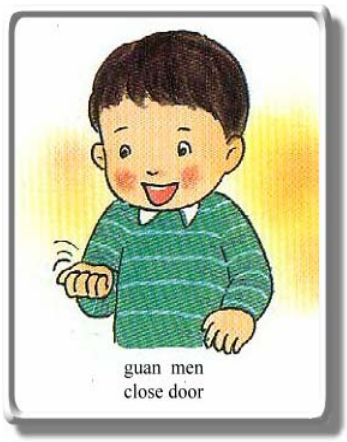
yuan *gu-gu*
circle full
'very circle' (FR-077-2)

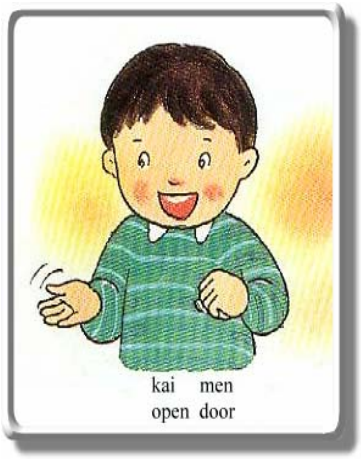
In (16) a baby turns around his fist in each demibeat. The fist faces left at the hearing of the first demibeat *yuan* 'circle.' The same movement repeats towards the opposite direction on the second and third demibeat.

(17) Two Demibeats per FR Movement

a. *guan men*
close door
'close the door' (FR-085-1-2)

b. *kai men*
open door
'open the door' (FR-085-1-1)





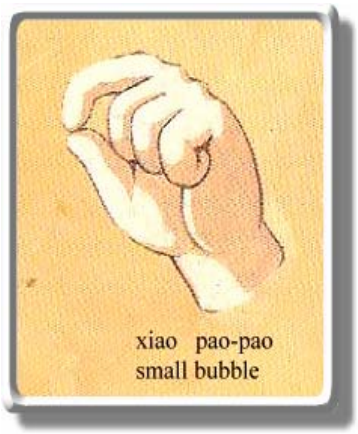
■ Left: (17a) / Right: (17b)

The example (17) is a movement with two demibeats. This movement is performed by gripping and opening one's hand.

(18) Three Demibeats per FR Movement

a. *zhua bu dao*
catch not COM
'fail to catch (something)' (FR-080-4)

b. *xiao pao-pao*
little bubble
'Little bubbles' (FR-012-1)



■ Left: (18a) / Right: (18b)

(18a) is to slowly release the palms; (18b) is to make a circle with the thumb and the index finger. Both of the movements are completed within three demibeats.

(19) Four Demibeats per FR Movement

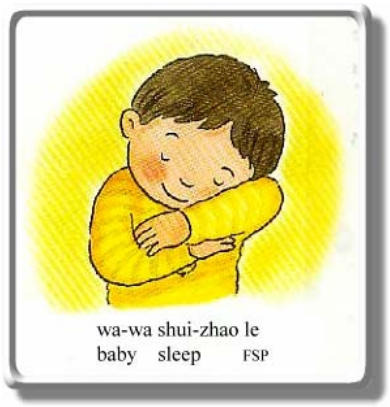
nie ***ge*** ***bao-zi*** *song* *ye-ye*
pinch CL dumpling send grandfather
'make a dumpling, and send it to my grandfather' (FR-088-2)

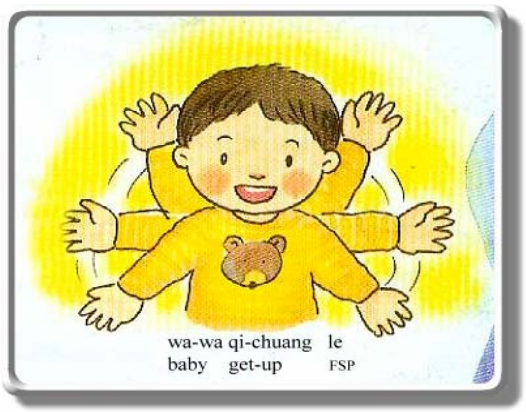
The movement of (19) is similar to the one of (17a). What makes a difference is the timing. The first movement *nie ge bao-zi* ‘make a dumpling’ takes four demibeats, while (17a) *guan men* ‘close the door’ requires only two demibeats.

(20) Five Demibeats per FR Movement

a. *wa-wa shui-zhao le*
baby sleep FSP
‘The baby fell sleepy.’ (FR-086-2-1)

b. *wa-wa qi-chuang le*
baby get-up FSP
‘The baby got up.’ (FR-086-4-1)



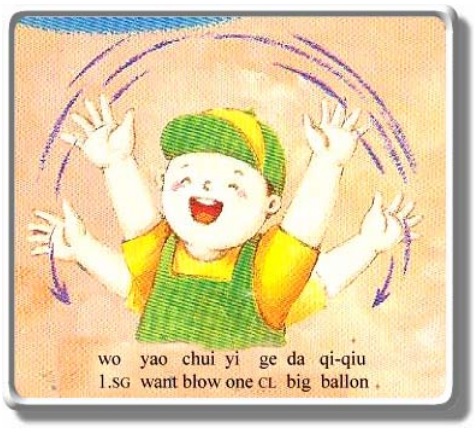


■ Left: (20a) / Right: (20b)

Either movement in (20) requires a larger size. In that event, one performs each movement by using the arms, not by fingers. The former is to pretend falling asleep; the latter is to get up. Both are clearly shown in the above pictures.

(21) Seven Demibeats per FR Movement

wo yao chui ***yi*** ***ge*** *da qi-qiu*
1SG will blow one CL big balloon
'I would make a big balloon.' (FR-010-1)



The case (21) is the misalignment between syllables and demibeats. The two syllables *yi* and *ge* shares a single demibeat. Thus, it calls for seven demibeats to make a big circle with two arms.

The age effect is obvious, as reported in the tables (22)-(25). The sum of the movements is 665 in our corpus. The number of the movements is 160, 234, and 271 alternatively in our three sub-corpora. The most distinguished pattern is one movement with one demibeat, 75.63% in (22), 69.23% in (23), and 52.77% in (24). The next salient patterns are the movements with two or three demibeats. This result remains regular throughout three tables. However, a worthy-noting point is the presence of the movements which are shown in a larger prosodic size.

(22) The Number of Demibeats per FR Movement (0-2 years old)

Demibeats per Movement	Total # of Movements	Percentage
1	121	75.63%
2	16	10.00%
3	17	10.63%
4	3	1.88%
5	3	1.88%
TOTAL	**160**	**100.00%**

(23) The Number of Demibeats per FR Movement (2-4 years old)

Demibeats per Movement	Total # of Movements	Percentage
1	162	69.23%
2	36	15.38%
3	20	8.55%
4	7	2.99%
5	7	2.99%
7	2	0.85%
TOTAL	**234**	**100.00%**

(24) The Number of Demibeats per FR Movement (4-6 years old)

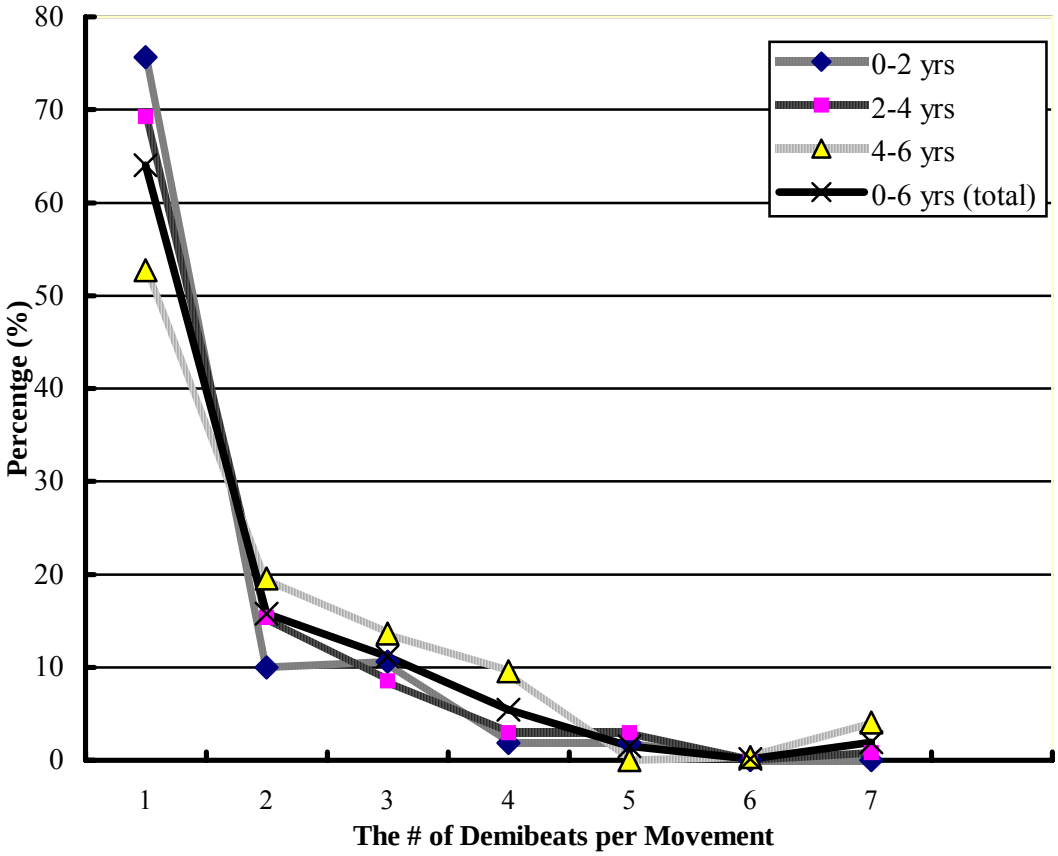
Demibeats per Movement	Total # of Movements	Percentage
1	143	52.77%
2	53	19.56%
3	37	13.65%
4	26	9.59%
6	1	0.37%
7	11	4.06%
TOTAL	**271**	**100.00%**

(25) The Number of Demibeats per FR Movement (TOTAL: 0-6 years old)

Demibeats per Movement	Total # of Movements	Percentage
1	426	64.06%
2	105	15.79%
3	74	11.13%
4	36	5.41%
5	10	1.50%
6	1	0.15%
7	13	1.95%
TOTAL	**665**	**100.00%**

In (22) we find none of the movements carrying more than five demibeats. Instead the larger-size movement gets present in the other two groups. In (23) 0.85% of the movements are with seven demibeats. In (24) the frequency increases to 4.06%. The increasing trend, as in (26), does matter, due to the fact that the finger movement is to some extent affected by age. An elder kid has a better command of a larger-size movement.

(26) The Number of Demibeats per FR Movement



To summarize, an optimal line of the finger rhyme is short. The prevailing cases are one movement in a printed line, and one movement takes one demibeat. The age effect obtains only when the prosodic size is examined. The elder kids are more likely to learn the movement with more than five demibeats.

In the next section, I will explore how IPs are rhythmically parsed in relation to the prosodic hierarchy (Selkirk 1972, 1978, 1980, 1981, Hayes 1989b). Besides, more in-deep questions await proper answers. One of those is variation found in the scansions of finger rhymes and partition of the finger movements.

4.3 Intonational Phrasing

The finger movements are IP-bounded with a support of two points. To begin with, a potential pause is intended for a following movement. Lyberg (1979) and Selkirk (1984) consider a pause to be a break between IPs. Nespor and Vogel (1986) agree that the ends of IPs are aligned to the positions on which pauses are placed. Second, each movement should be a sense unit. This semantics-based approach is fairly contended in many works (Halliday 1967; Downing 1970, 1973; Bing 1979; Selkirk 1978). I therefore posit that a finger movement is aligned to an intonational phrase.

Intonational phrases are an inventory of one or more phonological phrases, which are marked at the left edge of an X^{max}[30] , given that the X^{max} is branching. The representations come forth in many respects: syntactic configurations (Downing 1970, 1973, Bing 1979), phonetic pause (Selkirk 1978, Nespor & Vogel 1983), the boundary tone[31] (Trager & Smith 1951, Hockett 1958, Pierrehumbert 1980, Hsiao 1995), and sense units (Selkirk 1984). The principles are formulated as follows:

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[30] Selkirk (1986) proposed the end-based theory, where the ends of syntactic constituents can designate the prosodic structure. The parameter is given as follow.
(1) End-based Theory
a. X^{max}[
b.]X^{max}
c. X^{head}[
d.]X^{head}
There are two kinds of phonological phrases. One is maximal phonological phrases, which are based on the X^{max} parameters. The other is small phonological phrases, which are derived from the X^{head} parameters. The account of IPs mainly follows the X^{max} parameters.

[31] Pierrehumbert (1980) suggests a boundary tone for identifying the intonational phrase. The boundary tone, the L value in English, surfaces at the end of the final IP. The other preceding tone is a string of H marks. See below:
IP: [$_{I}$Emmet,] [$_{I}$alias the Rat,] [$_{I}$eats only cheese]
Tone: [H*L¯H%], [H*H*L¯H%], [H*H*L¯L%]

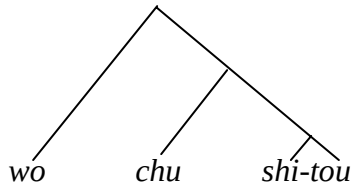
(27) a. Intonational Phrase (IP)

IP=< […x…ϒ]$_{\circ}$, SU >, where x = phonological phrase, $_{\circ}$ = pause
] = right edge, SU=sense unit

b. Phonological phrase (Ph)
{left, Xmax (+b)}, where (+b) = branching

This formulation demands that an intonational phrase, which are packed with one or more phonological phrases, be a sense unit finally accented with a boundary tone followed by a pause. Consider (28), where the symbol % refers to a potential pause between IPs.

(28) 'I show the stone.' (FR-372-5-1)



wo *chu* *shi-tou*
1SG give stone

#^{S}[	#^{VP}[	#^{NP}[		Ph
[			]	IP_1
[		] % [	]	IP_2
[	] % [		]	IP_3

The Ph boundaries are settled before the branching phrases, and therefore three IPs are generable as the possible rhythms. Each of the IPs is isomorphic with the domain of the phonological phrases. This is true as confined in the Strict Layer Hypothesis (Selkirk 1984, Nespor & Vogel 1986).

(29) Strict Layer Hypothesis (SLH)

a. Strict Layering: any constituent at a given level of the Prosodic Hierarchy is exhaustively contained in the constituent at the next higher level of the hierarchy.

b. Exhaustive Parsing: a domain at a given level of the Prosodic Hierarchy is exhaustively parsed by each domain at the next lower of the hierarchy.

The formation of IPs is also accounted for on a semantic base, namely, the condition of Sense Unit (Selkirk 1984). The constituents form a sense unit, if and only if they are in a modifier-modified or head-argument relation.

(30) Sense Unit (SU)

Two constituents C_i, C_j form a sense unit, if (a) or (b) is true of the semantic interpretation of the sentence.

a. C_i modifies C_j.
b. C_i is an argument of C_j.

Go back to the example (28). Without doubt, the immediate constituents *shi-tou* 'stone' forms a sense unit. The VP *chu shi-tou* meet the head-argument relation and thus surfaces as the second IP of the IP_3 rhythm.

Some of the finger movements are parsed into IP domains. This phenomenon is fairly obvious in the lines with more than three demibeats. Consider (31).

(31) FR-537-1 ‘A melon is falling from the wall.’

a. [*qiang shang luo xia yi ge gua*]$_{IP}$
wall above fall down one CL melon

b. [*qiang shang luo xia*]$_{IP}$ [*yi ge gua*]$_{IP}$
wall above fall down one CL melon

c. [*qiang shang*]$_{IP}$ [*luo xia yi ge gua*]$_{IP}$
wall above fall down one CL melon

d. [*qiang shang*] $_{IP}$ [*luo xia*] $_{IP}$ [*yi ge gua*]$_{IP}$
wall above fall down one CL melon

e. ?[*qiang shang*] $_{IP}$ [*luo xia*] $_{IP}$ [*yi ge*] $_{IP}$ [*gua* ∅]$_{IP}$
wall above fall down one CL melon

f. ?[*qiang*] $_{IP}$ [*shang*] $_{IP}$ [*luo*] $_{IP}$ [*xia*] $_{IP}$ [*yi*] $_{IP}$ [*ge*] $_{IP}$ [*gua*]$_{IP}$
wall above fall down one CL melon

In (31) four scansions are possible. A matrix sentence forms a single intonational phrase, as in (31a). There are three more types of rhythms, (31b)-(31d). The verb *luo xia* ‘falling’ is the head to its modifier *qiang shang* ‘on the wall’ in (31b) and to its argument *yi ge gua* ‘a melon’ in (31c). Both conform to Sense Unit Condition (Selkirk 1984). (31d) is also IP-parsed, where the IPs and the phonological phrases are one-to-one aligned. It deserves noting that the different types of movement parsing are reflected in the scansions of the children of different ages. For example, in (31a) the one-IP movement is not proper to younger kids, especially of 0-2 years old, who prefer a smaller partition, as shown in the

present corpus.

On the other hand, a serious problem is found in the foot-parsed movement (31e) and the demibeat-parsed movement (31f). These two cases violate the sense unit conditions, but allow a potential pause to make distinct IPs. In (31e), the head-argument constituents *yi ge gua* 'one melon' are broken down. Further in (31f), the immediate constituency is collapsed by the internal structures of *qiang shang* 'on the wall,' *luo xia* 'fall down,' and the numeral-classifier pair *yi ge*. The question is whether these parsing are well-formed IPs and stand alone for separate movements. Let us see more examples, where the beat-sharing is involved.

(32) FR-010-1 'I want to make a big balloon.'

a. [*wo* *yao* *chui* ***yi*** ***ge*** *da* *qi-qiu*]$_{IP}$
1.SG want blow one CL big balloon

b. [*wo* *yao* *chui*]$_{IP}$ [***yi*** ***ge*** *da* *qi-qiu*]$_{IP}$
1.SG want blow one CL big balloon

c. [*wo* *yao*]$_{IP}$ [*chui* ***yi*** ***ge*** *da* *qi-qiu*]$_{IP}$
1.SG want blow one CL big balloon

d. ?[*wo* *yao*]$_{IP}$ [*chui* ***yi*** ***ge***]$_{IP}$ [*da qi*]$_{IP}$ [*qiu* ∅]$_{IP}$
1.SG want blow one CL big balloon

e. *[*wo* *yao*]$_{IP}$ [*chui* *yi*]$_{IP}$ [*ge* *da*]$_{IP}$ [*qi-qiu*]$_{IP}$
1.SG want blow one CL big balloon

f. ?[*wo*]$_{IP}$ [*yao*]$_{IP}$ [*chui*] $_{IP}$ [***yi*** ***ge***]$_{IP}$ [*da*]$_{IP}$ [*qi*]$_{IP}$ [*qiu*]$_{IP}$
1.SG want blow one CL big balloon

g. *[*wo*]$_{IP}$ [*yao*]$_{IP}$ [*chui*] $_{IP}$ [*yi*] $_{IP}$ [*ge*]$_{IP}$ [*da*]$_{IP}$ [*qi*]$_{IP}$ [*qiu*]$_{IP}$
1.SG want blow one CL big balloon

In (32), at least three readings comply with Sense Unit Condition. (32a) is an intonational phrase which is built upon a complete matrix sentence. Each of the IPs in (32b) and (32c) possesses a head-argument or head-modifier node.

In §3, we render a masculine rhythm by aligning the demibeats of ICs or functors to the syllables. In (32), the case is such that the two syllables *yi* and *ge* shares a single demibeat (in bold face). The eight-syllable line reaches the masculine rhythm, a seven-demibeat line. In that event, the other well-formed IPs that are not subject to beat-sharing are rejected here.

Again, the question why (32d) and (32f) are proper movement scansions is raised. The intermediate constituency is not hold for the parsing of (32d), (32f) and (32g). That is, the verbs *yao chui* 'want to blow' and *qi-qiu* 'balloon' forms a single IP, and thus conflicts the Sense Unit Condition and Lexical Integrity (Chomsky & Halle 1968). Despite that, (32d) and (32f) are performed well by children. (32e) and (32g) are completely out of consideration, for they yield an undesired rhythm.

One-demibeat movement is the most frequent in the present corpus, 64.06% of the data. The inference is easily made for physiology reasons that none of the children has difficulty in

producing the movements with the least demibeats. It is common that a single demibeat forms a movement, as in (33).

(33) One Demibeat per Movement

a. [*miao*]$_{MV}$
meow (onomatopoeia)
'meow' (FR-084-2)

b. [*xiao*]$_{MV}$ [*dou*]$_{MV}$
little bean
'little beans' (FR-087-1)

c. [*pai*]$_{MV}$ [*yi*]$_{MV}$ [*pai*]$_{MV}$
hit one hit
'to hit (something)' (FR-052-2-1)

d. [*peng*]$_{MV}$ [*dao*]$_{MV}$ [*shi*]$_{MV}$ –[*tou*]$_{MV}$
bump COM stone
'to bump into a stone' (FR-087-3)

e. [*feng*]$_{MV}$ –[*che*]$_{MV}$ [*zhuan*]$_{MV}$ [*a*]$_{MV}$ [*zhuan*]$_{MV}$
windmill turn A turn
'The windmill is turning.' (FR-079-4)

f. [*kan*]$_{MV}$ –[*jian*]$_{MV}$ [*yi*]$_{MV}$ [*zhi*]$_{MV}$ [*xiao*]$_{MV}$ [*mao*]$_{MV}$
see one CL little cat
'see a little cat' (FR-084-5)

g. [*zou*]$_{MV}$ [*jin*]$_{MV}$ –[*lai*]$_{MV}$ [*yi*]$_{MV}$ [*ge*]$_{MV}$ [*xiao*]$_{MV}$ [*ren*]$_{MV}$
walk come.into one CL little man
'A little man came in.' (FR-085-3)

One movement is in (33a), two in (33b), three in (33c), four in (33d), five in (33e), six in (33f), and seven in (33g). These unmarked cases emergently call for a consideration of IP restructuring.

According to list restructuring (Nespor & Vogel 1986, Hsiao 1995), an IP is allowed to be formed by a single demibeat. The related IPs are separated by a potential pause. I show the formulation followed by the examples, lyrics of Song Dynasty and a government slogan.

(34) *List restructuring*

> In a sequence of more than two constituents of the same type, i.e., X_1, X_2, …X_n, an intonational break may be inserted after each repetition of the node X, i.e. X_1, X_2, …X_n.
>
> (Hsiao 1995: 105)

(35) *Song Lyrics*

a.

IP_1			IP_2	IP_3	IP_4
[*ren*	*you*	*bei*]	[*huan*]	[*li*]	[*he*]
people	have	sorrow	happiness	departure	reunion

‘People may have sorrow or joy, be near or far apart.’

b.

IP_1			IP_2	IP_3	IP_4
[*yue*	*you*	*yin*]	[*qing*]	[*yuan*]	[*que*]
moon	have	dim	bright	wax	wane

‘The moon may be dim or bright, wax or wane.’

(36) *Government Slogan*

IP_1	IP_2	IP_3	IP_4	IP_5
chong	*tuo*	*pao*	*gai*	*song*
flush	relieve	soak	cover	send

'The five burn-tips are as follows: flush, relieve, soak, cover and to the emergency.'

The list restructuring allows each constituent of a flat structure to be an independent IP. The elements of the flat structures are taken apart, such as the nouns *bei* 'sorrow,' *huan* 'happiness', *li* 'departure,' *he* 'reunion' in (35a), *yin* 'dim,' *qing* 'bright,' *yuan* 'wax,' *que* 'wane' in (35b), and the verbs *chong* 'flush,' *tuo* 'releieve,' *pao* 'soak,'*gai* 'cover,' *song* 'send' in (36). More importantly, the presence of the one-demibeat movement becomes reasonable, for the reasons of IP restructuring as well as the reasons of physiology.

The movements are also found to proceed foot by foot. In work by Nespor and Vogel (1986), the length factor plays a role. A uniform and average scansion is preferred in metrics. The ideal length can create a more rhythmic sense, which is based on the prosodic hierarchy. The length effect also leads to restructuring of IPs.

4.4 Foot Phrasing

While the alignment of movements is generable from IP phrasing, the footing process (Hsiao 1991) equally predicts the same types of movement parsing.

In Mandarin, the footing is sensitive to the domain of an intonational phrase[32]. The relevant conditions are reported in (37)-(38).

(37) *Foot Formation*

a. Immediate Constituent Foot (ICF): Any adjacent demibeats which are ICs are regarded as an ICF.

b. Adjacent Beat Foot (ABF): Any two adjacent demibeats which are not ICs are grouped into an ABF.

c. Jumbo Foot (JF): Any stray single demibeat which c-commands the demibeat of the neighboring foot can join in the foot to be a Jumbo Foot

d. Minifoot (MF): The leftmost single demibeat forms a Minifoot if and only if an intonational phrase boundary % follows it.

(38) *Application Criteria*

a. The ICF applies prior to the other footing processes, when all the conditions are ready.

b. Then the line is scanned from left to right for either of MF, ABF, and JF to apply.

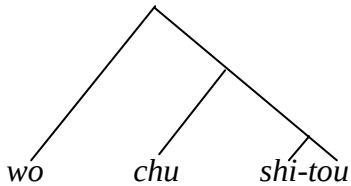
c. Footing is prevented from crossing any intonational phrase boundary.

This device of footing is rational. First of all, ICF and JF reflect the nature of sense units, where the immediate constituency and the modifier-modified condition are required.

[32] There is an assumption that the metrical and prosodic constituents be distinct. The metrical categories refer to as beats, foots, and so on; the prosodic categories stand for phonological phrase, IP and many others. Hsiao (1991b) suggests a footing process which forms a domain for tone sandhi.

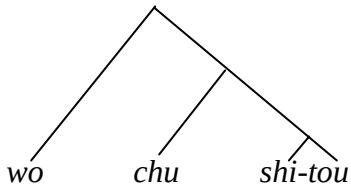
Second, ABF and MF met the demand of exhaust parsing in the prosodic hierarchy. I reanalyze the aforementioned line of the finger rhymes, as in (39).

(39) a. 'I show the stone.' (FR-372-5-1)



wo *chu* *shi-tou*
1SG give stone
[ ] IP_1
[ ] % [ ] IP_2
x x x x Lexical Demibeat
|_____| ICF
|_____| ABF

b. 'I show the stone.' (FR-372-5-1)



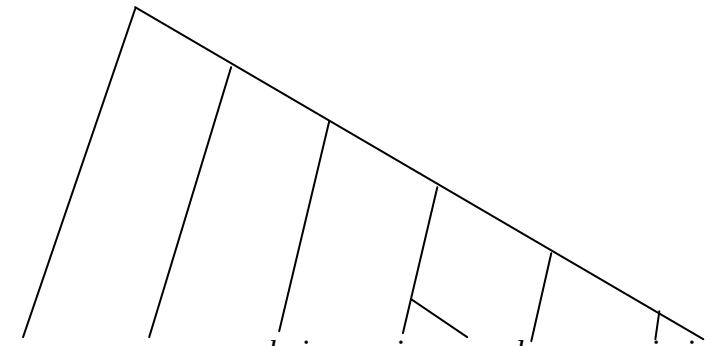
wo *chu* *shi-tou*
1SG give stone
[ ] % [ ] IP_3
x x x x Lexical Beat
|_____|f ICF
|_____|f JF
|____|f MF

In (39a), each syllable is assigned a lexical demibeat. A whole sentence constitutes a well-formed IP. The ICF prevails over ABF and subsequently derives two IPs in the IP_2

rhythm. In (39b), the demibeat *chu* c-commands an existing foot. Thus, these three demibeats can group together as a Jump Foot. The left demibeat followed by an intonational phrase boundary % becomes a Minifoot alone. It is amazing that the interaction of foot formation successfully derives IP_3.

The way of footing also accounts for the foot-based and demibeat-based movements, as in §4.3 which are resorted to IP restructuring. In (40) there are candidates of finger movements, where the boundaries of phonological phrases are settled on the left edge of X^{MAX}. IP_8 and IP_9 are ill-formed, since each yields a feminine rhythm. However, the presence of IP_6 and IP_7 that are rhythmically preferred remains a puzzle. Consider (40):

(40) 'I want to make a big balloon.'

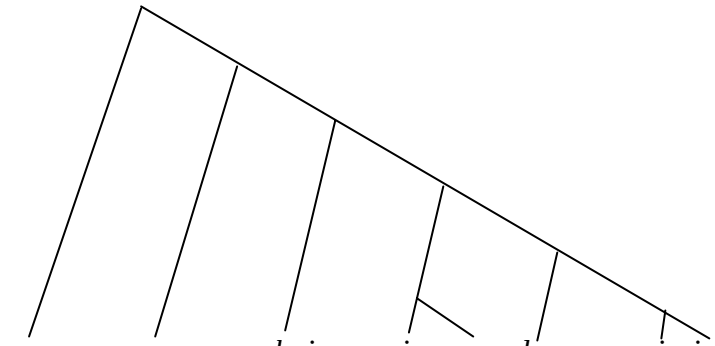


wo	*yao*	*chui*	*yi*	*ge*	*da*	*qi-qiu*	
1.SG	want	blow	one	CL	big	balloon	
$\#^{S}$[	$\#^{VP}$[	$\#^{VP}$[	$\#^{NP}$[	$\#^{NP}$[	$\#^{NP}$[		Ph
[*wo*	*yao*	*chui*	*yi*	*ge*	*da*	*qi-qiu*]	IP_1
[*wo*] %	[*yao*	*chui*	*yi*	*ge*	*da*	*qi-qiu*]	IP_2
[*wo*	*yao*] %	[*chui*	*yi*	*ge*	*da*	*qi-qiu*]	IP_3
[*wo*	*yao*	*chui*] %	[*yi*	*ge*	*da*	*qi-qiu*]	IP_4
[*wo*	*yao*] %	[*chui*	*yi*	*ge*]%[	*da*	*qi-qiu*]	IP_5

?[*wo* *yao*] % [*chui* *yi* *ge*]%**[** *da* *qi***]% [** *qiu* **]** IP_6
?[*wo*] % [*yao*] % [*chui*] %[*yi* *ge*]%[*da*]%**[***qi***] % [***qiu***]** IP_7
*[*wo* *yao*] % **[***chui* *yi***] %[** *ge* *da***]%** [*qi-qiu*] IP_8
*[*wo*] % [*yao*] % [*chui*] %**[***yi***] % [***ge***]%**[*da*]%[*qi*]%[*qiu*] IP_9

Consider the ungrammaticality of IP_8. The footing should not be across the IP boundaries. However, in (41), ICF and JF have the boundaries crossing the IP boundaries of IP_8, resulting in certain footing tensions. IP5 is thus optimal in releasing the footing tensions.

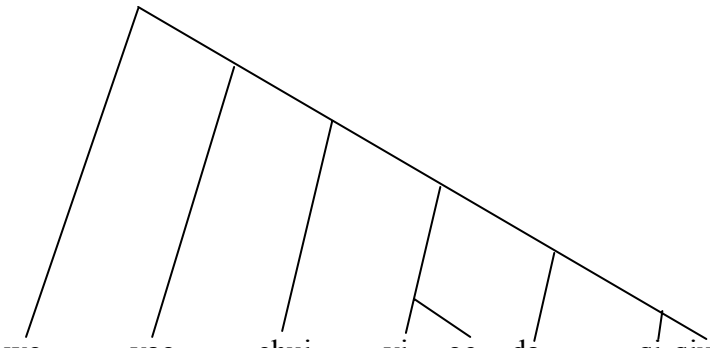
(41) 'I want to make a big balloon.'



wo	*yao*	*chui*	*yi*	*ge*	*da*	*qi-qiu*	
1.SG	want	blow	one	CL	big	balloon	
x	x	x	x	x	x	x x	Demibeat
			|_____|			|_____|	ICF
|_____|							ABF
		|_____|			|_____|		JF
[*wo*	*yao*] %	[*chui*	*yi*	*ge*]%[	*da*	*qi-qiu*]	IP_5
[*wo*	*yao*] %	**[***chui*	*yi***] %[**	*ge*	*da***]%**	[*qi-qiu*]	*IP_8

Next see the one-demibeat movement that is not subject to beat-sharing.

(42) ‘I want to make a big balloon.’



wo	yao	chui	yi	ge	da	qi-qiu	
1.SG	want	blow	one	CL	big	balloon	
x	x	x	x	x	x	x x	Demibeat
|____|	|____|	|____|	|___|	|___|	|____|	|___| |___|	*MF
		N/A					*ICF
[*wo*] % [*yao*] %		[*chui*] %	**[***yi***] % [***ge***]%**		[*da*]%	[*qi*]%[*qiu*]	*IP$_9$

In (42), the rhythm of IP$_9$ is achieved if and only if the process of MF works on. Nevertheless, MF is subject to the left most single demibeat, and it is unlikely to apply in prior to ICF. IP$_9$ is consequently bad.

The preference of rhythms shows that the oral prosody in some way influences the formation of movements. In the finger rhymes, syllables, demibeats and finger movements are strongly associated.

Footing phrasing fails to give an account to the presence of list restructuring. For example, IP$_6$ and IP$_7$ in (40) are frequently presented; the foot phrasing accept neither, since the immediate constituents *qi-qiu* ‘balloon’ are not allowed to be apart in terms of ICF.

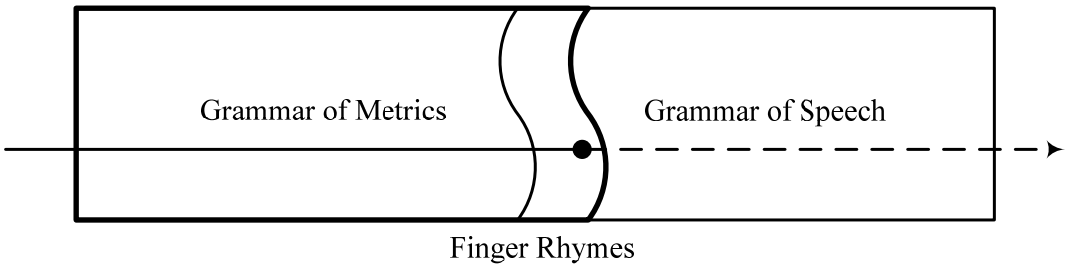
Fortunately, this opacity of rule-ordering is avoided in Optimality Theory (Prince and Smolensky 1993, 2004). In §4.5, this constraint-based approach is posited to yield these variations of the finger movements.

4.5 The Constraint-based Approach: Variations

In finger rhymes, the variations of both between and within individuals are largely observable. A line of the finger rhymes has a variety of scansions. A long line is usually parsed into small IPs in terms of sense units, while a short line can be scanned demibeat by demibeat or foot by foot. The accommodation of movement size is required by the inter-speaker differences, where a younger kid is constrained to make a large movement. For elder children, more variations are possible, and the difference is the frequency of uses. The elder children, in particular at the age of 4-6, prefer a large movement for the physiological capacity. In the following discussions, this is termed as intra-speaker variations.

Finger rhymes form a new genre floating between grammars which are constrained by certain metrical rules, as seen in (43). The IP-based movements approach to the grammar of speech; the demibeat-parsed or foot-parsed movements are near the grammar of metrics.

(43) Continuum of Grammars



In terms of Optimality Theory (Prince and Smolensky 1993, 2004), the constraints are universal, and the different optimal outputs result from the re-ranking of constraints. In this chapter, the partially ordered grammars model (Antilla 1995; Antilla and Cho 1998; Antilla 2000) and the floating constraints model (Reynolds 1994; Nagy and Reynolds 1997, Zuo 2002) are drawn to the various rhythmic sturctures of the finger rhymes, which shows a certain age-grading nature. That is, the ranking of certain constraints are unspecified, and different grammars derive from the re-ranking of these soft-ordered constraints.

A given movement can be completed within a demibeat, a foot, or an intonational phrase. The alignment constraints (44)-(46) are stated as follows.

(44) ALIGN-R (IP, MV): The right edge of an intonational phrase coincides with the right edge of a movement.

(45) ALIGN-R (DB, MV): The right edge of a demibeat coincides with the right edge of a movement.

(46) ALIGN-R (FT, MV)[33]: The right edge of a foot coincides with the right edge of a foot.

According to Selkirk's (1984) proposal, an IP is formed by a sense unit. And then I proposed the constraint ALIGN (IP, SU) in (47).

(47) ALIGN (IP, SU): Both edges of an intonational phrase are aligned to both edges of a sense unit.

ALIGN (IP, SU) dominates ALIGN-R (IP, MV) to avoid an ill-formed IP. On the other hand, ALIGN (IP, SU) does not interact with ALIGN-R (DB, MV) nor with ALIGN-R (FT, MV).

The other two constraints are MASCULINITY and MAXIMALITY. Nearly 83% of the data are masculine lines. Among them, the three-demibeat lines are the most common. In §3, I suggest a four-demibeat template, where the final demibeat can be a silent demibeat. The constraint (48) is used to show the preference of the masculine rhythm, while the constraint (49) is adopted to indicate the favorably maximal size of the finger movements.

(48) MASCULINITY: A masculine rhythm is preferred.

(49) MAXIMALITY: A movement contains maximally three demibeats.

[33] The sentence-final single syllable can be a foot. We assume there is a potential pause or a syllable lengthening at the end of a sentence. This view is valid with the support of the experiments by Bolinger (1962) and Hayes (1984, 2000). Zuo (2002) also proposes the constraint LONG-LAST that when two constituents in a domain are of different length, place the longer constituents at the right end of the domain.

MASCULINITY is crucial in the metrical grammar, and thus undominated in the finger rhymes. MAXIMALITY shows the preference of the finger movement types. Since there are movements with more than three demibeats in the present corpus, the ranking of MAXIMALITY should be at the bottom.

The finger rhymes are designed differently for the three age levels. With the different rankings of the constraints in (50)-(52), three sub-grammars can be captured. For the youngest children, the most frequent movements are demibeat-based, as governed by the ranking in (50). For the elder children, the movement size expands to a foot, as governed by the ranking in (51). For the eldest children, the IP-based movements are largely used, as governed by the ranking in (52).

(50) *0-2 years old*
MASCULINITY >> ALIGN (IP, SU) >> ALIGN-R (DB, MV) >> ALIGN-R (FT, MV) >>ALIGN-R (IP, MV) >> MAXIMALITY

(51) *2-4 years old*
MASCULINITY >> ALIGN (IP, SU) >> ALIGN-R (FT, MV) >> ALIGN-R (DB, MV) >>ALIGN-R (IP, MV) >> MAXIMALITY

(52) *4-6 years old*
MASCULINITY >> ALIGN (IP, SU) >> ALIGN-R (IP, MV) >> ALIGN-R (DB, MV), ALIGN-R (FT, MV) >> MAXIMALITY

With these three rankings, the inter-speaker variations are well attested. (53) is an example from the performance of children under 2 years old, (54) is an example of chidren between 2 and 4 years old, while (55) is an example of children above 4 years old.

(53) 'very round' (FR-077-2)

x	x	x
yuan	*gu*	*gu*
round	blow	blow

TEMPLATE: xxx<u>x</u>	MASCULINITY	ALIGN (IP, SU)	ALIGN-R (DB, MV)	ALIGN-R (FT, MV)	ALIGN-R (IP, MV)	MAXIMALITY
a. (xxx)			*!*	*		
☞b. (x)(x)(x)				*	***	
c. (xx)(x<u>x</u>)			*!		**	
d. (x)(xx)			*!	**		
e. (xx)(xx)	*!	**	**		**	

Candidate (53b) is optimal since it incurs no violations of ALIGN-R (DB, MV). That is, the movement is demibeat by demibeat, in particular for the children who are aged 0-2 years old. In candidate (53e), the lengthened final syllable results in a feminine rhythm. Thus, the candidate (53e) is dropped from the competition. Tableau (54) gives another type of the movement presentations. Each unit of the movements is a foot. Consider (54):

(54) ‘sands and sands’ (FR-014-1)

x x x x

sha-zi *sha-zi*

sand sand

TEMPLATE: xxxx	MASCULINITY	ALIGN (IP, SU)	ALIGN-R (FT, MV)	ALIGN-R (DB, MV)	ALIGN-R (IP, MV)	MAXIMALITY
a. (xxxx)	*		*!	***		
b. (x)(x)(x)(x)	*		*!*		****	
☞c. (xx)(xx)	*			**	**	
d. (x)(xxx)	*	**!	**	**		
e. (xxx)(x)	*	**!	**	**		
f. (x)(xx)(x)	*	**!*	***	*		

In (54) all the candidates violate MASCULINITY and pass the evaluation to the following level. Candiadtes (54d)-(54f) are not favored, since they are the IP-based movements that are not sense units. Candiate (54c) is chosen for it is the only candidate which obeys ALIGN-R (DB, MV). The other candiates thus fail in this competition. The optiomal finger movement for the children who are 2-4 years old is foot-based.

Consider now the children who are 4-6 years old. The physical movements are expanded, but rarely exceed over four demibeats. See (55):

(55) 'I make a bun, and send it to my grandfather' (FR-088-2)

x	x	x	x	x	x	x
nie	*ge*	*bao-zi*	*song*	*ye-ye*		
pinch	CL	bun	send	grandfather		

TEMPLATE: xxxx	MASCULINITY	ALIGN (IP, SU)	ALIGN-R (IP, MV)	ALIGN-R (DB, MV)	ALIGN-R (FT, MV)	MAXIMALITY
a. (xxxxxxx)				******(!)	***(!)	***
b. (x)(x)(x)(x)(x)(x)(x)			****!***		***	
c. (xx)(xx)(xx)(xx)			****!	***		
☞d. (xxxx)(xxx)				*****	**	
e. (xxx)(xxxx)		*!*		*****	****	
f. (xx)(xxx)(xx)		*!*		****	***	
g. (xx)(xx)(x)(xx)		*!		***	**	

Candidates (55e)-(55g) are rejected, with the parsed constituents that are not sense units. Candidates (55b) and (55c) are not desired by the constraint ALIGN-R (IP, MV). Candidate (55d) is better than candidate (55a), because (55d) has fewer violations. This implies that children prefer a short IP than a longer IP. The metrical line (55) is parsed into two IPs, one with four demibeats and the other with three demibeats.

There are a variety of ways to make the finger movements of the same line. In the following examples, the three constraint rankings discussed above may obtain different possible outputs. (56) is the demibeat-based movement, (57) is the foot-based movement, and (58) is the IP-based movement.

(56) 'I want to make a big balloon.'

x	x	x	x	x	x	x	x
wo	*yao*	*chui*	*yi*	*ge*	*da*	*qi-qiu*	
1.SG	want	blow	one	CL	big	balloon	

TEMPLATE: xxxx	MASCULINITY	ALIGN (IP, SU)	ALIGN-R (DB, MV)	ALIGN-R (FT, MV)	ALIGN-R (IP, MV)	MAXIMALITY
a. (xxxxxxx)			***!***	***		***
b. (xxxxxxxx)	*!		*******			****
c. (xx)(xxxxx)			***!**	**		*
d. (xxx)(xxxx)			***!**	****		
e. (xxxx)(xxx)			***!**	**		
g. (xx)(xx)(xxx)			***!*	*		
h. (xx)(xxxx)(x)		*!*	****	*		
i. (xx)(xx)(xx)(x)			***!		****	
j. (xx)(xx)(xx)(xx)	*!		****		****	
k. (x)(xxx)(x)(xx)(x)	*!	****	***	*****		
☞l. (x)(x)(x)(x)(x)(x)(x)				***	*******	
m.(x)(x)(x)(x)(x)(x)(x)(x)	*!			***	********	

The constraint MASCULINITY is undominated in the finger rhymes. As a result, the candidates (b), (j), (k) and (m) in the tableaux (56)-(58) are unacceptable, since each is a femine rhythm. The other candidates are retained by the IC beat-sharing of the QP *yi ge*. In (56), candidate (56h) violates ALIGN (IP, SU), and loses the competition. The optimal type of the movement is parsed by a demibeat, namely (56l), which does not violate the higher-ranked constraint ALIGN-R (DB, MV).

(57) 'I want to make a big balloon.'

x	x	x	x	x	x	x	x
wo	*yao*	*chui*	*yi*	*ge*	*da*	*qi-qiu*	
1.SG	want	blow	one	CL	big	balloon	

TEMPLATE: xxxx	MASCULINITY	ALIGN (IP, SU)	ALIGN-R (FT, MV)	ALIGN-R (DB, MV)	ALIGN-R (IP, MV)	MAXIMALITY
a. (xxxxxxx)			*!**	******		***
b. (xxxxxxxx)	*!			*******		****
c. (xx)(xxxxx)			*!*	*****		*
d. (xxx)(xxxx)			*!***	*****		
e. (xxxx)(xxx)			*!*	*****		
g. (xx)(xx)(xxx)			*!	****		
h. (xx)(xxxx)(x)		*!*	*	****		
☞i. (xx)(xx)(xx)(xx)				***	****	
j. (xx)(xx)(xx)(xx)	*!			****	****	
k. (x)(xxx)(x)(xx)(x)	*!	****	*****	***		
l. (x)(x)(x)(x)(x)(x)(x)			*!**		*******	
m.(x)(x)(x)(x)(x)(x)(x)(x)	*!		***		********	

In the tableau (57), the foot-phrased movement (57i) is chosen. On the one hand, candidate (57i) observes ALIGN-R (FT, MV), which are violated by the other candidates. On the other hand, candidate (57i) has the masculine rhythm, which is preferred in the corpus.

(58) 'I want to make a big balloon.'

x	x	x	x	x	x	x	x
wo	*yao*	*chui*	*yi*	*ge*	*da*	*qi-qiu*	
1.SG	want	blow	one	CL	big	balloon	

TEMPLATE: xxxx	MASCULINITY	ALIGN (IP, SU)	ALIGN-R (IP, MV)	ALIGN-R (DB, MV)	ALIGN-R (FT, MV)	MAXIMALITY
a. (xxxxxxx)				******(!)	***(!)	***
b. (xxxxxxxx)	*!			*******		****
c. (xx)(xxxxx)				*****(!)	**(!)	*
d. (xxx)(xxxx)				*****(!)	****(!)	
e. (xxxx)(xxx)				*****(!)	**(!)	
☞g. (xx)(xx)(xxx)				****	*	
h. (xx)(xxxx)(x)		*!*		****	*	
i. (xx)(xx)(xx)(x)			*!***	***		
j. (xx)(xx)(xx)(xx)	*!		****	****		
k. (x)(xxx)(x)(xx)(x)	*!	****		***	*****	
l. (x)(x)(x)(x)(x)(x)(x)			*!******		***	
m.(x)(x)(x)(x)(x)(x)(x)(x)	*!		********		***	

The tableau (58) generates the outputs that are the larger IPs. Candidate (58h), in violation of sense unit condition, is not desired. Candidates (58i) and (58l) do not oberve ALIGN-R (IP, MV), so that both cannot pass the evaluation to the following levels. Candidates (58a), (58c)-(58g) incur violations of the lower-ranked constraints. In finger rhymes, the short movements are preferred. Candidate (58g) emerges to be the optimal output, with fewer violations of ALIGN-R (DB, MV), ALIGN-R (FT, MV) and MAXIMALITY.

The floating constraints and the partial re-ranking are needed to account for the inter-speaker variations. Mandarin finger rhymes are sensitive to age. Some of the movements are scanned by demibeat, some by foot, and others by IP. In terms of the finger-rhyme rhythms, children have different sub-grammars at different ages. The three constraint rankings proposed in (50)-(52) successfully account for the rhythmic variations.