Doctoral Dissertation

Optimality Theoretic Accounts of Child Word Truncation

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Optimality Theoretic Accounts of Child Word Truncation

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Abbreviation Keys

A	Approximant
C	Consonant
F	Foot
L	Liquid
N	Nasal
Ob	Obstruent
OT	Optimality Theory
Ś	Primarily stressed syllable
S	Stressed syllable
S_{ON}	Sonorant consonant
SSG	Sonority Sequencing Generalization
TSC	Truncation of syllable conflation
TSO	Truncation of syllable omission
V	Vowel
W	Unstressed syllable
µ	Mora
σ	Syllable
ω	Prosodic word

List of Constraints

ABSTRACT

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The present study explores children's word truncation from the perspective of Optimality Theory (Prince and Smolensky, 1993; McCarthy and Prince, 1994a), focusing on 'truncation of syllable conflation' (TSC) found in the child production of [bænə] for the target *banána* and [bun] for *ballóon*. Previous studies on early word truncation have revolved around 'truncation of syllable omission' (TSO). TSC has been regarded as a deviation from TSO and rarely discussed. It has long been observed both stressed and word-final syllables of the target are highly likely to be retained while non-final, unstressed syllables are prone to omission (e.g. *tomato* → [meto]). This observation does not hold true for TSC, where part of the word-initial unstressed syllable is produced (e.g. /b/ in *banána* →[bænə]) while part of the stressed syllables is deleted (e.g. /n/ in *banána* →[bænə]).

This study shows that TSC is a frequent phenomenon of child word productions. Of a total of 117 truncated productions by four children in Pater (1997), TSC accounts for 27%, while 62% amounts to TSO. Syllable conflation in fact occurs frequently in infants' word truncation: [poːkio] for *Pinocchio* (Allen and Hawkins, 1978); [baːnə] for *banana* and [bɔŋ]

for *belong* (Smith, 1973); [peto] for *potato* (Kehoe and Stoel-Gammon, 1997b). TSC is significant in prosodic development since it can serve as evidence to back up the claim that children have some knowledge of the correct adult forms and they are aware of syllable structure from a very early age.

We observe that specific target words are subject to TSC: target words that are truncated through syllable conflation contain an intervocalic liquid (e.g. *delicious* → [dɪʃəs], *garage* → [gaːʤ]), nasal (e.g. *banana* → [bænə]) or coronal stop /t/ (e.g. potato → [pedo]). We also show that some targets words like *banana* take different shapes of truncation according to children: some children produce [bænə] as TSC and others [nænə] as TSO. The major objective of the present study is to provide principled accounts of such variation as well as explanation of TSC. This is attained by an approach based on Optimality Theory (OT).

In order to construct an OT model of child phonology, assumptions are made: child grammars consist of the same universal constraints as adult phonology; the constraint hierarchy differs from child to child and across ages; the adult target word is the input form of child word. Under these assumptions, the issue of interpersonal variation in truncation is explained by different ranking of the same set of constraints. Developmental variation is also captured by the changing ranking of constraints over time.

Under the framework of OT, we account for the production of a trochaic foot, for which structural constraints PARSE-σ, FTBIN and ALIGNLEFT are employed, and the preservation of both stressed and word-final unstressed syllables (e.g. [méto] for *tomáto,* [ɛ́fɛnt] for *élephant*), for which we employ faithfulness constraints STRESS-FAITH and ANCHOR-RIGHTI-O. TSC is explicated by constraints on syllable onsets that militate against liquid and nasal onsets. Moreover, both TSC and TSO are explained in principled ways by the interaction of the same set of constraints on the output forms.

Chapter 1

Preliminaries

1.1 Introduction

Children produce their first words around the end of the first year of life, mostly between 10 and 15 months (Radford *et al*., 1999: 106). Children's early words are different from those of adults in the sense that they are much simpler in syllable structure; composed of a narrower range of sounds; and semantically used more narrowly or in context-bound ways (Hoff, 2007: 176).[1] Children's words or child words are defined as sound production by children when they try to use sounds meaningfully in contrast to babbling which has no obvious link to words in the adult language (Goodluck *et al*., 1991: 18). Child word productions should be phonemically related to adult words and consistently used to refer to specific contexts or objects (Owens, 2005: 310).

Children's speech development is traditionally divided into four periods as presented in Ingram (1989: 2) although there is much variation among individuals:

1. prelinguistic development – birth to end of first year
2. single-word utterances – from around 1 year to 1.5 years of age
3. the first word combination – from around 1.5 to 2 years of age
4. simple and complex sentences – the third year of life.

The first period from birth to 1 year features pre-linguistic development. Children's sound production in this period is characteristic of babbling. The period from the end of the first year

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[1] A 12-month old infant named Adam used the word 'duck' to refer to a toy duck he plays with when bathing, but he did not say 'duck' to indicate the toy duck in other contexts or real ducks. However, he extended the use of the word to indicate other ducks 2 weeks later (Hoff, 2007: 176).

to 18 months is classified as the second period characterized by one-word utterances. At 18 months, children produce about 50 words and their word productions explode until 24 months. This is the third period. In the fourth period from 24 to 36 months, children produce both simple and complex sentence-level utterances.

Children's words at 18 months and older tend to systematically differ from adult language. They undergo not only segmental change like fronting of velars (e.g. *duck* [gʌk]), stopping (e.g. *see* [tiː]) and gliding (e.g. *red* [wed]), but also prosodic change like syllable deletion or truncation (e.g. *potato* [tero]), syllable epenthesis (e.g. *blue* [bəlu]) and cluster reduction (e.g. *spoon* [bun], *play* [be]). Truncation of multisyllabic words, one of the major characteristics of children's early words, is of particular interest to us. In this dissertation, we will explore word truncation by children aged roughly between 18 months and 3 years, who belong to the third and the fourth periods identified in Ingram (1989).

Children's prosodic structures did not draw attention from researchers until recently. Early studies on child phonology focused on segments (or speech sounds) that children produce. They presented lists of acquired segments and sound substitutions at a given time and the order of acquisition of segments (cf. Edwards and Shriberg (1983: 125-152)). Since the early 1970s, there have been works on language acquisition based on phonological rules (Smith, 1973; Ingram, 1974). They tried to capture children's early words by means of phonological rules and processes. For example, in order to account for cluster reduction like /s/-reduction (e.g. [bun] for *spoon*) and liquid reduction (e.g. [beː] for *play*), Ingram (1974) and Smith (1973)[2] proposed a rule that deletes /s/ before a consonant and a rule that deletes a post-consonantal sonorant. In the discussion of weak syllable deletion, Ingram claimed that unstressed syllables in the word-initial

[2] In the study of his son Amahl (aged 2-4), Smith (1973) analyzed his phonology in two different ways: the first analysis saw the child's phonology as derivation from the adult forms through realization rules, and the second analysis as an independent system. Of the two analyses, he concluded that the first analysis is better to account for Amahl's phonological data.

position or in three-syllable words are more likely to be deleted in children's production.[3] Those accounts, however, are nothing but descriptive, far from being explanatory.

As recent studies on child phonology have shifted focus to prosodic structures as well as segmental development (Kehoe, 2001), much attention has been paid to acquisition of prosodic structures[4] and to prosodic patterns like syllable truncation. Among research works on word truncation are the trochaic template account (Gerken, 1994, 1996; Fikkert, 1994), the prosodic structure account (Demuth and Fee, 1995; Demuth, 1996b, 1996c) and the perceptual prominence account (Echols and Newport, 1992; Echols, 1993; Snow, 1998). In contrast to rule-based approaches, they attempt to elucidate why certain syllables are more likely to be omitted beyond the descriptive statement.

Although they differ in whether the focus is on children's outputs or on the prosodic characteristics of the target word, they share the view that child word truncation occurs on a basis of syllable: i.e. relatively weak syllables like word-initial unstressed syllables tend to be omitted, whereas stressed or word-final unstressed syllables are more likely to be produced. For example, *banana* is normally truncated into 'nana' although there is considerable variability in the production of vowels as seen in [nɛːnʌ], [nænæ], [nænə], [nænʌ], and [nɑnʌ] (Pater, 1997; Kehoe, 1999/2000).

Note, however, that there are a number of truncations like [bænə] for *banana*.[5] In this case, the initial unstressed syllable is not completely deleted. Rather, the onset consonant /b/ of the unstressed syllable is produced. Looking at the output [bænə], we find out that first two

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[3] Edwards and Shriberg (1983: 159-163).

[4] Syllable (Ingram, 1978; Fikkert, 1994; Salidis and Johnson, 1997; Kehoe and Stoel-Gammon, 2001), feet and prosodic words (Demuth, 1996 a-c, 2003, 2006); and relations with suprasegmental elements like stress, intonation and rhythm (Jusczyk, Cutler and Redanz, 1993; Snow, 2006; DePaolis *et al*., 2008).

[5] There is also variability of vowels in the *bana*-type productions: [bænə] by Julia (Pater, 1997), [baːnə] by Amahl (Smith, 1973), [bɑni] by 27m6 and [bænʌ] by 28m3 in Kehoe (1999/2000).

syllables of the target *banana* are conflated into a syllable. Specifically, the onset of the first syllable (/b/) and the rhyme of the second syllable (/æ/) of *banana* are combined into a syllable of the output. We call such case 'syllable conflation.' It is also found in truncation of SWW targets such as *fávorite* → [fɛvət] and ŚWS targets like *búffalò* →[bəfo] (Pater, 1997). The two rightmost syllables are conflated: the onset of the word-medial syllable (/v/ in *favorite*; /f/ in *buffalo*) and the rhyme of the word-final syllable (/ət/ in *favorite*; /o/ in *buffalo*) are combined to constitute a syllable (/vət/; /fo/). The illustration of syllable conflation is offered in (1), where two syllables involved in conflation and the resultant syllable are represented in parentheses.

(1) Syllable conflation

	Target word		Truncated form
banana	(bə)(nǽ)nə	→	(bæ) nə
favorite	fé(və)(rət)		fɛ(vət)
buffalo	bə́(fə)(lò)		bə(fo)

Syllable conflation is found for various target words in word productions of a number of children: e.g. *delícious* → [dɪʃəs] (Pater. 1997), *ballóon* → [bun] and *potáto* → [pedo] (Pater. 1997; Kehoe and Stoel-Gammon, 1997b); *Pinócchio* → [po ː kio] (Allen and Hawkins, 1978); *belóng* → [bɔŋ] (Smith, 1973; Pater. 1997); and *bróccoli* → [bʌkgi] (Lewis, Antone and Johnson, 1999).

Truncation of syllable conflation has rarely been dealt with in previous studies including the three approaches mentioned above. Generally, they have identified truncation with syllable deletion and considered syllable conflation a deviation from the normal pattern of syllable deletion. In addition, no one has provided systematic accounts of inter-personal variations in truncation. As we noted, for the same target *banana*, some children pronounce as 'nana' and others as ‘bana.’ We will show that such variation among children is not explained by any of the above-mentioned approaches.

This study will deal with child word truncation focusing on truncation of syllable conflation. The data to be discussed include contributions from Echols and Newport (1992), Gerken (1994, 1996), Fikkert (1994), Pater (1997), Kehoe and Stoel-Gammon (1997a, 1997b) and Kehoe (1999/2000). In particular, I will analyze the data extracted from Pater (1997) as an empirical basis for exploration of syllable conflation.

1.2 Purpose of the study

One of the major goals of this study is to shed new light on syllable conflation. Although child word truncation largely involves the omission of a whole unstressed syllable, as seen in *tomáto* [meto], there are also truncations of syllable conflation like *banána* [bænə], *delícious* [dɪʃəs] and *fávorite* [fɛvət]. In fact, syllable conflation is found in a substantial number of child word productions in English. Despite its high frequency, syllable conflation has been disregarded as a minor, deviant phenomenon. More interestingly, when two syllables are conflated, the onset of the first syllable and the rhyme of the second syllable make up a syllable as illustrated in (1). It may imply that children have knowledge about syllable structure: that is, they might be aware that a syllable consists of the onset and the rhyme.

Secondly, the present study aims to explore children’s truncation patterns, especially focusing on the content of truncation (which part of the target word is actually produced by children) and the manner of truncation (whether it is by the omission of a syllable or by the conflation of two syllables into one). From previous findings, we will search for possible factors contributing to child word truncation. Specifically, we will examine whether truncation rates are different depending on the metrical structure of the targets and whether any segmental features affect truncation. The former is hinted from the different truncation frequency between *potáto* and *kàngaróo* (Kehoe and Stoel-Gammon, 1997a). The latter is raised from the observation that words with intervocalic sonorants are more likely to be truncated than those with intervocalic obstruents. For example, *elephant* and *telephone* are more frequently truncated than *octopus* and *crocodile* (Kehoe and Stoel-Gammon, 1997a). In addition, when WS and WSW targets are truncated, those with intervocalic sonorants /r, l, n/ tend to be truncated by syllable conflation rather than the omission of the initial unstressed syllable, as seen in *balloon* [bun] and *banana* [bænə].

The third objective is to review previous accounts of children's word production: the trochaic template account (Gerken, 1994; Fikkert, 1994), the prosodic structure account (Demuth and Fee, 1995; Demuth, 1996b, 1996c) and the perceptual salience account (Echols and Newport, 1992; Snow, 1998). The review of the literature will cover not only factors that may influence truncation but also faults and missing points in the previous research of child word truncation. In particular, we will see that these approaches cannot account for syllable conflation, as hinted from their prediction that *banána* will be reduced to 'nána'. Moreover, they pay little attention to variation in truncation among children (e.g. [nænə] vs. [bænə] for *banana*).

In this light, the last but most important goal of the present study is to give an account of syllable conflation as well as an account of interpersonal variation in truncation. In the data analysis of truncated forms collected from Pater (1997), we find that words containing intervocalic /r, l, n/ tend to experience syllable conflation and that the sonorants are absent from children's truncated forms. Based on this observation, I will suggest two different approaches to syllable conflation: one draws on children's perceptual limitation; the other turns to constraints on production. The first approach will assume that children cannot distinguish highly sonorous consonants /r, l, n/ from vowels, nor can they perceive them as syllable onsets. Under the assumption, *delicious*, for example, is perceived as two syllables with the onsets /d/ and /ʃ/, rather than being perceived as three syllables with the onsets /d/, /l/ and /ʃ/. As a result, a child word for *delicious* would become [dɪʃəs]. I will go into detail about this approach in Chapter 4.

The second approach is based on Optimality Theory (Prince and Smolensky, 1993). Since the advent of Optimality Theory (henceforth, OT), there have been numerous constraint-based accounts of child word productions (Gnanadesikan, 1995; Demuth, 1995, 1997a, 1997b; Pater, 1997; Kehoe, 1999/2000; Ota, 2006). Their central notions are that children's word production is governed by universal (but violable) constraints and that these constraints differ from child to child and from age to age. The OT-based approach will be able to explain syllable conflation in *delicious* [dɪʃəs], for example, by employing a constraint *L-ONS that militates against liquid onsets. It restrains /l/ from appearing in the child production, resulting in [dɪʃəs] rather than [lɪʃəs] or [dəlɪʃəs].[6] We can also capture inter-speaker and intra-speaker variation in word production. For example, the variation between [bænə] and [nænə] is accounted for by different rankings of the same set of constraints depending on speakers. Let us consider the smallest set of constraints, {*N-ONS, I-CONTIG-σ}.[7] The candidate [nænə] violates *N-ONS twice since it has two syllables starting with a nasal. The other candidate [bænə] has one violation mark with respect to *N-ONS due to the nasal onset of the second syllable and one violation mark with respect to I-CONTIG-σ since /b/ and /æ/ are not contiguous to each other in the target word. If *N-ONS is ranked higher than I-CONTIG-σ, which means the violation of the former constraint is more fatal than that of the latter, then we will yield [bænə] as illustrated in (2).[8]

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[6] To single out [dɪʃəs] by ruling out [lɪʃəs], [dəlɪʃəs] and other candidates, we also need other constraints and their hierarchical relationship, which will be discussed fully in Chapter 5.

[7] *N-ONS is a constraint that disapproves of a nasal onset and I-CONTIG-σ is a constraint that requires the segments within a given syllable of the output should be taken from a contiguous string within the input.

[8] In the tableau of OT, '*' marks the violation of a constraint and the most serious violation is marked by '!'. The optimal output with respect to the given constraints is denoted by '☞.'

(2) *N-ONS >> I-CONTIG-σ

banana / bənǽnə /	*N-ONS	I-CONTIG-σ
a. [nænə]	**!	
b. ☞ [bænə]	*	*

On the other hand, the reversed ranking will yield [nænə] as illustrated in (3).

(3) I-CONTIG >> *N-ONS

banana / bənǽnə /	I-CONTIG-σ	*N-ONS
a. ☞ [nænə]		**
b. [bænə]	*!	*

In other words, a child who produces [bænə] has the ranking of (2) in his grammar at the time of speech, and a child who produces [nænə] has the ranking of (3) in his grammar.

1.3 Organization of the dissertation

Throughout the dissertation, I will use the term 'children' to refer to those who are in the third through fourth period of speech development identified by Ingram (1989): i.e. those aged roughly between 18 months and three years old. Child age is given as years;months.days (e.g. 2;3.25 for 'two years, three months and 25 days'). The term 'target' or 'target word' will be used for an adult word that a child intends to produce. 'Child word' and 'child word production' all refer to real production for a target word by children.

Target words will be represented in italics and their phonetic transcription will be given in broad transcription if necessary, while children's word production will be represented in narrow transcription using square brackets.[9] By *balloon* [bun], for example, we mean that [bun] is a child word production for the target word *balloon*. In particular, the term 'truncation' is defined as the reduction in the number of syllable of a word, and 'child word truncation' refers to truncation conducted by children. When marking word stress, instead of the International Phonetic Alphabet (IPA) convention,[10] we will represent primary stress with an acute accent '´' and secondary stress with a grave accent '`' being placed above the stressed vowel.[11] It is applied regardless of whether words are orthographic or transcribed forms (e.g. télephòne or /tέləfòn/). For simplicity's sake, a consonant will be denoted by 'C' and a vowel by 'V'; a stressed syllable is denoted by 'S' (or σ_S) and an unstressed syllable by 'W' (or σ_W). When there is more than one stressed syllable, the primarily stressed syllable will be denoted by 'Ś.'

The dissertation is comprised of six chapters.

In the latter part of Chapter 1, I give a brief description of prosodic units such as the mora, the syllable, the foot and the prosodic word and their hierarchical structures since they are needed in subsequent discussions.

Chapter 2 discusses patterns of child word truncation and reviews previous studies on child word truncation including the trochaic template account; the prosodic structure account and the perceptual salience account. The review reveals their limitations in accounting for prosodic patterns of early words, and unaddressed issues are raised such as syllable conflation

[9] The present study employs child truncations from several works as the data in order to explain truncation patterns. When representing child productions by the phonetic transcription, we stick to the original phonetic representation of the sources. As a result, the transcription system may be inconsistent: some words are transcribed in a phonemic sense (e.g. [bun]) and others in an allophonic sense using diacritics (e.g. [b^{w}un]).

[10] When stress is transcribed in the International Phonetic Alphabet (IPA) convention, primary stress is denoted by the superscript '□' and secondary stress by the subscript '□' before the stressed syllable: e.g. [□tɛlə□fon].

[11] Trager and Smith (1951) introduced four levels of stress in English, marked as '´', '^', '`', and '˘' to indicate decreasing order of prominence (Katamba, 1989:222) and Chomsky and Halle (1968) used the integers 1 – 4 to mark stress with 1 as the strongest and 4 the weakest stress. I will follow the notion that the most heavily stressed syllable receives the 'primary' stress and other stressed syllables receive 'secondary' stress (Giegerich, 1992).

and variation in truncation among children.

In Chapter 3, a particular focus is directed to truncation of syllable conflation. Based primarily on the data of word truncation from Pater (1997), we compute the proportion of syllable conflation and examine the target words that are subject to syllable conflation in an effort to find out common features among them. The results of data analysis will demonstrate that sonorous consonants are less frequently produced and targets containing them are subject to syllable conflation.

Chapter 4 explores the relation between sonority and children's perception of syllables in a word. First, we will show acoustic similarity between a sonorant[12] and a vowel and then discuss sonority theory. It is assumed that children may not distinguish an intervocalic sonorant and neighboring vowels. Under the assumption, we suggest that children are more likely to truncate words with an intervocalic sonorant since they may not perceive a syllable starting with a sonorant. This suggestion will prove successful in providing a partial explanation of syllable conflation but ineffective in accounting for truncation in general.

Chapter 5 is dedicated to an OT-based approach to child word truncation. It shows how the interaction of constraints in OT grammar explains children's prosodic patterns including the production of a foot and the preservation of the stressed syllable and the word-final syllable. Syllable conflation is also addressed via the different rankings between conflicting constraints as briefly illustrated in (2) and (3). Variations in truncation among children like [nænə] vs. [bænə] for *banana* and across ages like [pedo] vs. [teto] for *potato*[13] are explained by the different rankings of the same set of constraints.

In Chapter 6, we give a summary of the major findings of the present study and discuss

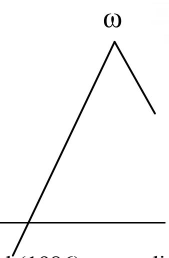
[12] I will use the term 'sonorant' to refer to sonorous consonants throughout the dissertation in order to avoid confusion with a distinctive feature [sonorant].
[13] Julia (Pater, 1997) produced [pedo] aged 2;1.25-2;1.20 and [teto] at 2;5.15.

some implications and limitations. This research argues that children are aware of prosodic well-formedness and that early word truncation is not attributable to lack of their perceptual capacity but to constraints on their word production.

1.4 Introduction of the prosodic constituents

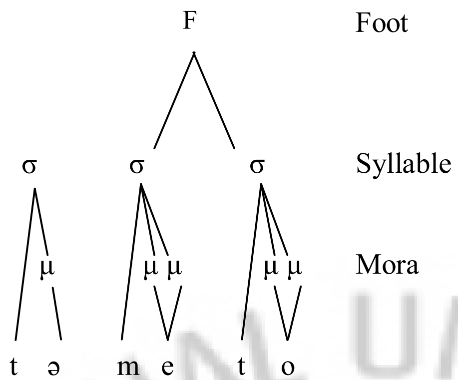
This section introduces prosodic constituents such as the syllable, the mora, the foot, the prosodic word and their hierarchical arrangements called *prosodic hierarchy* (Nespor and Vogel, 1986; McCarthy and Prince, 1986, 1994b).[14] We rely on prosodic constituents and the prosodic hierarchy for the discussion about children's prosodic patterns. The hierarchical arrangement of the word *tomato*, for example, is represented in Figure (4). The lowest unit, mora denoted by μ, is a subsyllabic constituent concerned with syllable weight. The syllable denoted by σ is the immediate superordinate unit of the mora and the subordinate unit of the foot. A syllable that is not footed is directly attached to the prosodic word along with the foot. We will briefly discuss each of the prosodic constituent and its acquisition by children.

(4) Prosodic Hierarchy at the word level



Prosodic word

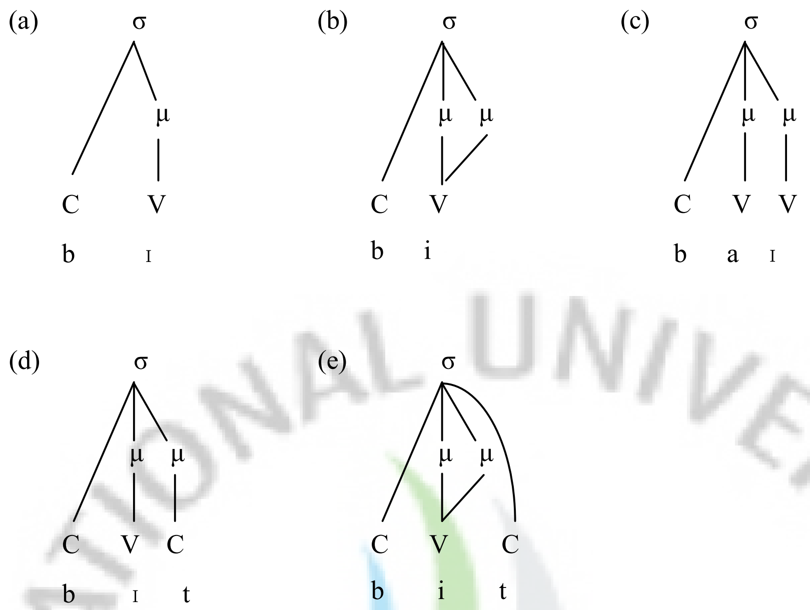
[14] In Nespor and Vogel (1986), prosodic hierarchy is comprised of, from large to small, the phonological utterance, the intonational phrase, the phonological phrase, the clitic group, the phonological word, the foot and the syllable. However, we will deal with the hierarchy at and below the word level composed of the mora, the syllable, the foot and the prosodic word, where the more is the lowest constituent as proposed in McCarthy and Prince (1994).



First, the lowest mora is a unit of syllable weight. A syllable with two moras is a heavy syllable, for which we write $\sigma_{\mu\mu}$, and a syllable that has one mora is a light syllable, which will be represented as σ_{μ}. Languages differ in which segments are regarded as moraic. In English, tense vowels and diphthongs are assigned two moras, while lax vowels are allotted one mora. Concerning consonants, prevocalic consonants are irrelevant to the mora; only the first consonant after a lax vowel is moraic, while the next consonant or any consonant after a tense vowel is non-moraic.

The figures in (5) illustrate the moraic representation of different syllables in English. Since syllable-initial consonants are irrelevant to the mora, they are directly adjoined to the syllable node denoted by σ. The syllable /bɪ/ in (5a) has one mora so it is a light syllable. The tense vowel in *bee* /bi/ of (5b) has two moras, thus it is heavy. Likewise, *buy* /baɪ/ in (5c) containing a diphthong /aɪ/ is a heavy syllable. In *bit* /bɪt/ of (5d), the lax vowel /ɪ/ and the final consonant /t/ make it bimoraic. Finally, *beat* [bit] in (5e) is also heavy since it contains a tense vowel /i/. Its final consonant /t/ is not counted as a mora as directly associated with the syllable node.

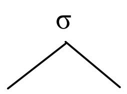
(5) Moraic representation of different English syllable types

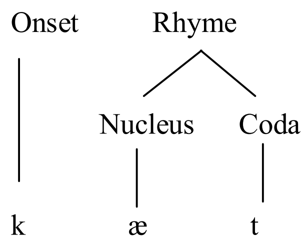


The acquisition of mora has been discussed in light of the vowel distinction. Demuth (1996b) and Fikkert (1994) proposed that children initially produce one monomoraic syllable (σ_{μ}) or two monomoraic syllables ($\sigma_{\mu}\sigma_{\mu}$) in their early words before they acquire bimoraic syllables ($\sigma_{\mu\mu}$). That is why vowel length errors occur in early production. Conversely, Salidis and Johnson (1997) and Kehoe and Stoel-Gammon (2001) argued that children could control vowel length from the beginning of production. That is, the distinction between monomoraic and bimoraic syllables is acquired early.

The immediate superordinate of the mora is the syllable. In addition to the moraic representation like (5), the syllable can be represented by the *onset* and the *rhyme* as illustrated in a tree diagram of (6), which shows the hierarchical syllable structure of *cat* /kæt/.

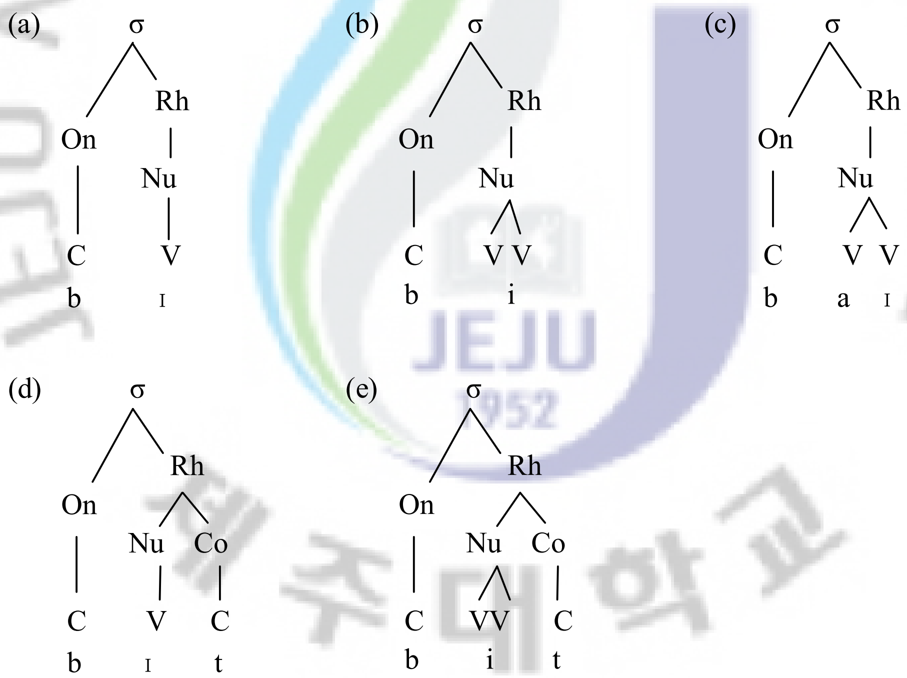
(6) Representation of the syllable





The prevocalic consonant /k/ is the *onset* and the vowel /æ/ is the *nucleus* or the *peak* and the postvocalic consonant /t/ are the *coda*. The nucleus and the coda form the *rhyme*. The English syllable types discussed in (5) can be represented by means of the onset-rhyme constituency as in (7).

(7) Onset-rhyme representation of English syllable types



A tense vowel in (7b) and a diphthong in (7c) are represented with two Vs to mark two timing positions. Heavy syllables are characterized by the branching node: the branching nucleus in

(7b) and (7c) and the branching rhyme in (7d) and (7e). The onset-rhyme representation will prove more instrumental in describing child truncated productions.

Studies on phonological acquisition show that the most common syllable type of child early words is CV[15] and that the structural complexity of the syllable is gradually built up (Ingram, 1978; Watson and Skucanec, 1997; McLeod, van Doorn and Reed, 2001a, 2001b). Children employ several strategies to conform to a CV pattern: deleting elements from consonant clusters (e.g. *play* [be]) or epenthesizing a vowel between clusters (e.g. *blue* [bəlu]), deleting the final consonant (e.g. *bib* [bi]). Such strategies may evidence that children are aware of syllable structure from a very early age although they are less aware of the existence of segment-sized units (Spencer, 2005: 38). There are other phonological processes in prosodic acquisition that resort to the syllable structure as illustrated in (8).

(8) Phonological processes with reference to syllable structure

Process	Example	Source
Final consonant deletion	*dog* [gɑ], *fish* [bɪ]	Edwards and Shriberg (1983)
Final devoicing	*bed* [bet], egg [ek]	Ingram (1978)
Prevocalic voicing	*paper* [beːbə]	Smith (1973)
Syllable deletion	*banana* [nænə]	Kehoe (1999/2000)
Reduplication	*pudding* [pupu], *water* [wɑwɑ]	Edwards and Shriberg (1983)

As early as one year of age, children tend to delete final consonants (*dog* [gɑ]) but initial consonant deletion is unusual.[16] They also tend to devoice stop sounds in final position (e.g.

[15] It is consistent with the fact that CV is the most common type of syllable in languages of the world: all languages have the syllable type CV (Clements and Keyser, 1983: 28).

[16] There are a few exceptional cases like *gun* [ʌn] and *shoe* [u] (Edwards and Shriberg, 1983: 328).

bed [bet], *egg* [ek]) but voice before vowels (e.g. *paper* [beːbə]). They very often resort to the whole syllable for the omission of unstressed word initial syllables (e.g. *banana* [nænə]) and reduplication (e.g. *biscuit* [bebe], *barrow* [wæwæ]). On top of (8), we show that children adhere to the well-formedness of syllable structure when producing truncated words, which bolsters children's early acquisition of syllable structure.

The foot is a prosodic constituent above the syllable and below the prosodic word. Feet are important in explaining stressed representation in a word.[17] Generally, feet must be binary either at the moraic or syllabic level, which is the one known as *foot binarity* (McCarthy and Prince, 1994b). Feet that have the stressed syllable on the left are labeled *trochaic* and those feet having the stressed syllable on the right are *iambic*. Based on the typological findings in Hayes (1981) and the assumption of foot binarity, quantity homology and trochaic default,[18] McCarthy and Prince (1993, 1996) proposed the foot inventory: syllabic trochee, moraic trochee and iamb.

(9) Foot types (McCarthy and Prince, 1993: 46)

Iamb	Moraic trochee	Syllabic trochee
$\sigma_\mu\sigma_{\mu\mu}$ $[\mu\mu] = \sigma_{\mu\mu}, \sigma_\mu\sigma_\mu$	$[\mu\mu] = \sigma_{\mu\mu}, \sigma_\mu\sigma_\mu$	$\sigma\sigma$

In languages that do not recognize distinctions of quantity, a foot consists of two syllables [σσ] by foot binarity and it is interpreted to be trochaic by trochaic default (McCarthy and Prince,

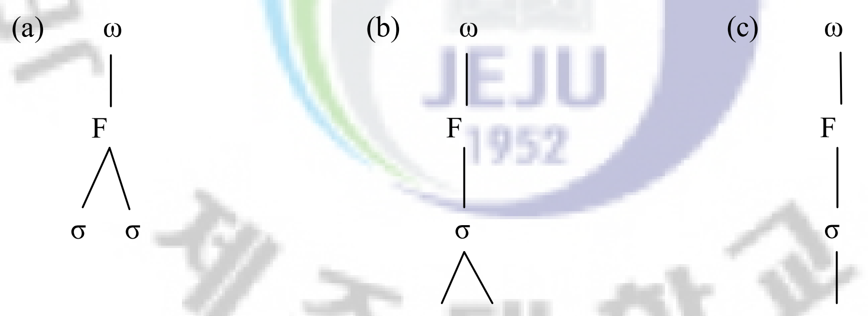
[17] Although stress is realized with the involvement of loudness, duration, pitch variation and vowel quality, it is not a feature manifested with such phonetic parameters, but it is given by the foot structure (Gussenhoven and Jacobs, 2005: 186).

[18] Quantity homology states that for two elements a, b of a foot, if a >b quantitatively then a>b stresswise; *trochaic default* means that if two elements in a foot are equal in quantity, they are assumed to form a SW foot. That is, $\sigma_\mu\sigma_\mu$ is considered as a trochee. Meanwhile, in languages which do not recognize distinction of quantity (i.e. quantity-insensitive), trochaic default is applied (McCarthy and Prince, 1996: 7).

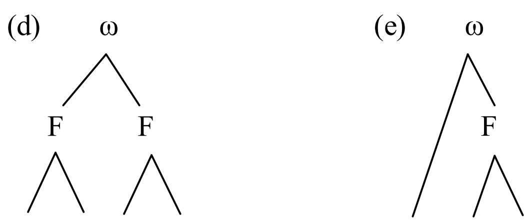
1996: 8). According to Hayes (1981), in quantity-sensitive systems where stress is concerned with syllable weight, heavy syllables are always foot-final; therefore the foot must be iambic $\sigma_{\mu}\sigma_{\mu\mu}$. Both [$\sigma_{\mu}\sigma_{\mu}$] and [$\sigma_{\mu\mu}$] are symmetric at the syllabic level and at the moraic level, respectively. Thus, they are assumed to be trochaic by trochaic default: both are denoted by [μμ]. However, [μμ] is also labeled an iamb to describe languages that use both [$\sigma_{\mu}\sigma_{\mu\mu}$] and [μμ] since a language may require all feet have the same labeling (McCarthy and Prince, 1996). Consequently we obtain the foot inventory given in (9).

Finally, we will deal with the prosodic word. Feet are organized into prosodic words, denoted by ω. The smallest prosodic word is called the *minimal word*, which contains either two moras or two syllables due to the foot binarity. (10a) and (10b) represent minimal words, whereas (10c) is regarded as marked and disfavored. In English, a monomoraic form like (10c) is not recognized as a well-formed prosodic word.

(10) Typology of prosodic words (Demuth, 2006: 131)



disyllabic foot (e.g. *kitty*) bimoraic foot (e.g. *dog*) monomoraic



σ σ σ σ σ σ σ

two feet (e.g. *alligator*) containing an unfooted syllable (e.g. *banana*)

Prosodic words larger than a minimal word include (10d) consisting of two feet and (10e) composed of a foot plus an unfooted syllable. Unfooted syllables are immediately dominated by the prosodic word as in (10e). As productions of Kyle in Salidis and Johnson (1997) shows, those supraminimal prosodic words rarely appear in early word production.

In child phonology minimal words are regarded as an important prosodic structure. Children's early word productions are reported to undergo a stage where words are minimally and maximally a binary foot (Demuth and Fee, 1995; Demuth, 1995; Demuth, 1996a; Salidis and Johnson, 1997). For example, Kyle (Salidis and Johnson, 1997) predominantly produced binary feet between 11 and 16 months. Productions in binary feet account for 60-70% of his words during the period, beginning to decline after 16 months. Examples of his words are given in (11).

(11) Productions by Kyle (Salidis and Johnson, 1997)

	target	output	Age	target	output	age
Production of core syllable	*bread*	[bɛ]	11	*belt*	[bə]	13
	hair	[hɛ]	11	*mirror*	[mə]	15
	fish	[fɪ]	12	*carry*	[kə]	17
Production of a binary foot	*block*	[gak]	11	*dog*	[dæk]	14
	hat	[hæt]	11	*truck*	[tʌk]	15
	cup	[kʌp]	11	*shapes*	[sɛps]	16
	picture	[pəʃɛ]	12	*giant*	[gi]	18
	coop	[kup]	13	*green*	[gri]	18

In sum, early child words feature the production of a minimal word[19] and the simpler subminimal form CV appears just briefly in the very early stage of language development in English (Kehoe and Stoel-Gammon, 2001) and Dutch (Fikkert, 1994). The present study will show that early English words are characteristic of the trochaic production through word truncation.

[19] Note that there is cross-linguistic evidence that the forms and structures in children's early word productions may be affected by the prosodic structure of the ambient language (Vihman *et al*., 1998; Demuth *et al*., 2006). Both English-learning infants and French-learning infants aged 13-20 months in Vihman *et al.* do not exclusively show trochaic productions. Among American infants trochees and iambs are similar in frequency, which can be traceable to production patterns of adults around them.

Chapter 2

Patterns of Child Word Truncation

2.1 Introduction

It has been observed that young children truncate multisyllabic words in their word productions. The truncation does occur in systematic ways. Most often, children delete unstressed syllables, but in some cases they delete stressed syllables as well or their productions contain content from two syllables of the target. This chapter aims to investigate patterns of children's truncation for multisyllabic targets. In section 2.2 we explore patterns of child word truncation in general and draw some generalization. For this end, we review previous works on early word truncation. Most of the findings are from English data (Echols and Newport, 1992; Pater, 1997; Kehoe and Stoel-Gammon, 1997a, 1997b; Lewis, Antone and Johnson, 1999 etc.), and some are with reference to Dutch words (Fikkert, 1994, 1995). Section 2.3 also reviews studies in which patterns of word truncation are explained. The goal of this review is to propose research questions that are overlooked in previous studies and provide the groundwork for the present study.

2.2 Review of literature on truncation patterns

Studies on child word truncation have largely revolved around the content of truncation. The content of truncation indicates which syllable of the adult target appears on the child production and which syllable is omitted. Researchers have noted that stressed syllables are more likely to be produced than unstressed syllables and non-final unstressed syllables are more vulnerable to deletion than word-final unstressed syllables (Ingram, 1978; Allen and Hawkins, 1978; Echols and Newport, 1992; Gerken, 1994; Kehoe, 2001; Schwartz and Goffman, 1995). However, there are many truncated words that are ambiguous in content. For example, [bǽnʌ] for *banana*, it is difficult to say whether it is the initial syllable or the medial syllable that is omitted.

In order to clarify the notion of word truncation, we give a concrete definition of word truncation, syllable omission and syllable conflation. In the present study, 'word truncation' or simply 'truncation' is defined as the reduction in the number of syllables in a child output compared with the target word. Both [nǽnʌ] and [bǽnʌ] for *banana* are classified as truncation since they are two syllables reduced from their three-syllable target. Reductions at the segmental level that do not incur a reduction in the number of syllables are not regarded as truncation. For example, the production [kάgɪdάʊ] for *crocodile* is not a truncated form since it preserves three syllables although it undergoes the reduction of consonant cluster and the segmental changes. What is important is whether the number of syllables in a target is retained or reduced. Examples of truncation and non-truncation are given in (1).

(1) Examples of truncation and non-truncation

	Target word	Child's production
Truncation	banana elephant animal	[nǽnʌ], [bǽnʌ] [έlbɪnt], [ǽfə] [ǽml̩],[20] [ǽmʊs]
Non-truncation	kangaroo crocodile crocodile	[tɪ̀ŋgəwú] [kάgɪdάʊ] [άkɪdɑl]

[20] /l/ that serves as a peak in a syllable is called a syllabic consonant and is denoted by a subscript '□' like l̩.

Word truncation and 'syllable omission' (or syllable deletion) have been used indiscriminately. In this dissertation, however, syllable omission is distinguished from truncation. It refers literally to the omission of a syllable as a whole from the target word. For example, in the production [nænə] for the target *banana*, the word-initial syllable is deleted: this belongs to 'syllable omission.' It also belongs to truncation by definition. Note that the production [bænə] for the same target *banana* is not included in the category of syllable omission since its onset /b/ survives. We dubbed such production 'syllable conflation' in Chapter 1. It is surely a word truncation by definition. In sum, word truncation is a broader category encompassing both syllable omission and syllable conflation. Table (2) shows examples of truncation of syllable omission (henceforth, TSO) and truncation of syllable conflation (henceforth, TSC).

(2) Types of truncation

	Target word	Child's production
a. Syllable omission	*muséum* *médicine*	[ziːʌm] [mɛsɪn]
b. Syllable conflation	*delícious* *búffalò*	[dɪʃəs] [bʌfo]

In (2a), an unstressed syllable of the target is omitted: the word-initial unstressed syllable in *muséum* [ziːʌm] and the word-medial unstressed syllable in *médicine* [mɛsɪn]. TSC in (2b) occurs when two syllables of the target are conflated into one syllable. In *delícious* [dɪʃəs] and *buffalo* [bʌfo], the onset consonant of one syllable and the rhyme of the other syllable of the targets are combined to constitute a syllable of the child words: the onset of the initial syllable and the rhyme of the medial syllable in *delícious* [dɪʃəs] and the onset of the medial syllable and the rhyme of the final syllable in *buffalo* [bʌfo].

2.2.1 Truncation of disyllabic words

It has long been reported that WS word like *giraffe* is much more likely to be truncated than SW words like *tiger*. This tendency is found in Dutch as well as in English.

Fikkert (1994, 1995) showed that in Dutch, although SW words are occasionally truncated, their truncation is less frequent that the truncation of WS words.[21] Children in Fikkert's study (1994) displayed considerable differences in truncation rates and stress errors between disyllabic words with initial stress and with final stress. Table (3) shows that WS words are truncated more frequently than SW words.

(3) Percentages of truncated forms and stress errors in Dutch (Fikkert, 1995: 78-79)

	truncated forms		stress errors	
Child	SW	WS	SW	WS
Jarmo	5%	92%	3%	0%
Tom	5%	48%	5%	29%
Elke	4%	94%	3%	75%
Noortje	5%	57%	2%	42%
Leon	1%	29%	7%	12%
Robin	1%	41%	6%	51%
Tirza	7%	62%	10%	26%
Eva	9%	100%	6%	0%
Catootje	2%	11%	3%	33%
Eva2	0%	76%	17%	18%
Enzo	4%	23%	5%	11%
Leonie	0%	14%	12%	60%

Although there is variation in truncation rates among children (Jarmo, Elke, Eva and Eva2 almost always truncate WS targets, whereas Catootje and Leonie truncate merely over 10% of

[21] Fikkert's study is based on spontaneous longitudinal data from 12 children acquiring Dutch. The data collection was first conducted when the children were aged between 1;0 and 1;11 and continued until around 3 years old when they manage to acquire the most important aspects of prosodic structure.

their productions for WS targets), all of the 12 children show much higher truncation percentages for WS targets than SW targets. In terms of stress errors, disyllabic words in the form of WS show more errors (stress misplacement or level stress) than those of SW. The children except three children (Jarmo, Eva and Eva2) make fewer mistakes in pronouncing SW target words than WS targets.

Fikkert (1994, 1995) suggests that the different truncation patterns between SW and WS targets are due to children's natural preference for producing trochaic foot structure. According to the argument, SW targets conform to a trochaic foot in the first place, so they do not need to be truncated, whereas WS words are truncated into S in order to adhere to a trochee. For example, a disyllabic word with initial stress like *tiger* fits the template of itself, thus it is less likely to be truncated, as shown in (4a).

(4) a. F
S W
tiger

b. F
S (W)
/bɑlɔ́n/
omitted

By contrast, with respect to disyllabic words with final stress like a Dutch word *ballon* /bɑlɔ́n/, the initial syllable does not belong to the template, thus is deleted, as illustrated in (4b): the stressed syllable that fills the template is produced with the optional weak position of the template left empty. As a result, it is produced as [lɔn].

In terms of the content of truncation for disyllabic targets, children tend to preserve stressed syllables and word-final unstressed syllables, whereas word-initial unstressed syllables are likely to be omitted (Echols and Newport, 1992; Schwartz and Goffman, 1995). Echols and

Newport (1992) in their study of three children (aged 1;5-1;11) at the one-word stage demonstrated the high deletion rate of word-initial weak syllable. As shown in table (5), the deletion rate of the weak syllable from WS targets is 26% of the total of 29 words, whereas the proportion of deleted weak syllables for SW targets is 11% of the total 347 words. Stressed syllables are unlikely to be omitted regardless of the position in the word. The omission rate of stressed syllables is 1% for SW targets and 2% for WS targets. Echols and Newport (1992) attributed the difficulty producing word-initial unstressed syllables to the reduced perceptibility of those syllables.

(5) Proportion of syllables omitted for 2 Syllable targets by 18-23 month olds (Echols and Newport, 1992: 208)

Stress Level	Position	
	Initial	Final
Stressed	.01 (448)	.02 (128)
Unstressed	.26 (29)	.11 (347)

Note. The total number of syllables contributing to analysis is given in parentheses.

Schwartz and Goffman (1995) analyzed two-syllable experimental words produced by 20 children aged between 22 and 28 months, a larger group of older children than Echols and Newport (1992). Their analysis shows that unstressed syllables are much more likely to be omitted than stressed ones, particularly at the beginning of words. The mean proportion of omitted stressed syllables was 6% (range from 0 to 10%), whereas the proportion of omitted unstressed syllables was 17% (range from 0 to 45%). With respect to word position of unstressed syllables, initial unstressed syllables show the mean proportion of 25% (range from 0 to 67%), whereas for word-final unstressed syllables, the mean proportion was 5% (range from

6% to 20%). The result shows that the retention rate of final unstressed syllables is as high as that of stressed syllables.

As opposed to the intrinsic trochaic template proposed by Fikkert (1995), Schwartz and Goffman (1995) argued child word productions are sensitive to the frequency of prosodic patterns in their ambient language. That is, children learn to produce trochaic forms due to high frequency of SW or S forms in their ambient language.[22] There is an observation in favor of a learned preference for producing trochaic forms. Lewis, Antone and Johnson (1999) found in their longitudinal study of a child from 14-19 months of age that the child truncated SW targets more often than WS targets as illustrated in (6).

(6) Percentage of disyllabic targets reduced to one syllable by a child

Age (month)	SW (e.g., bottle)	WS (e.g., shampoo)
14	84[a] % (42[b])	100% (2)
15	85% (68)	75% (4)
16	83% (84)	80% (5)
17	70% (104)	60% (7)
18	42% (149)	20% (11)
19	35% (148)	10% (11)

Note. a. The number representing the percentage is an estimated value from the original percentage polygon from Lewis, Antone, and Johnson (1999: 50).
b. The total number of the target words for each month is given in parenthesis.

It seems that truncation occurs regardless of stress type, being less sensitive to stress and position. It should be noted that this child is younger than the children in Echols and Newport (1992) and Schwartz and Goffman (1995), who belong to the third period of speech development in Ingram (1989). Even though the production after the age of 19 months is not

[22] Several works argue for the learned preference for trochaic tendency. This will be discussed in the later part of the present section.

reported in Lewis, Antone and Johnson (1999), we can infer that truncation may be influenced by a learned preference for trochaic foot structure considering a higher probability of producing a trochaic form S(W) by older children.

2.2.2 Truncation of multisyllabic words

2.2.2.1 Truncation content

With respect to truncation of multisyllabic words with three syllables or more,[23] children tend to retain both stressed syllables and word-final syllables whereas non-final unstressed syllables are more likely to be omitted. Table (7) shows the strong effect of word-final position and prosodic stress on production. Notably, word-final stressed syllables are not omitted at all.

(7) Mean proportion of syllables omitted for targets of three or more syllables (Echols and Newport, 1992: 210)

Stress Level	Position		
	Initial	Medial	Final
Stressed	.16 (96)	.21 (82)	0 (84)
Unstressed	.44 (47)	.55 (112)	.10 (50)
Note. Numbers in parentheses are total number of syllables contributing to analysis.			

Kehoe and Stoel-Gammon (1997a, 1997b) showed not only the high retention rate of stressed syllables and word-final syllables the segmental effects on truncation. In the investigation of elicited productions of trisyllabic and quadrisyllabic targets (Kehoe and Stoel-

[23] In this section, truncation of multisyllabic words with more than four syllables is excluded from discussion. So refer to Kehoe and Stoel-Gammon (1997a) for truncation pattern and frequency of words of longer than four syllables.

Gammon, 1997a, 1997b),[24] they showed that most of the truncated forms consist of the stressed syllables and the word-final syllable of the target.

Table (8) depicts the productions of four-syllable targets. Of all productions, the forms of SSW$_2$ are predominant: they constitute 42% of all productions by 28-month olds and about 63% of all productions by 34-month-old children.

(8) Production patterns and percentage of quadri-syllabic words
(Kehoe and Stoel-Gammon, 1997a: 121)

Target	Age	Production patterns and proportion (%)			
		4-syl.	3-syl.	2-syl.	Others
ŚWSW	28 (69)	43	SSW$_2$ 43	S$_2$W$_2$[25] 12	2
	34 (69)	22	SSW$_2$ 68 SWS$_2$ 1	SS 8 S$_2$W$_2$ 1	
SWŚW	28 (66)	41	SSW$_2$ 41	S$_2$W$_2$ 6	22
	34 (63)	35	SSW$_2$ 57 SWS$_2$ 5	SS 1 S$_2$W$_2$ 2	

Note, however, that the production of S$_2$W$_2$, the rightmost trochaic foot, is much more frequent than the pair of two stressed syllables SS among two-syllable productions. This may imply that the alternation of strong and weak syllables is more selective or preferred than just a sequence of two strong syllables at least in disyllabic productions.[26] Another thing notable is that there is virtually no monosyllabic truncation in (8). It implies that children's truncation is minimally the right-most foot SW for SWSW targets.

[24] They elicited and collected word productions from three age groups (22, 28, 34 months old) for 3- and 4-syllable stimulus words, which are made up of 12 real trisyllabic words and 8 novel trisyllabic words. Real words are: *potato*, *tomato*, *banana* (WSW); *octopus*, *elephant*, *animal* (SWW); *crocodile*, *Tinkerbelle*, *telephone*, *dinosaur* (ŚWS); *kangaroo*, *chimpanzee* (SWŚ); *alligator*, *Helicopter* (ŚWSW); *avocado*, *Cinderella* (SWŚW). Novel words are intended to control the possible familiarity effects of target words (Kehoe and Stoel-Gammon, 1997a: 118).

[25] 'S$_2$' denotes the second stressed syllable and 'W$_2$' the second unstressed syllable of the target.

[26] The result is consistent with the result of Cutler and Norris (1988) that even adults detect SS worse than SW.

Productions of three-syllable targets by metrical pattern are illustrated in table (9). It also shows that both stressed and word-final syllables are more likely to be retained. WSW targets tend to be truncated into SW, SWW targets into SW_2 and SWS targets into SS. In particular, with regard to SWW targets, the productions of SW_2 take up an average of 40% of all productions, while SW_1 truncations account for about 4% of the entire productions.

(9) Production patterns and percentage of trisyllabic words
(Kehoe and Stoel-Gammon, 1997a: 121)

Target	Age	Production patterns and proportion (%)			
		3-syl.	2-syl	1-syl	others[a]
WSW	22 (93)	14	SW 70	S 7	9
	28 (192)	28	59		13
	34 (195)	67	33		
SWW	22 (177)	32	SW_1 6 SW_2 37	S[c] 14	11
	28 (187)	62	3 33		2
	34 (178)	47	2 50		1
ŚWS	22 (169[b])	35	SS 40	S_2 5	20
	28 (230)	77	23		
	34 (226)	66	31		3
SWŚ	22 (159)	32	SS 39	S_2 23	6
	28 (163)	78	19	1	2
	34 (148)	65	34		1

a. When it was not possible to tell which syllable children were attempting or when children reduplicated single syllables, the production was coded as Other.
b. The number of total productions by each age group is given in parentheses.
c. In SWW and WSW words, S refers to monosyllabic forms, which can be the preservation of the final or stressed syllable, or a conflation of both.

2.2.2.2 Effect of stress pattern

Table (9) also suggests that the proportions of truncation may vary among targets of different stress patterns and among age groups. In order to capture truncation rates among different metrical structures, I draw up table (10) based on the results in (9) so that it shows the proportion of truncation for each stress pattern and mean proportions across age groups, which are represented in gray cells. In terms of the mean proportion across three age groups, WSW targets show the highest truncation proportion (64%), followed by SWW (53%), SWŚ (42%) and ŚWS (41%). The result suggests that there is the interaction between stress pattern and truncation.

(10) Truncation proportion across stress pattern, across ages

	WSW	SWW	SWŚ	ŚWS	
22 months	86%	68%	68%	65%	72%
28 months	72%	38%	22%	23%	39%
34 months	33%	53%	35%	34%	39%
	64%	53%	42%	41%	Mean

However, the effect of stress pattern on truncation seems less evident in the productions of the youngest 22-month-old children. They have the highest rates of truncation for all target types. They reduce target words twice more often than they do not: the average truncation proportion of all stress patterns is 72%. The two older groups show no difference in mean truncation rates. The 28-month-old group displays a significantly high truncation proportion for WSW targets, while the 34-month-old children display higher truncation proportion of SWW targets. In sum, the solid connection between truncation and metrical types seems questionable.

2.2.2.3 Effect of segmental features

Let us now consider the effect of segmental features of the target. Table (11) provides the average proportion of truncation for each target in Kehoe and Stoel-Gammon (1997a, 1997b).

(11) Truncation rates of trisyllabic words (Kehoe and Stoel-Gammon, 1997a: 129)

WSW	SWW	ŚWS	SWŚ
Potato (56%)	Octopus (20%)	Crocodile (24%) Tinkerbelle (16%)	Kangaroo (21%) Chimpanzee (20%)
Tomato (56%)	Elephant (77%)	Telephone (71%)	

Banana (73%)	Animal (64%)	Dinosaur (54%)	

It shows that WSW target words are high in truncation rate regardless of their segmental contents, whereas SWW and ŚWS target words vary in truncation rate depending on whether they contain a word-medial sonorant or obstruent. Both *elephant* and *octopus* have the same metrical structure SWW, but they show contrastive truncation rates: *elephant* (77%) vs. *octopus* (20%). As for ŚWS targets, *telephone* is three times as high as *crocodile* in truncation rate (71% vs. 24%). It suggests that the feature of [sonorant] of the target word has some bearing on truncation.

Kehoe and Stoel-Gammon argue that target words that contain intervocalic sonorant in the weak syllable like *elephant* and *telephone* are more likely to be truncated than target words with intervocalic obstruent like *octopus* and *crocodile*. They try to account for the different truncation rates with 'resyllabification' by children. Their claim is that in child phonology the intervocalic sonorant is syllabified as the coda of the preceding stressed syllable. Then words with intervocalic sonorants have a word-medial onsetless syllable (a syllable consisting of only a vowel), which is vulnerable to deletion. For example, *elephant* and *telephone* are syllabified as *el-e-phant* and *tel-e-phone* as depicted in (12a). The onsetless word-medial syllables –e- are deleted, which leads the words to reduced forms: 'elephant' and 'telphon.'

(12) Resyllabification claimed by Kehoe and Stoel-Gammon

a.	din-o-saur	b.	cro-co-dile
	tel-e-phone		Tin-ker-bell
	an-i-mal		oc-to-pus
	el-e-phant		

On the other hand, syllabification of words with word-medial obstruents conforms to the usual principles of the Maximal Onset Principle and phonotactic constraints on consonant clusters.[27] Hence words like *crocodile, Tinkerbelle,* and *octopus* are syllabified as *cro-co-dile, Tin-ker-bell* and *oc-to-pus*, as displayed in (12b); there is no onset-less word-medial syllable. As a result, those words are less likely to be truncated compared to their counterparts with an intervocalic sonorant. In later chapters we will discuss the resyllabification account in detail.

To sum up, it is obvious from the statistical data in (11) that segmental information of the target word has effects on truncation. Moreover, this result clearly shows that the metrical structure of the target is comparatively less relevant to its truncation. If there were strong metrical effects, it would be predicted that the two target words of the same stress pattern should be similar in truncation rate.

2.3 Review of previous accounts of truncation

We have so far observed the patterns of child word truncation. Children do not delete a syllable randomly but in a systematic way. In terms of stress, stressed syllables are more likely to be produced than unstressed syllable; in terms of position, word-final unstressed syllables are more likely to be retained than non-final unstressed syllables. The most frequent truncation forms for each target type are as follows: WS→ S, WSW → SW_2; SW_1W_2 → SW_2; SWS →SS; $S_1W_1S_2W_2$ → SSW_2, all of which are the production of stressed syllables and word-final syllables. In terms of metrical effects on truncation, WSW targets show much higher truncation rates for 22- and 28-month-old children than other types (SWW and SWS), whereas there is little difference among metrical types for 34-month-old children. Furthermore, we observed that

[27] Maximal onset principle ensures syllable boundaries within a word are placed in such a way that onsets are maximal in accordance with the phonotactic constraints of the language (Giegerich, 1992: 170), and English phonotactics do not allow /nk/, /ŋg/, /mp/ for the onset, so *Tinkerbell* is not syllabified as Ti-nker-bell.

there are pairs of two words with the same metrical structure who are radically different in truncation rates: targets containing intervocalic sonorants are more likely to be truncated than targets containing obstruents.

In the present section, we discuss previous accounts of child word truncation based on the observations from the previous section. Each approach to be reviewed has different focal points: some focus on the characteristics of the target words; others focus on the prosodic representations of the output forms.

2.3.1 Gerken's trochaic template

The first approach to be reviewed is metrical templatic accounts. Studies espousing this approach include Allen and Hawkins (1978) and Gerken (1994, 1996). They argue that children have a trochaic template for producing a strong and an optional weak syllable, so syllables that do not fit the template are more likely to be omitted than those not.

Trochaic template account proposed by Gerken (1994) is distinguished from the claim that children have a bias toward trochaic rhythms (Jusczyk, Cutler and Redanz, 1993). Jusczyk, Cutler and Redanz's argument is about perceptual preference for trochee, but Gerken's is related to production template. Gerken (1994) proposed that children learning a language have a template that might be specific to the language; and as for English, the template is a trochaic S(W) template. Children apply the SW template to their intended utterance by mapping the strong syllable of the word onto the strong syllable of the template. Weak syllables that fit the template are retained, while weak syllables that do not are omitted. In her hypothesis, the common omission of word-initial weak syllables is not a matter of the position and stress of the given syllable as claimed by the perceptual salience account (Echols and Newport, 1992; Echols, 1993), but rather a matter of metrical structure.

This trochaic template explains the contrast in omission rates between the first weak syllable and the word-final weak syllable in WSW target words like *banana*. The high omission rate of the word-initial weak syllable of *banana* is attributable to its failure to be footed[28] while the final weak syllable is chosen to be part of the template as illustrated in (13a).

(13)

a.
```
*  F
|  /\
W S W
| | |
banana
```

b.
```
*  F
|  |
W  S
|  |
giraffe
```

c.
```
 F
/\
S W
| |
tiger
```

The template also accounts for different truncation rates between different metrical types: WS vs. SW and WSW vs. SWS, as noted in section 2.2. As illustrated in (13a), the weak initial syllable of WS targets like *giraffe* is vulnerable to omission since it is unfooted. By contrast, the weak syllable of SW targets like *tiger* fits the trochaic template as illustrated in (13c), so it is less likely to be omitted.

According to this templatic account, the higher rate of truncation in WSW targets compared to SWS targets is attributable to the presence of a syllable unfitted to the trochaic template. Since WSW targets contain a syllable (i.e. the initial unstressed syllable) that does not fit into the template as illustrated in (14a), which is prone to deletion, they are more likely to be truncated. On the other hand, SWS targets consist of two trochaic feet as shown in (14b), there is no extra syllable. Thus they are less likely to experience syllable deletion.

(14) Prosodic structures of WSW, SWW and SWS

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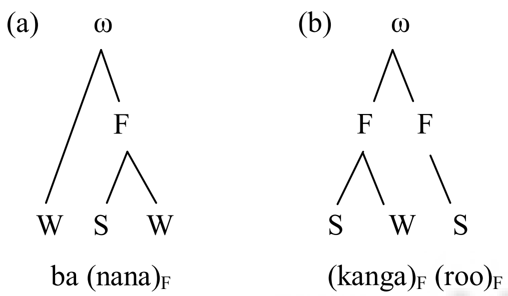
[28] Unfooting is represented throughout this section by associating the unfooted syllable to an asterisk * in the metrical structure.



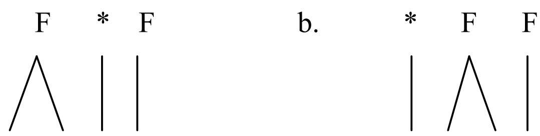
The trochaic template is motivated by the findings of Gerken (1994)'s two experiments on children's imitations of four-syllables nonsense words with SWWS and WSWS stress patterns, for example ZAMpakaSIS and paZAMkaSIS (capital letters indicate stressed syllables). The two weak syllables of each stress pattern display different frequency in children's productions: the percentage of syllables preserved in the child's imitated productions is listed below in (15).

(15) Percentage of syllables preserved in word imitations (Gerken, 1994: 575)

	SWWS target				WSWS target			
	ZAM	pa	ka	SIS	pa	ZAM	ka	SIS
Exp.1	66	40	24	63	29	66	43	71
Exp.2	86	59	39	88	41	93	79	88

Table (14) depicts that the first weak syllable of SWWS is more frequently preserved than the second weak syllable (49:24 in Experiment 1 and 59:39 in Experiment 2). In children's imitations of WSWS words, the first weak syllable is more frequently omitted than the second weak syllable (29:43 in Experiment1 and 41:79 in Experiment 2). The results imply that unfooted syllables that do not fit the trochaic template (W_2 of SWWS targets and W_1 of WSWS targets) are more prone to omission than those that fit into a trochaic template as illustrated in (16a) and (16b).

(16) a. b.



S WWS　　　　　　　　WS WS

ZAMpakaSIS　　　　　　paZAMkaSIS

Gerken (1996) extends the template account to the production of functional words in the child's utterance. Children showed a tendency to preserve the object articles that belong to a foot more often than those that are unfooted. As shown in (17), the preservation rates of the object articles are 84% for the sentence in (17a) and 72% for the sentence in (17c), which are much higher than 52% and 28 % for each sentence in (17c) and (17d).

(17) Percent of the preservation of the object articles (Gerken, 1996: 689)

a. He kicks the pig.	84%
b. He catches the pig.	52%
c. Tom pushed the giraffe.	72%
d. Tom pushes the giraffe.	28%

The metrical structures of each target sentence given in (18) account for the difference in omission rates.

(18)

* F F　　　　　　* F * F

W S W S　　　　　W S W W S

a. He kicks the pig.　　　b. He catches the pig.

F F * F　　　　　　F F * * F

S S W W S　　　　　　　　S S W W W S

c. Tom pushed the giraffe.　　　　d. Tom pushes the giraffe.

The object articles in (17a) and (17c) constitute a foot with the preceding verb and are less likely to be omitted, as illustrated in (18a) and (18c), whereas those in (17b) and (17d), since the preceding verb itself is a disyllabic foot, do not belong to a foot, as illustrated in (18b) and (18d), and display high rates of omission.

In the same vein, one may predict the same mechanism could apply to a word-initial weak syllable. That is, word-initial weak syllables could be frequently produced in the child's word forms if attached to the preceding word and constituting a prosodic word together. For example, take the sentence '*Tom pushed Michele*' as a target. The unstressed first syllable of *Michéle* could be attached to the preceding monosyllabic word *pushed* as shown in (19).

(19)　F　F　F

S　S　W　S

Tom pushed Michele.

Then, we may draw a misleading conclusion that a sentence-medial, word-initial syllable can be refooted if a strong syllable precedes it and thus likely to be preserved. However, the prosodic words are limited to one and only one lexical word plus adjacent functional morphemes and children's metrical templates are contained within the prosodic words (Gerken, 1996: 694-695). Therefore, word initial weak syllables remain susceptible to omission regardless of the prosodic structure of the preceding words.

We have so far observed that Gerken's trochaic template clearly explains the vulnerability of the word-initial unstressed syllables. Let us see how the template can account for the truncation of SWW targets. The template hypothesis predicts that children produce SW_1 for SWW targets like *elephant* since the stressed syllable and the adjacent weak syllable constitute a trochaic foot as exhibited in (20),[29] and the word-medial unstressed syllable is more likely to be preserved than the word-final unstressed syllable.

(20)

```
 F   *
/\   |
S W  W
| |  |
e l e phant
```

Note, however, that the production rates of SW_1 and SW_2 for SWW targets are respectively about 4% and 40% (Kehoe and Stoel-Gammon, 1997). In other words, children have a higher probability to produce '*elphant*' rather than '*ele*.'

In order to tackle this problem, Gerken (1994) proposes a CV(C) syllable template which requires a consonant and a vowel and optional consonants for a syllable. The CV(C) template is applied at the same time with the S(W) metrical template. Accordingly, children may select the final weak syllable from *elephant*[30] because it fits the CV(C) template, whereas the word-medial weak syllable fails to fit the syllable template. In sum, Gerken's templatic account suggests that two templates, the metrical template SW and the syllable template CV(C), interplay to determine which syllable children produce from their target. That is, given a

---

[29] SWW targets like *elephant* SWW may become a ternary foot (SWW). However since trochaic feet are the type permitted in English, the final syllable is declared extrametrical and invisible to the foot construction rule (Gussenhoven and Jacobs, 2005: 195). Extrametricality is marked by angled brackets < >. Then *elephant* consists of a trochaic foot with an extrametrical syllable attached: (e le <phant>)$_F$.

[30] Gerken regards the syllabification of *elephant* as 'el-e-phant,' the same as Kehoe and Stoel-Gammon (1997b), but it is doubtful since *elephant* can be syllabified as 'e-le-phant' by the onset first principle.

trochaic template, the stressed syllable of the target is mapped into the S slot of the template, and the W slot is filled with an unstressed syllable: the one that fits the syllable template if there is more than one unstressed syllable.

Despite the introduction of the CV(C) template, it remains still unclear which syllable is mapped into the W slot of the trochaic template when two weak syllables of SWW targets equally satisfy the syllable template CV(C). For example, both the word-medial and word-final unstressed syllables of *sesame* and *company* fit into the CV template. According to Gerken's template, the medial unstressed syllable should occupy the W slot, but we will see in the next chapter that the truncation of those targets tends to preserve the final syllable regardless of the CV structure of the syllable.

The issue of the retention of both stressed and word-final syllables also emerges in the truncation of SWSW targets. It was observed in section 2.2 that SWSW targets are predominantly produced as SSW. Since targets themselves consist of two trochaic feet, each syllable of the target fits into the trochaic template. Thus, according to the templatic account, no syllable is subject to omission, nor is truncation expected. In conclusion, the strong tendency to preserve the stressed syllables and the word-final syllables is not explained by the templatic approach.

There is another issue that is not explained by the templatic approach. The trochaic template may predict the same truncation rates for targets with the same stress pattern as a result of the effort to fit the trochaic template. However, as we have seen in the previous section, the truncation rate of *octopus* is 20% and that of *elephant* is 77% although they have the same metrical structure SWW. This implies that the metrical factor alone may not explicate children's truncation patterns.

Gerken's template may be challenged by other words on child word production. Some researchers argue that such preference to producing SW rhythm may result from children's exposure to the predominant prosodic features of their ambient environment, not inherent in their own language (Jusczyk *et al*., 1993; Schwartz and Goffman, 1995; Roark and Demuth, 2000; Demuth, 2003; Demuth *et al*., 2006). Jusczyk *et al*. (1993) shows 9-month-old infants show stronger sensitivity to SW stress patterns than WS pattern, but 6-month olds do not show any significant preference for SW patterns. It is consistent with the result of Lewis *et al.* (1999) as we already discussed. Roark and Demuth (2000) claim that children tend to produce higher-frequency prosodic structures earlier than lower-frequency structures, citing the difference in coda frequency between English and French children. Of the word tokens children typically hear and produce, coda appears in 60% in English, whereas 25% in French. According to them, children's tendency to produce a trochaic form may be due to the prevailing trochaic forms present in English.[31]

2.3.2 Fikkert's circumscription theory

Fikkert (1994) provided a theoretical account of children's stress acquisition based on the longitudinal observation of productions by 12 Dutch children. She proposed trochaic templates to explain children's word production. Her templatic approach is different from Gerken's is that Fikkert employed "prosodic circumscription" (McCarthy and Prince, 1993, 1996) to map the target into the template and presented developmental stages of prosodic acquisition. According to the circumscription theory, children circumscribe a prosodic unit from the adult target forms, and then map the materials in the circumscribed unit to their own prosodic template; the residue of the word is not realized.' The templates and different prosodic units circumscribed differ depending on developmental stages. The stages are summarized in (21).

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[31] Clopper (2001)'s analysis on stress patterns of disyllabic English words in the online version of Webster's Pocket Dictionary shows trochaic forms vastly outnumber iambic forms: 3624 to 995.

(21) The child's template in stress acquisition

	Child's template	Target	Output
Stage 1	S(W)	olifant /ó ː li ː fɑ̀nt/ vakantie /va ː kɑ́nsi ː /	[fɑnt] [kɑ́nsi ː]
Stage 2	SW	kabouter /ka ː bɑ́utər/ olifant /ó ː li ː fɑ̀nt/	[bɑ́utə] [ó ː fɑnt]
Stage 3	two equal stress	olifant /ó ː li ː fɑ̀nt/ konijn /ko ː nɛ́in/	[ó ː fɑ́nt], [ó ː fɪ fɑ́nt] [tɔ́tɔtɛ́in]
Stage 4	two varying stress	telefoon /tè ː ləfó ː n/	[té ː ləfò ː m] [tè ː ləfó ː n]

At stage 1, the child's temple is a trochaic foot; and the prosodically circumscribed portion is the foot at the right edge of the adult target. In other words, it is not merely the main stress but the right most stress (in fact, the foot with the right most stress) that is circumscribed: e.g. *olifant* /ó ː li ː fɑ̀nt/ 'elephant' is truncated into [fɑnt]; *vakantie* /va ː kɑ́nsi ː / 'holiday' into [kɑ́nsi ː].

At Stage 2, the child's template is still a trochaic foot, yet this time the trochaic template should be fully filled, and hence the child circumscribes another syllable if the circumscribed foot at Stage 1 consists only of a single syllable. For disyllabic targets, the whole material in the word is mapped into the template, but for longer target words, children utilize different strategies for different targets. For targets ending with a disyllabic foot, the foot is selected for production. In such case, the child's forms do not distinguish between Stage 1 and Stage 2: For example, at this stage *kabouter* /ka ː bɑ́utər/ 'gnome' is produced as [bɑ́utə] and *horologe* /hɔ̀rló ː ʃə/ 'watch' as [ló ː ʃə]. For targets with a final stressed syllable, i.e. with the right most foot consisting of one syllable, the next stressed syllable to the left coupled with the right-most syllable is selected. For example, *olifant* /ó ː li ː fɑ̀nt/ is truncated into [ó ː fɑnt]; *locomotief* /lò

ː ko ː mo ː tí ː f/ 'locomotive' into [lo ː ti ː f].

At stage 3, the child's prosodic template consists of two feet with level stress. Children are not yet aware of the main stress rule at this stage; thus, *olifant* /ó ː li ː fɑ̀nt/ is produced as [ó ː fɑ́nt] or [ó ː fɪ fɑ́nt] and *allemaal* /ɑ̀ləmá ː l/ 'all' is produced as [á ː ləmá ː l]. In order to form two feet, an extra syllable can be added: for example, *konijn* /ko ː nέin/ 'rabbit' is produced as [tɔ́tɔtέin]; *cassette* /cɑsέtə/'cassette' as [kɑ́ka ː sέtə]; and *pantoffels* /pɑ̀ntɔ́fəls/ 'slipper' as [fɑ́tɔtɔ́fɔs]. However, for trisyllabic target words which have initial stress but lack secondary stress (i.e. SWW), syllable epenthesis is not found in Fikkert's corpus to fulfill the two feet template; virtually, they are invariably realized as disyllabic words with initial stress during all stages, as demonstrated by productions [té ː tə] or [té ː kə] for *tekenen* /té ː kənə(n)/ 'to draw' and [jɑ́ŋə] for the target word *Janneke* /jɑ́nəkə/ (Fikkert, 1994: 228).

At Stage 4, the child learns that one of the feet of the word receives main stress. At first, children put the main stress on the right-most branching (i.e., disyllabic) foot, not to the final monosyllabic foot. For example, *telefoon* /tè ː ləfó ː n/ 'telephone' is produced as [té ː ləfò ː m] and *paraplu* /pà ː ra ː plý ː / 'umbrella' as [pɑ́ləpỳ ː]. In those child productions, the main stress falls on the first foot because the first foot of each of the target words consists of two syllables (that is, a branching foot) whereas the final one consists of one syllable. On the other hand, words like *pantoffels* /pɑ̀ntɔ́fəls/ 'slippers' and *Marijke* /ma ː réikə/ are produced as [pɑ̀ntɔ́fɔls] and [mà ː Rέikə], respectively, with the main stress falling on the final foot since the final foot is disyllabic. Later at Stage 4, children learn that in some of the produced forms, main stress is assigned incorrectly, namely for those targets that have final main stress like *telefoon* /tè ː ləfó ː n/, which is produced as [té ː ləfò ː m] at first; later children finally produce adult-like: [tè ː ləfó ː n].

Let us apply Fikkert's stages to English words of different stress patterns and we would obtain hypothetical truncated forms for tree- and four-syllable targets as presented in (22).

Regarding three-syllable targets, all metrical types go through truncation at Stage 1 and 2. At Stage 3 SWS types only experience stress errors, but not truncation, from which we could infer that children might truncate SWS targets less often than WSW or SWW targets at Stage 3. This is consistent with the predictions of Gerken's trochaic template account if we do not take the developmental stages into account.

(22) Hypothetical productions for multisyllabic English target words according to Fikkert's stages of stress acquisition

	SWW	WSW	ŚWS	SWŚ	ŚWSW	SWŚW
	elephant /élɪfənt/	tomato /təméto/	dinosaur /dáɪnəsɔ̀r/	kangaroo /kæ̀ŋgərú/	alligator /ǽlɪgèɪtər/	avocado /æ̀vəkɑ́do/
Stage 1	[élɪ]	[méto]	[sɔ́r]	[rú]	[gèɪtər]	[kɑ́do]
Stage 2	[élɪ]	[méto]	[dáɪsɔr]	[kǽŋru]	[gèɪtər]	[kɑ́do]
Stage 3	[élɪ]	[tə́méto]	[dáɪnosɔ́r]	[kǽŋgərú]	[ǽlɪgéɪtər]	[ǽvəkɑ́do]
Stage 4	[élɪfənt]	[tə̀méto] [təméto]	[dáɪnəsɔ̀r]	[kǽŋgərù] [kæ̀ŋgərú]	[æ̀lɪgéɪtər] [ǽlɪgèɪtər]	[æ̀vəkɑ́do]

In terms of truncation size, SWW, WSW, ŚWSW and SWŚW targets are truncated at most into two syllables since children circumscribe the right-most trochaic foot: thus, *elephant* may be truncated into [élɪ] not into [éfənt] or [élfənt], *tomato* into [méto], *alligator* into [gèɪtər], and *avocado* into [kɑ́do]. This implies children might rarely produce one syllable, that is, the stressed syllable alone for these targets. By comparison, ŚWS and SWŚ targets may be produced as one-syllable as well as two syllables, since the final syllable itself constitutes a foot. Thus, *dinosaur* and *kangaroo* may be produced as [sɔ́r] and [rú], respectively, at Stage 1, and at Stage 2, they may be produced as two syllables, [dáɪsɔr] and [kǽŋru], made up of two strong syllables of each target.

In Kehoe and Stoel-Gammon (1997a), children produce one-syllable truncations for ŚWS and SWŚ targets more often than for SWW or WSW targets. Moreover, one-syllable productions of SWW and WSW targets were not solely the stressed syllable but either the stressed syllable, or the final syllable or conflation of both. This is consistent with the findings on productions of ŚWS and SWŚ targets in table (9) of section 2.2. We noted in the previous section that when ŚWS and SWŚ targets are truncated into two syllables, two strong syllables are produced; no SW productions are made. Likewise, four-syllable targets like *alligator* and *avocado* are rarely produced as one syllable. As for the content of truncations of ŚWS and SWŚ targets, Fikkert suggested children at Stage 2 produce two strong syllables from the targets like *dinosaur* and *kangaroo*.

With respect to SWW targets, predicted two-syllable in (22) are not in keeping with the findings of Kehoe and Stoel-Gammon (1997a). In (22) two-syllable truncations of SWW targets should be of the form SW_1, but SWW targets in Kehoe and Stoel-Gammon (1997a) are more likely to be truncated into SW_2 rather than SW_1.

In contrast to truncations of SWW, truncations of SWSW targets are conforming to Fikkert's templatic account at least at Stage 1 and 2. As we have examined in Table (8), the children select and produce the right most SW foot much more often than the two stressed syllables SS from ŚWSW and SWŚW targets. For example, álligàtor is more likely to be produced as 'gator' not as 'alga'; and àvocádo as 'cado' not 'aca.' On the other hand, at Stage 3 the words should be produced as four syllables although with incorrect stress patterns. However, the findings from Kehoe and Stoel-Gammon (1997a) given in table (8) show that SWSW targets are more likely to be produced as SSW than SWSW: productions in the form of SSW account for 52% of all productions, while productions in the form of SWSW take up 35%. From a perspective of production, however, SSW consists of two trochaic feet, which is consistent with children's preference to produce trochaic stress patterns.

In summary, Fikkert's circumscription theory explains the truncation patterns of WSW, SWS and SWSW. Like Gerken's templatic account, word-initial unstressed syllables of WSW targets are vulnerable to omission due to their failure to fit into a trochaic template. With regard to SWS targets, Fikkert's description is better than Gerken's account since the data from Kehoe and Stoel-Gammon (1997a, 1997b) confirm that SWS targets are more likely to be reduced into SS (Fikkert's form) rather than SW (Gerken's form).

There are several issues that are not explained by Fikkert's circumscription theory including the segmental effect on truncation found in contrastive truncation rates between *elephant* (77%) and *octopus* (20%) and the strong tendency to preserve both stressed and word-final syllables, in particular the predominant production of SSW for SWSW targets. According to Fikkert's prosodic development, the truncation for SWSW targets should be the right-most foot S_2W_2 initially and move towards non-truncated SWSW forms as children grow up. That is, the production of SSW forms is not predicted.

2.3.3 Prosodic structure account

The next account to be reviewed is the prosodic structure account (Demuth and Fee, 1995; Demuth, 1996b, 1996c; Salidis and Johnson, 1997). It focuses on the representation of the child word form, and claims that child word shapes are influenced by children's abilities to access prosodic constituents in the prosodic hierarchy. We have seen in the previous section that Fikkert proposed an explanation of prosodic development focusing on the target's content. Unlike the trochaic templatic accounts, Demuth and Fee (1995) and Demuth (1996b, 1996c, 2003) focused on the prosodic well-formedness of the output forms. The primary argument of this account is that children's word shapes are initially limited to lower level units of prosodic hierarchy such as core syllable CV and feet, but become more sophisticated with higher level units like prosodic words over time. That is, children show an increasing ability to handle more complex prosodic structures in the prosodic hierarchy over time.

In the prosodic structure account, four stages are identified in the prosodic development in English and Dutch as presented in (23) and each stage will be described in more detail with the data from Dutch speaking children (Fikkert, 1994) as well as English speaking children (Demuth, 1996b):

(23) Stages in the Development of Prosodic Structure

Stage I	<u>Core Syllables</u> - CV No vowel length distinctions
Stage II	<u>Minimal word/ Binary Feet</u> a. syllable trochee- CVCV b. Closed Syllables - CVC c. Vowel length distinctions-CVV
Stage III	<u>Stress-Feet</u> a. One stress foot b. Two level stress feet c. One primary stress per word
Stage IV	<u>Phonological Words</u> Extrametrical syllables permitted

Stage I is characterized by core syllables. In this stage, children generally produce core syllables, even for target forms with coda consonants as seen in the child's form [kaː] or [kɑ] for a Dutch word *klaar* /klaːr/ and [tiː] or [tɪ] for *dit* /dɪt/ produced by Jarmo (1;4-15). At this stage, there is no vowel length contrast. Children's production of long vowels does not imply that the vowels are phonologically long (tense) vowels.

Stage II is a stage of minimal words or binary feet, where the output forms of children are CVCV, a foot consisting of two monomoraic syllables (Stage IIa); monosyllabic close syllable CVC (Stage IIb); or CVV, a monosyllabic foot with long vowels (Stage IIc). At Stage IIa, Dutch-learning children Robin (1;7-1;8) and Noortje (2;6-2;7) produce disyllabic forms by employing different strategies. Robin produces [mɔ́mə] and [bɔ́mə] for a disyllabic word *ballon* /bɑlɔ́n/ by shifting stress position. On the other hand, Noortje produces [kɪ́kə] and [tɛ́ɪjə] for monosyllabic target words *dik* /dɪk/ and *thee* /téː/ by adding extra syllables to monosyllabic adult target words. Children at this stage seem to be unable to produce monosyllabic bimoraic feet.

However, Fikkert (1994: 209) shows that most children move quickly to Stage IIb and be able to produce coda consonants. For example, Jarmo (1;6-1;7) produces [aːp] and [ɑp] for *aap* /aːp/, and [bɑf] for *bal* /bɑl/. Proceeding to the Stage IIc, Jarmo (1;10-2) shows vowel length distinction and produces CVV forms, although the vowel distinction occurs in a limited context. When a word final sonorant is deleted, the word should end in long vowels as in [tɛi] for *trein* /trɛin/ and [tyː] for *stoel* /stuːl/, whereas when the sonorant is realized, the sonorant come together with a short vowel as in [mɑm] and [mɔm] for *mann* /maːn/; and [bɔm] and [pɔm] for *boom* /boːm/. Such relations, however, are not found for obstruent final words as we can see in [aːp] or [ɑp] for *aap* /aːp/.

Stage III featuring stress-feet is the stage where children produce words beyond the minimal word. This stage is divided into three substages: Stage IIIa of one stress-foot, Stage IIIb of two feet with level stress, and Stage IIIc of one primary stress per word. At Stage IIIa, children seem to learn that adult words can consist of more than the binary foot as observed by Fikkert (1994: 214): for the target *telefoon*/téːləfòːn/, Robin (1;10-2;1) produces not only [fɔ́m], a size of the minimal word, but also [tɪ́foːm], one foot larger than the minimal word form. At Stage IIIb, children begin to produce two feet, although with level stress: Jarmo produces [óːfɑfɑ́n] for *olifant* /óːliːfɑ̀nt/. Although the target consists of the two feet with different degree, the child's production is of two feet with the same level of stress. In this stage, even a target word with only one stress is often pronounced as two level-stressed feet as illustrated by Noortje's (2;7-2;10) two-foot output [tɔ́tɔtɛ́in] for the target word *konijn* /koːnɛ́in/. At Stage IIIc, children seem to finally learn that there is one primary stress per word. A child named AS (2;3) produces [máːdo] for *tomato* /təméto/. This production bears only one stress in contrast to the production of two feet with leveled stress at Stage IIIb like [tɔ́tɔtɛ́in] for the target *koníjn*.

On Stage IV, children know that adult words consist of one foot and something more, which might not be a full foot (Fikkert, 1994: 215). The production of extrametrical syllables is allowed and the representation becomes adult-like. For example, the word-initial unstressed syllable in the word *tomato* /təméto/ is produced as in [dəmáːdo] by a child just named AS in Demuth (1996b), which is more developed compared to the one-foot production [máːdo] at Stage IIIc.

In sum, according to the prosodic account, the shape of children's early words are governed by the development of prosodic representation: at stage I, children's words are confined to the syllable level, actually core syllable; advancing through the foot level in Stage II, where the prosodic word and foot are undifferentiated; and to Stage III, where prosodic structures are developed to the level of prosodic word and children's word productions are more adult-like. The developing process is schematized by Demuth (1996b) as (24).

(24) The Development of Prosodic Representation (Demuth, 1996b)

Stage I	Stage IIa	Stage IIb,c	Stage III
			ω
			|
	F/ ω	F/ ω	F
	|	|	|
σ	σ	σ	σ
		|	|
		μ	μ

The diagram (24) shows that at Stage I there is no notion of a foot since child productions are all CV forms. Since the minimal form of a prosodic word (i.e. a foot) contains at least two moras or two syllables, child productions at this stage are not regarded as a prosodic word. At Stage IIa, child productions are in the form of trochaic trochee, which is a foot, which in turn becomes a prosodic word. At Stage IIb, c, the mora begins to appear and so do vowel distinctions. Child productions at this stage are in the form of two moras, which become a foot and thus a prosodic word as well. At Stage III, children begin to produce two feet. Thus, the level of a foot is subordinated to the level of a prosodic word since a prosodic word consists of two feet.

The stages are not clear-cut but overlapped for a certain time: children are relying on different levels of phonological structure simultaneously (Demuth, 1996b). For example, as the table in (25) shows, MH (1;7) produces for the target *dog* several output forms from Stage I through Stage IIb; PJ (1;11) produces different stage words; and AS (2;3) gets access to both Stage III and Stage IV.

(25) Overlapping stages of prosodic word development

Target	Child's form	Stage	Child
dog	/dʌ/	Stage I	MH (1;7)
	/dʌʔ/	Stage IIb	
soup	[sʊ]	Stage I	PJ (1;11)
	[suː]	Stage IIc	
	[sup]	Stage IIb	
tomato	[máːdo]	Stage III	AS (2;3)
	[dəmáːdo]	Stage IV	

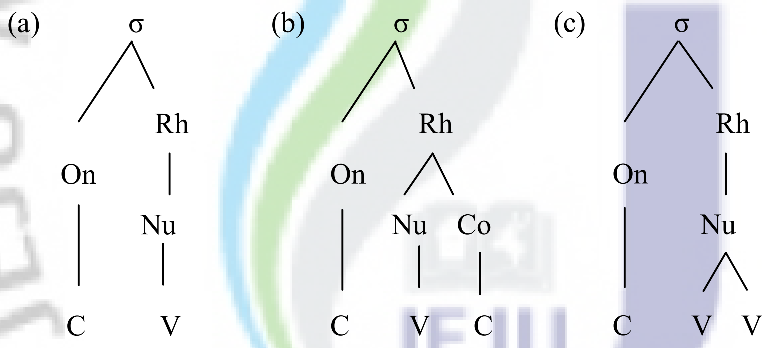
The prosodic structure account would say the truncations of WS(W) into S(W) are ascribed to the children being at Stage III where they can produce a stress foot but cannot produce the unfooted initial syllable. In short, this approach can account for the trochaic productions by children like the trochaic template account.

As opposed to the template-based approaches, the prosodic structure account focuses on not which syllable is extracted from the target but on the well-formedness of the child's production. Both truncated forms, SW_1 and SW_2 for SWW targets are well-formed stress feet, so is predicted that the production rates of both forms should be similar. However, we know well that the rates are asymmetrical: SW_2 is much more frequently produced. Thus, this account cannot explain the different frequency of SW_1 and SW_2 productions for SWW targets.

Different truncation rates between *elephant* (77%) and *octopus* (20%) cannot be tackled either. If a child stood at Stage III thus could only produce a stress foot for SWW targets, children should truncate both *elephant* and *octopus* as disyllabic trochaic feet. We can infer from the radical difference in truncation rates between them that even when *octopus* is not truncated, *elephant* is highly likely to be truncated into a disyllabic foot. It means children are in Stage IV when pronouncing *octopus* and Stage III when pronouncing *elephant*. Although the overlapping of stages is recognized (Demuth, 1996b), it is unfair to say that developmental stages differ among target words.

Another counterargument against the prosodic account is concerning the order of the acquisition of prosodic structures. Stage I and Stage II imply that children cannot access the lowest level of structure, *mora*, at the beginning; the mora seems to emerge after the higher units, *syllables* and *feet*, as vowel distinction occurs only at Stage IIc. The order of acquisition of monosyllables may be accounted for by a theoretical approach on the syllable structures between the core syllable CV, the closed CVC and the one with a long (tense) vowel CVV.

(26) Syllable structures



In (26a), the core syllable shows no branching; both CVC in (26b) and CVV in (26c) have a branching node. The CVC syllable in (26b) allows the rhyme to branch into a nucleus and coda, whereas the branching in (26c) occurs at the nucleus node. If we assume that the less branching structure is more unmarked and that the syllable that branches at a higher node is simpler, then we could conclude that CV is the most unmarked: CVC is more unmarked than CVV; thus, CVC is acquired before CVV since unmarked structures are acquired earlier by the 'implicational laws' of Jacobson (1968).[32] In other words, vowel distinction is emerged after the

[32] Edwards and Shriberg (1983).

closed syllable is emerged. Indeed, there is ample evidence that English children acquire vowel length contrast very early, rather than after the acquisition of coda consonants (Salidis and Johnson, 1997; Kehoe and Stoel-Gammon, 2001).

2.3.4 Perceptual salience account

The final approach to be reviewed is based on children's perceptual limitations (Echols and Newport, 1992; Echols, 1993; Snow, 1998). This approach, known as the perceptual salience account, claims that children only extract perceptually prominent elements from the target speech and reproduce them, and stressed syllables and word-final syllables are the ones that are perceptually salient.

The perceptual salience account correlates the child's productions with the prominence of syllables determined by acoustic characteristics and word positions. Researchers (Echols and Newport, 1992; Echols, 1993; Kehoe and Stoel-Gammon, 1997b; Snow, 1998) who argued for this account claimed that children's truncations are based on their perceptual limitations; children can extract perceptually salient syllables from the stream of speech (Echols and Newport, 1992) and thus they only produce those salient syllables, omitting perceptually less prominent syllables.

This perception-based account for truncation can be traced back to Waterson (1971). She proposed that children may be capable of perceiving 'schemata,' structures that extract out perceptually salient features of adult words such as stress and prominence and produce their own forms based on the perceived patterns. As to the deletion of syllables found in children's early words, linguists such as Echols and Newport (1992) and Snow (1998) claim that stressed syllables are acoustically more prominent than unstressed ones and word-final syllables are perceived as more salient than non-final syllables; thus children are likely to reproduce such perceptually salient syllables and omit less prominent ones.

Stressed syllables are pronounced with a greater amount of energy than unstressed syllables in phonetic terms. Thus, they are more prominent in the flow of speech: stressed syllables are generally louder, longer in duration and higher in pitch than surrounding syllables (Ladefoged, 2001: 231-232). Specifically, English stressed syllables are 1.6 times as long as unstressed syllables (Laver, 1994: 532) and heavy syllables stand out more prominently in the perceived flow of speech than do light syllables (518). Such prominence has been regarded to contribute to higher preservation capability of stressed syllables.

The claim that word-final syllables are perceptually more salient is more difficult to support than perceptual salience surrounding stress. Echols and Newport (1992: 193) argued for acoustic cues for word final syllables since a syllable that is word final also has the potential for being phrase final or sentence final, and speech contains more acoustic cues to phrase boundaries. They presented as evidence of the salience of final position the observation that Japanese learning children acquire functional markers and inflections on verbs at early ages (Echols and Newport, 1992: 195). In Japanese, functional makers are sentence final and verb inflections are word final or sentence final. Usually, functional markers are unstressed and acquired later. Thus, they claim the early acquisition of Japanese functional markers implies the salience of final position.

Further evidence of perceptual salience of stressed syllable and word-final syllables is found in child-directed speech. Normally, infant-directed syllables are longer in duration, higher in pitch and louder as compared to adult-directed syllables (Fernald and Kuhl, 1987; Albin and Echols, 1996). Acoustic prominence of stressed syllables and word-final syllables is adamantly noticeable in infant-directed speech. According to Albin and Echols (1996), stressed syllables are longer and higher-pitched than unstressed syllables, and word-final syllables are longer and higher-pitched than nonfinal syllables in the infant-directed speech. They claim unstressed final syllables may be similar to stressed syllables, which is not the case in adult-directed speech: final, unstressed syllables in adult-directed speech may be more similar to nonfinal unstressed syllables. Their analyses also reveal that even in utterance-medial position, not to mention in utterance-final position, unstressed word-final syllables were significantly longer than unstressed nonfinal syllables (196 ms to 125 ms).

The perceptual salience account can be supported by children's strong tendency to produce stressed and word-final syllables of the target words compared to unstressed, non-final syllables. Echols and Newport (1992), in the study of three children at the one-word stage (aged 1;5-1;11), found that stressed syllables in the adult target words were more frequently preserved than unstressed ones, and word final syllables are more frequently reproduced than non-final syllables. We have already confirmed the results in section 2.2, which is summarized in (27).

(27) Mean proportion of syllables omitted for multi-syllabic targets (Echols and Newport, 1992: 206)

Stress Level	Position	
	Nonfinal	Final
Stressed	.06 (644)	.02 (219)
Unstressed	.51 (188)	.11 (397)
Note. Numbers in parentheses are total number of syllables contributing to analysis.		

Table (27) clearly shows that stressed syllables regardless of position are low in omission rates (stressed nonfinal syllables: 6%, stressed final syllables: 2%), compared to unstressed syllables. About one in every two unstressed nonfinal syllables is omitted (51%), whereas unstressed final syllables are much more likely to be produced (the omission rate is as low as 11%).

This perception-based account explains the content of truncations such as WS → S, SWS → SS, WSW → SW, SWW → SW_2 and SWSW → SSW. Note that the approaches discussed previously cannot account for the higher probabilities of retaining a word-final unstressed syllable than a non-final unstressed syllable; the difference in production rates between SW_2 and SW_1 for SWW targets; and the predominance production of SSW forms for SWSW targets. These issues are easily captured by the perceptual salience account.

However, there are a number of examples of child words arguing against this account. The first example is concerned with the syllable epenthesis. There is no way of explaining the addition of a syllable that is not present in the adult word like in [dɔgi] for *dog*. By contrast, the trochaic template account would expect a syllable to be added to monosyllabic targets like *dog* and a Dutch word *thee* /té ː / in an attempt to form a trochaic foot, thus producing [dɔgi] and [tέɪjə] for each target (Kehoe, 2001). The prosodic structure approach also allows a syllable to be added to the child word form since it focuses on the well-formedness of the word shape: [dɔgi] is a well-formed disyllabic trochaic foot.

Secondly, it does not offer an explanation for findings of Gerken (1994) regarding different production rates between weak syllables of SWWS, WSWS targets. As we have seen in subsection 2.3.2, the first weak syllable of SWWS targets is more frequently preserved than the second weak syllable: the preservation rates are W_1 59% and W_2 39% in Experiment 2. With regard to WSWS targets, the first weak syllable is more frequently deleted than the second weak syllable: the preservation rates are W_1 41% and W_2 79% in Experiment 2). Both of the weak syllables from either SWWS or WSWS are neither stressed nor word-final. That is, they are equally vulnerable to omission in terms of perceptual prominence. Therefore, the perceptual salience account may predict similar production rates between the two weak syllables.

Thirdly, since this account resorts to the acoustic prominence of the syllables derived from prosodic stress and word position, it would be predicted that target words of the same stress pattern may have similar truncation rates. However, the two SWW targets, *elephant* and *octopus* greatly differ in the rates of truncation: *elephant* is much more likely to be truncated

(77%) than *octopus* (20%).

As we noted, the perceptual salience account is based on children's perception limitation. This is challenged by the fact that children frequently alternate between truncated and non-truncated forms. A 34-month-old girl studied by Kehoe (1999/2000: 43) pronounces the target word *banana* both as a truncated form [hǽnǽ] and a full form [bənǽnʌ].[33] The alternate use indicates that children might perceive the target as its adult form, but sometimes truncate the target possibly because there may be limitation on production.

2.4 Remaining issues and research questions

2.4.1 Summary of previous accounts

In the preceding section, we provided a critical review of previous approaches to child word truncation. The summary of major accounts is as follows:

Gerken (1994, 1996) and Fikkert (1994) propose that children have their own metrical template specific to their ambient language and that they produce syllables that fit into the template and delete those that do not. According to this account, the deletion of a word-initial unstressed syllable (e.g. *banana* → [nænə]) is because the syllable does not fit into a trochaic template English children have. Meanwhile, Demuth and Fee (1995) and Demuth (1996b, 1996c) put emphasis on the prosodic representation of the output and argue that children's word shapes are governed by prosodic constituents in prosodic hierarchy. According to the account, the truncation of *banána* into [nænə] occurs at the stage of stress feet (i.e. stage III), until which

[33] In many cases, children alternate between full and truncated forms for the same target during the similar development period (Kehoe and Stoel-Gammon, 1997b: 537).

children have not yet acquired the ability to produce a prosodic word with unfooted syllables (stage IV). Other researchers (Echols and Newport, 1992; Echols, 1993; Snow, 1998) explain children's word truncation on the basis of perceptual limitations. They hypothesize children's production is controlled by their perceptual capacity and affected by the acoustic features of the target word. They argue stressed and word-final syllables that receive acoustic prominence are perceptually more salient, thus more likely to be produced by children. The deletion of the initial syllable in *banána* → [nænə] is, therefore, attributable to lack of its prominence compared to the other syllables.

Of the previous studies on child word production, only the prosodic structure account focuses on the output itself and claims that children try to satisfy constraints on prosodic shape. In contrast, the trochaic template account and the perceptual salience account focus on the characteristics of the target (i.e., which syllable of the target will be preserved) and not on the output. They deal with little regarding stages of prosodic acquisition, whereas the prosodic structure account helps understand how prosodic representations change over time.

In sum, the trochaic template account and the perceptual salience approach focus predominantly on the information of the target word: i.e. which syllable of the target will be retained. The former attributes truncation to children's inclination to produce a trochaic form and the latter regards children's perceptual limitation as the primary factor. On the other hand, the prosodic structure account focuses on the output itself: child words are constrained by prosodic well-formedness.

2.4.2 Remaining issues

It should be noted that all the approached reviewed succeed in providing accounts of some patterns of truncation including the vulnerability of word-initial weak syllables to omission and the retention of stressed syllables. The high probability of retaining word-final syllables is explained more satisfactorily by the perceptual salience account. We have shown that each approach has issues unresolved and some issues are not explained by any account.

One of them is how to explain that truncation is influenced by segmental information of the target word as well as by stress and word position. We have seen that target words like *elephant* and *telephone* are more frequently truncated than words like *octopus* and *crocodile*. It suggests that target words containing intervocalic sonorants are more likely to be truncated than those containing intervocalic obstruents.

Another important issue that should be addressed is concerned with TSC. The previous approaches see syllables as the basis of word truncation. In other words, it is the unit of syllable of the target word that is engaged in truncation process, as we have used such clauses as 'unstressed syllables tend to be omitted; 'stressed or word-final syllables are more likely to be preserved.' However, in the TSC like [bænə] for *banana*, the deleted material is not a syllable of the target, but it is the subsyllabic units from two syllables: rhyme of the first syllable and the onset of the second syllable. Accordingly, the previous accounts are insufficient to account for TSC.

According to the approaches we discussed in section 2.3, stressed syllables are highly likely to be retained. In particular, consonants of stressed syllables have been argued to be produced with great accuracy for English-learning children (Klein, 1981).[34] However, we encounter child words in which the consonant of a stressed syllable is not produced and instead the onset of the preceding unstressed syllable appears on the child production: e.g. TSC such as [bænə] for *banana* is the case. TSC shows different behaviors from what we considered in section 2.2 the generalized patterns of truncation.

34 Quote from Echols and Newport (1992: 194).

Let us explore TSC for the target *banana* from the perspective of the previous approaches.

According to the trochaic template, the word-initial weak syllable of *banana* is deleted completely because it does not fit into the template. This is contradictory since the onset /b/ of the initial unstressed syllable, that is destined to be deleted, is produced in the child output [bænə]. Moreover, Fikkert's prosodic circumscription targets prosodic units like foot or syllable, but in TSC the circumscribed materials from the targets are not a prosodic unit. While the onset of the first syllable and the rhyme of the second syllable are copied and mapped into the child's output, they do not form a prosodic unit.

TSC poses a challenge to the perceptual salience approach. According this approach, a word-initial unstressed syllable should be deleted since it is perceptually non-salient. So the part of the initial unstressed syllable is supposed to be deleted. However, the segment /b/ of the initial unstressed syllable of *banana* is produced in [bænə]. This suggests that the child may perceive the unstressed initial syllable as well. In conclusion, the perceptual salience account also fails to give a clear account of syllable conflation.

By contrast, the prosodic structure may be able to explain TSC since its focus is on the well-formedness of the output forms. For the target *banána*, [bænə] is a well-formed trochaic foot, so it is an accepted form within this account. According to Demuth and Fee (1995),[35] "segments may be drawn from any part of the target word" to satisfy constraints on prosodic structure, while "largely drawn from stressed syllables." Therefore, this approach may allow TSC of [bænə] for *banána*.

Note, however, that *banana* is produced as both [bænə] and [nænə] depending on children. It is an important issue how variability in the manner of truncation can be explained. Some children truncate it using syllable omission and others conflate two syllables into one, as

[35] Kehoe (1999/2000: 29).

presented in (28).

(28) Variant truncations of *banana* by child

Manner	Truncation	Child	Source
TSO	[nænə]	Trevor, Derek, Sean	Pater (1997)
	[nænæ]	18m4	Kehoe (1999/2000)[36]
	[nɛːnʌ]	28f1	
	[nænə]	22f1	
TSC	[bænə]	Julia	Pater (1997)
	[baːnə]	Amahl	Smith (1973)
	[bɑni]	27m6	Kehoe (1999/2000)
	[bænʌ]	28m3	

We have observed that the templatic account and the perceptual salience account predict only TSO regardless of segmental contents of the targets. On the other hand, the prosodic structure account leaves a leeway for variability. According to this account, both [nænə] and [bænə] are well-formed forms and it allows segments of the output to be drawn from any part of the target word. However, the arbitrariness in drawing any segments to fit into the given prosodic representation is too powerful to accept. The arbitrariness may allow double truncations for any target. In addition, we will see in the next chapter that the target like *balloon* is rarely truncated by syllable omission: it is rarely produced as [lun]. All of the four children in Pater (1997) produce *balloon* as [bu], [bun], [bʊn], [bʌ] or [bum], none of which contains /l/, the onset of the stressed syllable. On the other hand, target like *tomato* never undergoes TSC as [teto] or [tedo]. In conclusion, the prosodic structure account does not clarify why targets like *balloon* and *tomato* rarely show variability: all truncated forms for *balloon* belong to TSC, and those of *tomato* are TSO.

[36] Children subjects in Kehoe (1999/2000) are identified according to age and gender without using real names: 18m4 refers to an 18-month-old male child numbered 4.

In summary, previous studies on child word truncation have been conducted regarding a syllable as the unit of truncation, overlooking segmental information and subsyllabic unit of the target. However, we observed that targets with intervocalic sonorants are more frequently truncated and that in TSC subsyllabic units of the target (the onset from one syllable and the rhyme from the other syllable) are copied into a child production. Furthermore, we will find out in the next chapter that targets containing intervocalic sonorants are more likely to undergo TSC. Lastly, variability in truncation (TSO vs. TSC) among children is rarely addressed in previous research. Most of the previous research focuses only on TSO. In this view, the present study will investigate TSC as well as truncation in general and seek a way of explaining variations in truncation among children.

We have observed that some of the previous studies focused on children's perceptual limitation and others on constraints on the output forms and that a single approach cannot solve all the issues discussed above. In this view we will assume that young children have limitation on production as well as on perception and that their word truncation is partly due to both aspects of limitation. We also assume that child phonology has the same substance as adult phonology (Fikkert, 2007). Under this assumption, child word production will be explored by means of the notions and tools in adult phonology.

Chapter 3

Truncation of Syllable Conflation

3.1 Introduction

As reviewed in Chapter 2, most of the previous studies have paid little attention to TSC, viewing the syllable as the basic unit of truncation and argued that relatively weak syllables (metrically, prosodically or perceptually) are prone to omission.

The present chapter will investigate TSC in more detail and show that there is a relation between truncation and the feature [sonorant] of sounds in the target as suggested in Kehoe and Stoel-Gammon (1997a, 1997b). For this, section 3.2 analyzes the data of truncations obtained from Pater (1997: 216-218). The finding will serve as the basis of our account of TSC and truncation patterns as a whole. Section 3.3 will discuss the implication of TSC and provide a brief review of previous description for it. In section 3.4 I will propose scenarios for explaining TSC. Among 3 scenarios, two will be further discussed in the following chapters.

3.2 Data analysis

There are two objectives of the data analysis. The first objective is to investigate the frequency of TSC compared to that of TSO in the children's truncation. It is noted that previous studies on child word production have viewed truncation and syllable omission as identical. They consider TSC as marginal or deviant. However, we will show that syllable conflation frequently occurs in word truncation. The other objective is to find out the characteristics of the target words subject to syllable conflation. We will find out that sonorant sounds are rarely produced in the child words and they may result in TSC.

3.2.1 Database

The primary source for our data analysis originates from Pater (1997). The database to be analyzed is a collection of truncated word forms for 67 target words produced by four children Derek (1;0.6-3;2.1), Julia (1;221-3;1.3), Sean (1;1.25-3;2.20) and Trevor (0;8-3;1.8) (Pater, 1997). The source data by stress type are provided in Appendices B-D,[37] and the rearranged data by truncation manner (TSO and TSC) are given in Appendix E, which is intended for later discussion about the choice of syllable onset. As mentioned earlier, child productions are represented by the narrow phonetic transcription since they refer to real production for a given target by definition. Hence, there are such unusual transcriptions as [iː] and [aːː] to denote vowel length.

To compute the frequency of TSC and TSO, the number of truncation in each category is counted. The counting is conducted as follows: If a child produces two different productions for the same target regardless of the age, they are included in the database as two different productions. For example, Julia pronounces *tomato* differently at varying times as follows:

tomato	[meno]	Julia (1;9.22-1;10.27)
	[meto]	Julia (2;0.11-2.10.30)

Then it is counted as two different productions. If for the same target words, different children pronounce the same, then they are regarded as different truncations. For example, for the target *banana*, Derek, Sean and Trevor produce the same word [nænə]:

[37] Although *buffalo* and *dominoes* are ŚWS, they are classified as SWW targets in Pater (1997). In terms of truncation, they show similar behaviors to SWW targets in the data. Thus, I also put them into the same class along with the SWW targets.

banana	[nænə]	Derek (2;3.0-2;4.0)
	[nænə]	Sean (1;8.28-1;11.19)
	[nænə]	Trevor (0;11.10-1;6.8)

Then it is counted as three productions. As a result, we obtain a total of 177 truncations: 67 truncated outputs for 23 WSW targets, 58 for 25 WS targets, 49 for 17 SWW targets and 3 for two ŚWS targets.

3.2.2 Classification into TSO and TSC

The data demonstrate that the children show a strong tendency to produce both stressed and word-final syllables and to omit non-final unstressed syllables. Their word productions are strictly consistent with trochaic patterns. That is, trisyllabic targets are truncated into SW and disyllabic targets into S. Some truncations occur through the omission of an unstressed syllable and others through the conflation of two syllables. Examples are given below:

(1) Examples of syllable omission and conflation

	Target	truncation	Child
a.	museum	[ziːʌm]	T (2;2.27)
	dessert	[zɚt]	J (2;8.7-2;9.24)
	elephant	[ɛfɛnt]	S (2;1.19)
		[ɛ́lfɪnt]	S (3;1.18-3;1.27)
b.	delicious	[dɪʃəs]	J (1;11.27)
	garage	[graːʤ]	T (1;10.5-2;0.24)
	garage	[graːʤ]	T(2;3.3)
	favorite	[fevət]	J (2;0.25-2;6.1)

Regarding WS(W) target words, syllable omission is when the unstressed initial syllable as a whole is omitted from the target words. In (1a), *museum* is produced as [ziːʌm] by removing the word-initial unstressed syllable. Syllable omission in SWW targets refers to either the omission of the word-medial weak syllable or the word-final weak syllable. In *elephant* [ɛfɛnt] in (1a), the medial unstressed syllable is omitted.

Syllable conflation for WS(W) targets involves conflating the initial unstressed syllable and the stressed syllable. As seen from *delicious* [dɪʃəs] and *garage* [graːʤ] in (1b), the onset consonant of the stressed syllable is not produced. Instead the onset of the preceding unstressed syllable is produced along with the rhyme of the stressed syllable. As a result, the onset /d/ from the first syllable and the rhyme /ɪ/ from the second syllable constitute the first syllable of the child truncation [dɪʃəs]. Syllable conflation for SWW or ŚWS targets occurs when word-medial and word-final syllables are conflated. In this case, the initial stressed syllable is preserved intact. In *fávorite* [fevət], the onset of the medial syllable and the rhyme of the word-final syllable constitute the second syllable of the truncation. We will limit the notion of TSC to such cases that when two syllables are involved in truncation, the nucleus of the second syllable is preserved whereas that of the first syllable is deleted. According to this limitation, [ɛ́lfɪnt] for *elephant* does not belong to TSC while [graːʤ] for *garage* are classified as TSC.

3.2.2.1 Truncation of target words starting with an unstressed syllable

As noted above, syllable omission for WS and WSW target words refers to the omission of the word-initial weak syllable, and syllable conflation indicates the truncation when the initial unstressed syllable and the stressed syllable of the target are coalesced into the first syllable of the child word. Examples of TSO are given in (2) and examples of TSC are presented in (3).

(2) TSO for WS, WSW targets

Stress type	Adult Target	Child Output	Child[38] (age)
WS	again	[gɛn]	J (1;10.1-2;1.24)
	alone	[won]	D (2;6.24)
	apart	[part]	T (1;9.29)
	around	[wau ː n]	T (2;0.8)
	dessert	[zɚt]	J (2;8.7-2;9.24)
	enough	[nʌf]	T (1;10.5-1;11.25)
	machine	[ʃɪ]	T (1;8.26-2;4.13)
	Merced	[sɛd]	T (1;11.12-2.11.10)
	Michele	[ʃɛ ː u]	T (1;6.25-2;5.26)
	today	[de]	D (2;8.19-3;2.0)
WSW	banana	[nænə]	D (2;3.0-2;4.0),
	Modesto	[dɛsto]	T (2;8.15)
	museum	[zi ː ʌm]	T (2;2.27)
	potato	[teto]	J (2;5.15)
		[te ː to]	T (1;919-1.10.5)
	pretend	[tɛnd]	J (2;1.20-2;3.30)
	remember	[mæmə]	J (1;10.8-3;0.1)
		[mæmbə]	J (2;1.18-2.7.29)
	Theresa	[ri ː sə]	T (2;11.10)
	together	[gɛ ː dɚ]	T (1;9.27-2;0.27)
	tomato	[meno]	J (1;9.22-1;10.27)
		[meto]	J (2;0.11-2.10.30)
		[me ː do]	T (2;0.27)
	umbrella	[bwɛa]	D (1;11.30)
		[bɛla]	S (2;0.1)
		[bre ː wa]	T (1;11.5)
	vagina	[ʤai ː nə]	T (2;11.10)

In the child word productions in (2) the first syllable of the target is deleted entirely not to mention its onset consonant. For example, Trevor at age 2;0.27 deletes the first syllable in *tomato* and produces [me ː do]. In this sense, we can say truncation of words occurs at the syllabic level in (2).

On the other hand, the child outputs listed in (3) retain the ‘onset’ of the unstressed initial

[38] J, D, T, S refers to Julia, Derek, Trevor and Sean in Pater (Pater, 1997), respectively.

syllable and its 'rhyme' is deleted. For example, Derek produces [bun] for *balloon* by deleting the rhyme of the first syllable as well as the onset of the second syllable of the target. Thus we can say the truncations in (3) occur at the subsyllabic levels.

(3) TSC for WS, WSW targets

Stress type	Adult Target	Child Output	Child (age)
WS	balloon	[bun]	D (2;2.25-2;4.26)
		[bʊn]	J (1;9.18-1;10.23)
	belong	[bɔŋ]	J (1;11.27-2;0.26)
	Denise	[dis]	T (1;1.17-2;2.15)
	garage	[gaːʤ]	T (1;10.5-2;0.24)
		[graʤ]	T (2;3.3)
	Marie	[mi]	T (1;6.17-1;9.2)
	police	[pis]	J (2;1.10-2;5.3)
		[plis]	J (2;6.5)
		[piːs]	T (2;4.13)
WSW	banana	[bænə]	J (1;11.6-2.5.29)
	delicious	[dɪʃəs]	J (1;11.27)
	gorilla	[gʌːwa]	T (1;11.14)
	maracas	[maːkas]	T (2;0.27)
	piano	[pæːno]	T (1;11.9-2;2.23)
	potato	[pedo]	J (2;0.25-2;1.20)

In sum, syllable omission and syllable conflation can be described by three structural parameters:

(4) a. Truncation occurs at the level of syllable. [Yes, No]
 b. The onset of the stressed syllable is produced. [Yes, No]
 c. The onset of the initial unstressed syllable is deleted. [Yes, No]

Regarding TSO, all the parameters have the default value of 'Yes.'[39] For example, in the

[39] We note that syllable omission is more frequent manner of truncation. Thus, the value of the syllable omission is

truncation [nænə] for *banana,* the whole of the initial syllable /bə/ is deleted (4a: Yes); the onset of the stressed syllable /n/ is produced (4b: Yes); the onset of the initial unstressed syllable /b/ is deleted (4c: Yes). TSC is more complex in the value of the parameters. The majority of syllable conflations in (3) have the value of 'No' for all three parameters. Take, for example, *belong* [bɔŋ]. The deleted materials from *belong* are the rhyme of the first syllable and the onset of the second syllable (4a: No); the onset of the stressed syllable, /l/ is deleted (4b: No); the onset of the initial unstressed syllable, /b/ is produced (4c: No).

(5)

Parameter	*banana* [nænə]	*belong* [bɔŋ]	*garage* [graʤ]
(4a)	[<u>Yes</u>, No]	[Yes, <u>No</u>]	[Yes, <u>No</u>]
(4b)	[<u>Yes</u>, No]	[Yes, <u>No</u>]	[<u>Yes</u>, No]
(4c)	[<u>Yes</u>, No]	[Yes, <u>No</u>]	[Yes, <u>No</u>]

Not all the syllable conflations can be defined by three 'No' values. For example, for *garage* [graʤ], the deleted materials from the target are the rhyme of the first syllable (4a: No); the onset of the stressed syllable, /r/ is produced (4b: Yes); the onset of the initial unstressed syllable, /b/ is produced (4c: No). In short, syllable omission in WS(W) targets has a set of parameter values {Yes, Yes, Yes}, while syllable conflation has {No, No, No} or {No, Yes, No}.

Now, let us count the number of child productions falling into each category for WS and WSW target words. The results are presented in table (6). When it is not possible to tell whether the stressed onset is preserved or not or when there is far too much change in segments like [jə] for *another* and [fæfue] for *Nathaniel,* they are classified as Others.

(6) The number and percentage of omission and conflation for WS(W) targets

Target Form	One σ omission	Two σs conflation	Others

given as the default value.

WSW_f	67[a] (23)	45 (67%)[b]	11 (16.5%)	11 (16.5%)
WS	58 (25)	31 (53%)[c]	27(47%)	0
Total	125 (48)	76 (61%)	38 (30%)	11 (9%)

Note. a. The number of productions by children for targets (given in parentheses).
b. The proportion for WSW targets only.
c. The proportion for WS targets only.

In summary, there are 67 truncated forms for 23 WSW target words and 58 truncated forms for 25 WS target words, which brings the total to 125 productions for 48 targets. The total number of TSO is 76, accounting for 61%; and the number of truncations of syllable conflation is 38, taking up 30%. It is notable that WS targets, in particular, display no substantial difference between omission and conflation (53% : 47%). Furthermore, given that syllable omission for WS targets includes 18 productions whose targets start with onsetless syllable like *around*, *away* and *alone*, the proportion of TSC for WS targets will be considerable.

3.2.2.2 Truncation of trisyllabic targets starting with a stressed syllable

Truncations of SWW and ŚWS targets from Pater (1997: 221) are also divided into two categories: syllable omission and syllable conflation. Table (7) provides target words and their truncated forms by syllable omission. Here, syllable omission refers to either the case that the medial unstressed vowel is deleted while both the initial stressed and word-final syllables are produced or when the word-final syllable is deleted. We will show the latter case is infrequent.

(7) TSO for SWW, ŚWS targets

Adult Target	Child Output	Child (age)
ábacus	[ækus]	T (1;9.2-2;0.8)
Állison	[æ ː sʌn]	T (2;0.8-2;2.3)
ánimal	[æmʊ]	D (2;1.14-3;1.24)
bícycle	[baɪko]	J (1;8.4-1;10.13)
cámera	[kæmʌ]	S (2;0.13)
	[kæmə]	T (1;5.6-1;11.25)
	[kæmɚ]	T (2;0.3)
cínnamon	[sɪmɛn]	J (1;11.15)
cómpany	[kumni]	T (2;2.23)
dóminòes	[da ː nouz]	T (2;2.23)
élephant	[ɛ ː fɪnt]	T (1;11.14-2;6.15)
	[ɛfɛnt]	S (2;1.19)
	[ɛlfɪnt]	S (3;1.18-3;1.27)
gállopey	[gabi]	J (1;9.14)
médicine	[mɛsɪn]	J (2;0.25-2;6.1)
sésame	[sɛ ː mə]	D (2;2.8)
	[semi]	D (2;6.26-3;1.28)
trícycle	[twaɪkl]	D (2;8.18-2;10.4)
vítamin	[ga ː mɪn]	T (1;530)

I found that most of the target words in (7) have the final syllable with a coda consonant or a syllabic consonant. For such targets, their truncation preserves the final syllable: e.g. *a*$_1$*ba*$_2$*cus*$_3$ → *a*$_1$*cus*$_3$ [ækus] and *cin*$_1$*na*$_2$*mon*$_3$ → *cin*$_1$*mon*$_3$ [sɪmɛn]. Among targets with an open syllable as the final syllable are *company*, *gallopey*, *sesame* and *camera*. The first three words end with a tense vowel /i/, whereas the final word *camera* ends with a lax vowel /ə/. The former words are truncated by the deletion of the medial, unstressed syllable, while the latter is truncated by the deletion of the final, unstressed syllable. In fact, the only productions that I classified as the omission of the word-final syllable are those for the target *camera*. Its truncated forms are [kæmʌ], [kæmə] or [kæmɚ]. If it is the case that the final syllable is wholly deleted, the production should not contain any information of the syllable. However, it is difficult to determine whether the final vowel of the productions is from the medial syllable or from the final syllable of the target since both have a lax vowel /ə/. In this light, I exclude the child productions for *camera* from our discussion hereafter until a further remark is made. In short, all the productions in (7) except for the three productions preserve the word-final syllable and delete the word-medial unstressed syllable.

Syllable conflation in the trisyllabic targets starting with a stressed syllable is different from that of WS(W) targets in the sense that two rightmost syllables are conflated into a weak syllable of the child forms and the word-initial stressed syllable is always produced. Examples of TSC and their targets are provided in (8).

(8) TSC for SWW, ŚWS targets

Adult Target	Child Output	Child (age)
búffalò	[bʌfo]	J (2;0.14-2;3.9)
bróccoli	[baki]	J (1;7.6-2;0.19)
cómpany	[kʌmpi]	J (1;11.14), S (2;0.27)
dúngarees	[gʌŋgiːz]	T (1;10.1)
fávorite	[fevət]	J (2;0.25-2;6.1)
sésame	[sɛsi]	S (2;5.14)
spátula	[bæːʧʌ]	T (1;11.23)

In contrast to (7) where most of the targets end with a consonant, the target words in (8) largely end with an open syllable except for *dungarees* and *favorite*. Hence we can draw a conclusion that the final syllables ending with a consonant are more likely to appear as a whole in the child production that those ending with a vowel. However, even when it is an open syllable, the final syllable is not completely omitted but produced partly: the vowel (or the rhyme) of the final syllable is produced in child productions, as the underlined part demonstrates in *buffalo* /bʌ́fəl<u>ò</u>/

→[bʌf<u>o</u>], *company* /kʌ́pən<u>i</u>/ → [kʌmp<u>i</u>] and *favorite* /févər<u>ɪt</u>/ →[fev<u>ət</u>]. If we exclude three productions for *camera* in (7), truncated productions for SWW and ŚWS targets all contain at least the rhyme of the final syllable. We can set structural parameters to distinguish syllable omission and syllable conflation, similarly to (4).

(9) a. Truncation occurs at the level of syllable. [Yes, No]
b. The onset of the word-final syllable is produced. [Yes, No]
c. The onset of the word-medial syllable is deleted. [Yes, No]

Unlike WS(W) targets, SWW and ŚWS targets show two different sets of parameter values for syllable omission: {Yes, Yes, Yes} (e.g. *abacus* [ækus]) and {No, Yes, No} (e.g. *elephant* [ɛlfɪnt]). In *abacus* [ækus], the medial syllable as a whole is deleted (9a: Yes); the onset of W_2, /k/ is produced (9b: Yes); the onset of W_1, /b/ is deleted (9c: Yes). The parameter values of *buffalo* [bʌfo] are all 'No.' In *elephant* [ɛlfɪnt], the deleted part is not the whole medial syllable but the vowel of the medial syllable, so it has value 'No' for the first parameter. Since /l/, which serves as the onset of the medial syllable, is produced in the child form, the value for the third parameter is 'No'. On the other hand, truncations of syllable conflation have all 'No' for three parameters. In *buffalo* [bʌfo] for *buffalo*, the onset /f/ of the medial syllable is produced (9c: No) while the onset /l/ of the final syllable is omitted (9b: No).

(10)

Parameter	*abacus* [ækus]	*elephant* [ɛlfɪnt]	*buffalo* [bʌfo]
(9a)	[<u>Yes</u>, No]	[Yes, <u>No</u>]	[Yes, <u>No</u>]
(9b)	[<u>Yes</u>, No]	[<u>Yes</u>, No]	[Yes, <u>No</u>]
(9c)	[<u>Yes</u>, No]	[Yes, <u>No</u>]	[Yes, <u>No</u>]

Based on the parameter, the classification of truncations reveals that among the total of 52 productions for 19 SWW targets, the proportion of TSO is 63% and TSC amounts to 19%, as illustrated in (11).

(11) Truncation of tri-syllabic targets with the word-initial prime stress: $\acute{\sigma}_1\sigma_2\sigma_3$

	TSO of either σ_2 or σ_3		TSC of σ_2 & σ_3		Others[a]
Examples	abacus [ækus]	camera [kæmə]	buffalo [bʌfo]	favorite [fevət]	
Proportion	60% (31[b])	6% (3)	19% (10)		15% (8)

a. When it was not possible to tell which syllable children are attempting due to great segmental changes, the production is coded as others.
b. The total of each case is represented in parentheses. The percentage is against the all productions of the targets.

Interestingly, it is in merely 6% of the truncation that the final unstressed syllable is completely deleted and the medial weak syllable is produced. The partial presence of the medial syllable entails syllable conflation. In conclusion, TSO occurs in 66% and syllable conflation is undertaken in 19% of the truncations.

3.2.2.3 The proportion of TSC

To sum up the results, TSO account for 62% and TSC occurs in 27% of all 177 truncated productions. The proportions by target type are presented in (12).

(12) The number and percentage of syllable omission and conflation for all data

Target Type	Output total	One σ omission		Two σs conflation		Others	
		No.[a]	%[b]	No.	%	No.	%
WSW	67 (23)[c]	45	67 %	11	16.5 %	11	16.5 %
WS	58 (25)	31	53 %	27	47 %	0	
SWW ŚWS	49 (17) 3 (2)	34	66 %	10	19 %	8	15 %
Total[d]	177 (67)	110	62 %	48	27 %	19	11%

Note a. No. refers to the number of productions.

b. The proportion is against all productions of each target.
c. The number of target words is given in parentheses.
d. In the row of Total, the figures are as to the total of productions with WS, WSW, SWW and ŚWS combined

To compute the mean TSC proportion of the four children, the number of each truncation type for each child is used, as provided in (13). The proportion of TSC for each child (marked by shade) is obtained by dividing the total number in row (13d) by the number of TSC in row (13b).

(13) The number of each truncation and the proportion of TSC by child

	Derek	Julia	Sean	Trevor
a. number of TSO	15	26	14	55
b. number of TSC	3	22	7	16
c. number of Others	0	4	8	7
d. subtotal	18	52	29	78
e. TSC proportion	0.17	0.42	0.24	0.21

The mean proportion of TSC for the four children is 0.26 and the standard deviation is about 0.096.[40]

3.2.3 Analysis of target words

In the previous section, we have found out that conflations occur in about 27% of truncations for WS, WSW and SWW targets and the mean proportion of TSC for the four children is 26%. In this section, we will examine the characteristics of the target words that go through TSC and decide what causes some of them are truncated by syllable omission and others by syllable

[40] Since the sample size is small as 4, we use the *t*-distribution to compute the confidence interval of a population mean. The result is that the mean lies in the interval [0.26-0.11, 0.26+0.11] at 95% confidence level (the degree of freedom is 3).

conflation.

First, perusing WS and WSW targets of TSC (presented in (3)) demonstrates that the stressed syllable starts with a liquid /r, l/ or with a coronal stop /t/ or /n/: e.g. *delicious* [dɪʃəs], *balloon* [bun], *maracas* [maːkas], *garage* [gaːʤ], *banana* [bænə], *potato* [pedo] and *guitar* [gaːr]. In other words, /r/, /l/, /n/, and /t/ are not realized in the word-medial position although they are the onset of a stressed syllable.[41] This suggests that there may be another influential factor than prosodic stress to

Across all target words in the data, words containing an intervocalic liquid as the stressed onset are truncated by syllable conflation except for some words: *Theresa* [riːsə], *alone* [won] and *around* [wauːn]. The liquid /r/ in *Theresa* is realized as in [riːsə] by Trevor (2;11.10). It is notable that [riːsə] for *Theresa* was produced at a relatively older age - when he was almost three years old. Words starting with a vowel like *alone* and *around* are not truncated by syllable conflation even though they contain a liquid as the onset of the stressed syllable. These words are truncated through the omission of the initial syllable (in fact, a vowel), and the liquid is substituted with an approximant: e.g. *alone* [won] by Derek (2;6.24) and *around* [wauːn] by Trevor (2;0.8). With a few exceptions like these, liquids in between the initial syllable and the stressed syllable of WS(W) targets trigger syllable conflation.

With respect to the intervocalic coronal stop /n, t/, we need to use more caution to assert that they lead to syllable conflation. First of all, coronal stops /t, n/ are not as influential as liquids /r, l/ in triggering syllable conflation. The target word *banana* with /n/ as the medial onset is truncated into [bænə] as well as into [nænə] depending on children: [bænə] is a case of syllable conflation and [nænə] is a case of syllable omission. Likewise, *potato* is truncated by

41 As noted earlier, it is contrary to the argument of Klein (1981) that consonants of stressed syllables tend to be produced with great accuracy for English-learning children.

syllable omission into as well as syllable conflation. The production [pedo] by Julia (2;0.25-2;1.20) is the only truncation whose target word contains a coronal oral stop /t/, whereas there are two truncations of syllable omission: [teto] by Julia (2;5.16) and [teːto] by Trevor (1;9.19-1;10.5). Likewise, the target *guitar* is truncated by syllable omission into [tar] by Sean (2;2.12) as well as by syllable conflation into [gaːr] by Trevor (1;7.20-2;1.5). Moreover, words like *pre**t**énd* and *to**d**áy* that have the coronal oral stops in the word-medial onset position are reduced by syllable omission into [tɛnd] and [de]. In short, when the target has /n/ or /t/ as the onset of the stressed syllable, it can be truncated by both syllable conflation and syllable omission depending on children, and syllable conflation induced by /n, t/ is infrequent, compared to that caused by liquids.

There is another case of syllable conflation except when /r, l, n, t/ are involved. The target word *piano* that contains an onsetless stressed syllable is produced as [pæːno], where the onset of the initial unstressed syllable of the target serves as the onset of the stressed syllable of the child form. Strictly speaking, it is different from other truncations of syllable conflation. It is just obtained by deleting the vowel of the initial unstressed syllable. However, this production is placed into the category of syllable conflation since the truncation occurs at the subsyllabic level (4a: No) and the onset of the unstressed syllable is produced (4c: No). (4b) is irrelevant since there is no onset of the stressed syllable. Therefore, when the stressed syllable of WS(W) targets starts with not only /r, l, t, n/ but also a vowel, the onset of the word-initial unstressed syllable is produced instead of the stressed onset.

On the other hand, when the stressed syllable of WS(W) targets starts with other consonants (i.e. /m/ or obstruents), they are truncated by syllable omission as seen in *tomáto* [meto], *muséum* [ziːʌm] and *togéther* [gɛːdɚ]. Note that it is the rhyme of the stressed syllable that is always preserved rather than the whole stressed syllable whether it is TSC or

TSC. Since TSC and TSO are required to be described in combined way, we would say that the onset to be produced along with the stressed rhyme is chosen between two onset consonants before the stressed vowel. It seems that it depends on the segmental features of the stressed syllable of the target which onset consonants will be chosen. If the stressed syllable is onsetless or has a liquid or coronal stop (/r, l, n, t/) as the onset, the onset of the word-initial unstressed syllable is selected and produced.

With regard to SWW or ŚWS[42] targets, we can predict a similar result to that of WS(W) targets: that is, words that are truncated by syllable conflation contain highly sonorous sounds. Since targets the two unstressed syllables for SWW targets are involved in TSC, our concern may be in whether the final unstressed syllable starts with a sonorant sound or not. The perusal of target words in (8) shows that the onset of the final syllable is a coronal sonorant /l, r, n/ or /m/ (/l/ in *broccoli*, *buffalo* and *spatula*; /r/ in *dungarees* and *favorite*; /n/ in *company*; /m/ in *sesame*).

Liquids /r, l/ are highly influential in triggering syllable conflation. All but *camera* in the data that contain a liquid go through syllable conflation. Nasals /n/ and /m/ are not as powerful as liquids as a trigger of syllable conflation. The target *sesame* containing /m/ is also truncated by syllable omission into [sɛ ː mə] or [semi] as shown in (7). Truncations of *company* also vary among children: Trevor produces [kumni] in (7) by deleting the medial unstressed syllable, while Julia and Sean produce [kʌmpi] in (8), conflating the medial and final syllables. Moreover, there are several truncated outputs in (7) whose target contains an intervocalic nasal: *dominoes* [da ː nouz], *cinnamon* [sɪmɛn], *animal* [æmʊ], *sesame* [sɛ ː mə], *vitamin* [ga ː mɪn] and *company* [kumni].

In sum, conflation occurs when the onset of the final syllable of the targets is one of the

[42] Since we have only two ŚWS targets in our data (*buffalo* and *dominoes*) and they behave the same as SWW targets, we will not label them separately hereafter except when necessary.

coronal sonorant /r, l, n/ or /m/, but target words that contain intervocalic /n/ or /m/ do not necessarily use syllable conflation (e.g. *company*, *sesame*).

3.3 Results and discussion

3.3.1 Summary and implication of TSC

We have so far investigated truncated word forms produced by four children aged 1-3 in Pater (1997). We found that all the child words conform to the trochaic foot S(W); all the stressed vowels of target words are preserved and nearly all the word-final vowels (or at least final rhymes) are preserved. We divided truncations into syllable omission (i.e. TSO) and syllable conflation (i.e. TSC). While TSO accounts for 62% of the total productions in our data, TSC also occurs quite often: in 27% of all the productions. The mean TSC proportion of four children is 26%.

We have found several interesting points regarding TSC. First, when two syllables are merged into one, it does not occur in arbitrary manners. Syllable conflation takes place in such a way that the onset of one syllable and the rhyme of the other syllable from the target constitute a syllable of the child's version. As table (14) illustrates, when two adjoining syllables are conflated, the output form is either C_1V_2(C) or $C_1C_2V_2$(C).

(14) Onset-rhyme combination from two syllables

Target word	from σ_1	from σ_2	Combi-nation	child's output	Child (age)
a. police /pəlís/	p p	is lis	pis pli	[pis] [plis]	J (2;1.10-2;5.3) J (2;6.5)
b. garage /gəráʤ/	g g	aʤ raʤ	gaʤ graʤ	[gaʤ] [graʤ]	T (1;10.5-2;0.24) T(2;3.3)
c. banana /bənǽnə/	b b	æ næ	bæ *bnæ	[bænə] [blæna]	J (1;11.6-2.5.29) J (2;3.20-2;4.5)
d. delicious /dəlɪ́ʃəs/	d d	ɪ lɪ	dɪ *dlɪ	[dɪʃəs] *[dlɪʃəs]	J (1;11.27)

Note: σ_1 refers to the first syllable and σ_2 the second syllable involved in conflation.

The former cases are represented in the upper row of each target in (14). They cling to the onset-rhyme structure of syllable. In other words, the onset of the first syllable and the rhyme of the second syllable of the target are merged to form a syllable in the child production. Such a pattern of syllable conflation suggests children are aware that a syllable consists of the onset and the rhyme. This can also serve as evidence for the syllable structure of the onset-rhyme split.[43]

In addition, the lower rows of each target in (14) show that child output forms follow the English phonotactics concerning onset cluster. In truncations like *garage* [graʤ] and *police* [plis], both onsets of the syllables involved in conflation are produced, resulting in consonant clusters. The consonant clusters, however, do not mar the well-formedness of the syllable structure. Consonant clusters in [graʤ] and [plis] are permissible onset clusters in English. Well-formed onset clusters survive on the child outputs as shown in (14a) and (14b). However, *delicious* is not truncated into [dlɪʃəs], nor is [bnænə] produced for the target *banana*. Both */dl/ and */bn/ are not possible consonant clusters in onsets.[44] Ill-formed onset clusters are either absent in the child production or substituted by well-formed ones like */bn/ → /bl/ in (14c). In this light, we conclude that children are aware of well-formed syllable structures. In other words, the transition toward the adult-like production allows for phonological well-formedness.

Secondly, the data analysis reveals that target words that are truncated by syllable conflation contain intervocalic liquid /r, l/, nasal /n, m/ or coronal stop /t/. Liquids /r, l/ powerfully trigger syllable conflation. Except for *Therésa* and *cámera*, all the targets containing a liquid as the onset of the stressed syllable (for WS, WSW targets) or of the word-final syllable (for SWW, ŚWS targets) are truncated by syllable conflation. Nasals /n, m/ and /t/ can also

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[43] Evidence of the onset-rhyme structure is found in speech errors like spoonerisms (e.g. *preach seduction* for the intended utterance *speech production*) and blends (e.g. smoke+fog→ smog; motor+hotel→ motel) (Fudge, 1987).

[44] In English, permissible consonant clusters in onset include /dr/, /dw/, /bl/, /br/, /bw/, /pl/, /pr/, /pw/, /gl/, /gr/, /gw/ (Giegerich, 1992: 155).

cause syllable conflation, but sometimes target words containing them are truncated by syllable omission: *banana* is truncated into [nænə] by omission as well as into [bænə] by conflation; *potato* is truncated into [teto] by syllable omission and into [pedo] by syllable conflation; and *sesame* is truncated into [sɛːmə] by syllable omission and into [sɛsi] by syllable conflation. To be exact, of the total of 48 productions by syllable conflation, only one has intervocalic /m/ in its target (*sesame* [sɛsi]); three truncations have intervocalic /n/ in their targets (*banana* [bænə], *Denise* [dis], *company* [kʌmpi]); 4 productions have intervocalic /t/ in their targets (*potato* [pedo]; *guitar* [gi], [ga], [gaːr]), and all the others have intervocalic liquids /r, l/ contained in their targets.

(15) Proportion of intervocalic consonant in conflated truncations

Intervocalic C	/r, l/	/n/	/m/	/t/	Total
No. of production	40	3	1	4	48
Proportion	.833	.063	.021	.083	1

As illustrated in (15), of all the 48 conflated productions, those whose target contains one of intervocalic liquids /r, l/ account for about 83%; the conflation whose target contains nasals /n/ and /m/ takes up about 6% and 2%, respectively; and the conflation whose target has intervocalic /t/ is around 8%. Notably, *banana*, *sesame*, *company*, *potato* and *guitar* are truncated by syllable omission as well. Therefore, while intervocalic liquids /r, l/ are highly likely to trigger syllable conflation, words with /n, m, t/ can or cannot be truncated by syllable conflation, depending on children.

When syllable conflation occurs, the consonant that triggers the conflation is not produced in the truncation. The trigger itself is deleted except *police* [plis] and *garage* [graʤ]. In terms of outputs, table (15) suggests that liquids are most unlikely to be produced in child word productions, followed by /n, t/ and /m/ in order. As a matter of fact, it seems that the production of /m/ is rarely restrained in child word productions. [sɛsi] for *sesame* is only one syllable conflation that /m/ is involved and *sesame* is also truncated into [sɛ：mə] and [semi] with /m/ being produced. Besides, as provided in (16), there are a number of truncations containing /m/ in our data even when /m/ comes in the position of the target where otherwise it triggers syllable conflation.

(16) Truncations where intervocalic /m/ is produced

Type	Target	Truncation	Child
WS	cement	[mɛnt]	D (2;11.27)
WSW	tomorrow	[mowo]	J (1;7.16-2;.0.17)
		[moro]	T (1;8.12-2.1.14)
	tomato	[meto]	J (2;0.11-2.10.30)
		[me：do]	T (2;0.27)
	remember	[mæmə]	J (1;10.8-3;0.1)
		[mæmbə]	J (2;1.18-2.7.29)
SWW	animal	[æmʊ]	D (2;1.14-3;1.24)
	cinnamon	[sɪmɛn]	J (1;11.15)

Take, for example, /m/ in *cement* [mɛnt] from (16). Although /m/ is the onset of the stressed syllable for the WS target *cement*, it does not bring about syllable conflation. For the SWW target *cinnamon*, /m/ is the onset of the word-final unstressed syllable. Then *cinnamon* should be truncated into [sɪnən] by syllable conflation as *sesame* is truncated into [sɛsi]. However, that is not the case. /m/ does not trigger syllable conflation at all, and it survives in the child productions. In conclusion, *sesame* [sɛsi] is an exceptional truncation and /m/ is produced more freely than any other conflation triggers /r, l, n, t/.

3.3.2 Discussion

We have shown that TSC occurs frequently as well. Furthermore, syllable conflation is not an exceptional phenomenon only found in our data from Pater (1997). Truncated words by syllable conflation are found in many other literatures as presented in (17).

(17) Examples of syllable conflation from various sources

Target	output	Source
Pinocchio	[po：kio]	Allen and Hawkins, 1978
banana	[ba：nə]	Smith, 1973
belong	[bɔŋ]	
banana	[bǽnə]	Kehoe, 1999/2000
balloon	[b^{w}un]	Kehoe and Stoel-Gammon, 1997b
potato	[péto]	
broccoli	[bʌkgi]	Lewis, Antone and Johnson, 1999
cereal	[sio]	

A child named Erick in Allen and Hawkins (1978) produced [po：kio] for the target *Pinócchio*. The stressed consonant /n/ in *Pinocchio* is not produced but the word-initial consonant /p/ is produced. Amahl in Smith (1973) produced [ba：nə] for *banána* and [bɔŋ] for *belóng* at two years. We can also find many other productions in Kehoe (1999/2000) and Kehoe and Stoel-Gammon (1997b): [péto] for the target *potáto* by a 28-month old and [bænə] for *banana* by another 28-month old. There are several truncated forms by syllable conflation in productions by a younger child Kyle aged 14-19 months from Lewis, Antone and Johnson (1999).

While examples of TSC are contained in those works in (17), they did not contain any detailed discussion of syllable conflation. Note also that the previous studies we reviewed in Chapter 2 failed to offer a clear account of TSC as we already observed. While TSC has been rarely examined, there are some works that mentioned syllable conflation. Smith (1973) described the process of truncation, *banana* → [baːnə], employing realization rules. Fikkert (1994) regarded syllable conflation, even though she did not use the term, as a result of an assimilation process.

3.3.2.1 Smith's rule-based account

Smith (1973) proposed that the word forms of Amahl are derived from the adult words by realization rules employed by the child. TSC [baːnə] for *banana* can be described by two rules. The first rule deletes an initial or post-consonantal unstressed vowel (Rule 14); the second rule deletes the post-consonant sonorant (Rule 16).[45] Then the production [baːnə] at age 2 for the target *banana* is derived from the target via two stages as follows:

(18)	banana	→	[bnaːnə]	(by Rule 14)
	[bnaːnə]	→	[baːnə]	(by Rule 16)

The second rule is initiated by the rule of consonant cluster reduction: blue → [buː].

As to the first rue, however, the treatment by Amahl of words containing unstressed initial syllables was inconsistent. He deleted the unstressed initial syllables as exemplified by *tomato* [maːduː], *behind* [aɪnd] and *without* [aʊt] (Smith, 1973). If we apply the same rules to the target *tomato*, we predict [teto] for *tomato* through the derivation: *tomato* → tmato (by Rule 14) → tato (by Rule 16), yet *tomato* is produced as [maːdu:] by Amahl and as [meːdo] by Trevor and [meto] by Julia (Pater, 1997). It is never truncated to [teto]. Consequently, Smith's rule-based approach cannot sufficiently account for much of TSC.

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45 Smith (1973:14-22) identified 26 realization rules in Amahl's phonology at 2 years old.

3.3.2.2 Fikkert's assimilation account

Fikkert (1994) discussed syllable conflation as segmental changes in truncated word forms. She suggested the conflation of two syllables found in *Pinocchio* [póːkioː] and *belong* [bɔŋ] is the assimilation of place of articulation. She argued that certain features of the target are selected for the child production along with the selected foot (trochaic feet). According to Fikkert (1994: 241), since feature [coronal] has weak position in child phonology,[46] coronal segments are vulnerable to assimilation to labial or dorsal in Dutch children's word productions[47]. That is, coronal segments behave as if they were underlyingly underspecified for the place of articulation. Hence if the word-initial consonant is either labial or velar, and the foot-initial consonant is a coronal, then the coronal consonant becomes assimilated to the word-initial consonant in term of place feature. For example, with regard to *konijn* /koːnέin/, the initial consonant is a labial /k/ and the foot-initial consonant is a coronal /n/. When the right-most foot is circumscribed, the foot-initial consonant becomes assimilated to a labial, resulting in [kέin]. For the same reason, *ballon* /bɑlɔ́n/ is truncated into [bɔn].

(19) Assimilation of place of articulation

Adult target	Child form	
konijn /koːnέin/ 'rabbit'	[kέin]	
ballon /bɑlɔ́n/ 'balloon'	[bɔn]	
kapot /kaːpɔ́t/ 'broken'	*[kɔt]	[pɔt]

[46] Labials and coronals are generally established earlier than velars. If both labials and coronals are produced, their relative frequencies are documented to vary across children and languages. Thus, neither [labial] nor [coronal] is strongly confirmed as universal default place or articulation in child language. However, [labial] may be the more common place feature than [coronal] in child English (Bernhardt and Stemberger, 1998: 291-292).

[47] In English, however, assimilation of place of articulation mainly refers to either coronal-to-velar or labial-to-velar assimilation. That is, a coronal or a labial is affected by a following velar usually in the CVC structure and assimilated to a velar, which is often called *velar harmony* (Radford *et al.*, 1999: 109). For example, coronal-to-velar assimilation includes *dog* [gɔg], *duck* [gʌk], *tickle* [gɪgu], *tongue* [kʌŋ]; labial-to-velar assimilation includes *back* [gæk], *big* [gɪg], *blanket* [gægi], *book* [gʊk] and *buggy* [gʌgi] (Pater, 1997).

kabouter 'gnome'	/ka：báutər/	*[kɑutə]	[bɑutə]

Meanwhile, if the target foot-initial consonant is labial or velar, no substitution takes place. For example, *kapot* /ka：pɔ́t/ and *kabouter* /ka：báutər/ have a labial foot-initial consonant, /p/ and /b/, respectively. Their right-most foot is circumscribed and produced as [pɔt] and [bɑutə] without any segmental change.

Fikkert's assimilation account can explain a number of English data of syllable conflation: for example, *banana* [bænə], *garage* [ga：ʤ], *potato* [pedo], *maracas* [ma：kas], *belong* [bɔŋ]. These targets have a labial (/b/ in *banana*, /p/ in *potato*, /m/ in *maracas*) or velar (/g/ in *garage*) word-initial consonant and a coronal (/n, r, t/) foot-initial consonant (i.e. stressed consonant). However, it cannot account for [dɪʃəs] for *delicious* and [dis] for *Denis*. These targets have a coronal word-initial consonant as well as a coronal foot-initial consonant. When truncated into a foot, they do not need any process of assimilation because two consonants already agree in place of articulation.

There are other truncations that cannot be accounted for by this account. Fikkert's account conditions syllable conflation to take place between a foot-initial syllable (i.e., stressed syllable) and its previous unstressed syllable, but it occurs between two weak syllables of SWW targets (e.g. *buffalo* [bʌfo], *favorite* [fevət] and *company* [kʌmpi]). Hence her account cannot be applied to these truncations. Besides, Fikkert views TSC as place assimilation without considering the manner features, so her account cannot explicate why words with a labial word-initial consonant and a coronal fricative do not undergo assimilation: e.g. like *museum* [zi：ʌm], *machine* [ʃɪ], *Merced* [sɛd] and *Michele* [ʃɛ：u]. Lastly, we know that *banana* is produced as [nænə] and *potato* as [teto] depending on children. They are the foot extracted from the target without place assimilation. These truncations of syllable conflation do not stick to the assimilation account. Therefore, Fikkert's account is not sufficient to expound our English data.

3.4 Scenarios of an account of TSC

We have thus far noted that TSC along with TSO is not explained clearly and in a principled way by relying on previous studies and accounts of child word truncation. In this section we will consider possible scenarios for syllable conflation to ultimately seek an account of truncation in general.

The first scenario may turn to perceptual prominence of sounds. Let us consider the possibility that the manner features of the intervocalic /r, l, n, t/ play a role in truncation. The onset of the stressed syllable of WSW and WS targets in (3) and of the word-final unstressed syllable from SWW targets in (8) is one of /r, l, n, m, t/. Excluding /m/, the consonants have some acoustic features in common. They share [+diffuse] and [−grave] in terms of acoustic features *diffuse* and *grave*, as defined by Jakobson and Halle (1956). *Diffuse* is characterized by lower concentration of energy in a relatively narrow, central region of the spectrum, accompanied by a decrease of the total amount of energy, and *grave* features concentration of energy in the lower frequencies of the spectrum (Jakobson and Halle, 1956: 29-31).

(20) Acoustic features of /r, l, n, t/

	r	l	n	t
Diffuse	+	+	+	+
Grave	−	−	−	−
Sonorant	+	+	+	−

The consonants /r, l, n, t/ are all diffused in energy over a relatively broad range; thus may be weaker acoustically compared to segments with energy concentration. Besides, their energy due to the feature [−grave] is concentrated relatively in the upper frequencies of the spectrum. Since the higher frequencies of the human voice have less energy (Ladefoged, 2001: 173), those segments with [−grave] have less energy, which in turn implies they are acoustically less prominent.

We might surmise that those segments are, by virtue of acoustic features, perceptually less prominent than its counterpart in the preceding unstressed syllable: e.g., /l/ is weaker than /b/ in *balloon* [bun], and /r/ is weaker than /g/ in *garage* [ga ː ʤ]. Hence /l/ and /r/ are not detected by children. On the presupposition that children tend to produce a trochaic pattern (since all the truncations in our data conform to a trochaic foot), children might choose the stronger consonant as the onset along with the stress bearing vowel from the stress syllable, thus produce [bun] for *balloon* and [ga ː ʤ] for *garage*. However, such a surmise is challenged the fact that sonorous sounds indeed have high acoustic intensity, so they are perceptually more salient than stops or fricatives (Kehoe and Stoel-Gammon, 1997b: 537). Therefore, it is improbable that perceptual saliency of consonants might cause the conflation.

The second scenario concerns ‘sonority.’ Table (15) shows that words with intervocalic sonorants /r, l, n, m/ account for 92% of all the targets of TSC. Excluding /t/ from the present discussion, we assume that syllable conflations are likely to occur between the syllable starting with a sonorant and its preceding syllable. This may have an implication for a possible account by virtue of the “sonority theory”. Sonorants /r, l, n, m/ have highly similar characteristics to vowels: they have high sonority values, which enables them to serve as the syllable nucleus. Then it is assumed that children might not distinguish sonorant consonants from vowels or might perceive them as onsets. For example, with regard to *delicious* /dəlɪ́ʃəs/, children might not consider the medial syllable /lɪ/ to form a single syllable on its own; instead, they might perceive *delicious* as two syllables - one starting with /d/ and the other starting with /ʃ/. This scenario will be developed and discussed in the next chapter. We will discuss sonority theory, and then propose an account of syllable conflation based on sonority theory and children's perceptual capability.

As the last scenario, let us think of a constraint-based approach to truncation. As we have seen above, intervocalic liquids /r, l/ fail to serve as the onset of a syllable and are deleted even when they are from stressed syllables. By contrast, the onset of the word-initial unstressed syllable is produced in the child outputs (e.g. *delícious* [dɪʃəs], *garáge* [gaːʤ]). Thus, we can assume there is a strong constraint on the production of liquids. Similarly we can assume there is a constraint on the production of nasals, although not as strong as that on liquids. Nasals /n, m/ show similar behaviors as liquids in that they are not produced even in the position of a stressed syllable, as demonstrated in *banana* [bænə] and *sesame* [sɛsi]. However, they can be produced, as seen in *banana* [nænə] and *sesame* [semi]. If the two constraints work on child word productions, we can rarely see intervocalic liquids of the target realized in the child production and intervocalic nasals of the target are less likely to be produced than intervocalic obstruents in the child production.

If the onset is determined by vying between two consonants before the stressed vowel for WS(W) targets or before the word-final vowel for SWW targets,[48] it seems that the less sonorous one is chosen as the onset: e.g. between /p/ and /l/ from *police*, /p/ is less sonorous and thus is selected to take the onset position. This is consistent with the general pattern of consonant cluster reduction: the less sonorous consonant that is produced in the cluster reduction like *spoon* [bun] and *blue* [bu]. Since the higher the sonority of the consonant, the more marked onset it can be (Prince and Smolensky, 1993; Gnanadesikan, 1995), we decide that more unmarked onsets are chosen in the child production. In this light, we will be able to

[48] Stressed vowels of WS(W) targets are always preserved and word-final vowels of SWW targets are preserved almost always at least in our data.

account for TSC based on constraints on outputs. I will elaborate on the constraint-based approach to child word truncation in Chapter 5 with reference to the data given.

Chapter 4

Sonority-based Approach to Truncation

4.1 Introduction

We have noted that previous studies on child word production did not address TSC and variability among children. This chapter will deal with TSC[49] and suggest an approach to TSC based on sonority theory. The approach to be taken here is motivated by the observation that the majority of target words that undergo TSC contain intervocalic sonorants /r, l, n. m/. Furthermore, we observe that the *elephant*-type words are much more likely to be truncated than the *octopus*-type words. It implies the involvement of sonority in truncation.

To propose an account of TSC, we will investigate acoustic characteristics of sonorant sounds. Acoustic features of a sound are relevant to what we can hear.[50] I assume that children are underdeveloped in terms of auditory perception and thus may confuse acoustically similar sounds. If sonorants are acoustically similar to vowels, children may confuse a sonorant consonant and a vowel. Then we can put forward the likelihood that children may perceive a string of a vowel, a sonorant and a vowel as one unit, without perceiving the pair of a sonorant and a vowel as a syllable on its own.

The hypothetical account of TSC of *delicious* [dɪʃəs] will be as follows: /l/ in *delicious*

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[49] The variability of truncation manner among children, i.e., the matter of [bænə] vs. [nænə] for *banana* will be addressed in chapter 5 along with TSC.

[50] The acoustics of speech is used to explain why certain sounds are confused with one another (Ladefoged, 2001: 161).

/dəlɪ́ʃəs/ is perceived as if it were a vowel. The medial vowel cluster in the resulting word /dəVɪ́ʃəs/ (V denotes a vowel resulting from the misperception of /l/) is not perceived as two syllables. This is inspired by the observation that two adjacent vowels that belong to separate syllables are sometimes perceived as forming the nucleus of one syllable just like diphthongs.[51] Then *delicious* might be perceived as two syllables with /d/ and /ʃ/ being the onsets.

To develop this approach, section 4.2 investigates acoustic qualities of vowels and sonorant consonants. This will bring us to a conclusion that sonorant consonants and vowels are acoustically similar, and as a result they cause auditory confusion to young children. In section 4.3, we will discuss sonority theory and the relation between sonority and the perception of syllables. In section 4.4 we will propose an account of TSC based on the discussion of section 4.3. The proposed account will also explain the sonorant effect found in the difference in truncation rate between *elephant* and *octopus* in section 4.5. In the last section, we will present limitations of the present approach and residual issues.

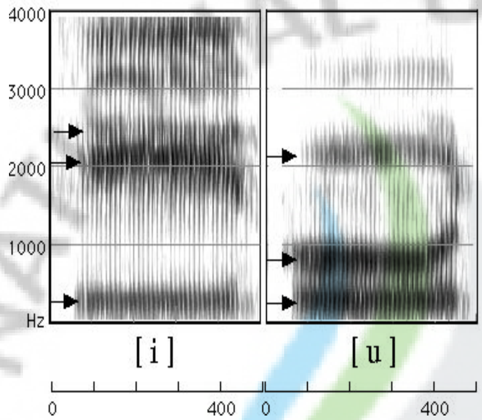
4.2 Acoustic similarity of sonorant consonants to vowels

In this section, the acoustic similarity of sonorant consonants to vowels will be represented in terms of acoustic energy and sonority. The sonority of a sound is 'the loudness of the sound relative to that of other sounds with the same length, stress, and pitch' (Ladefoged, 2001: 227). Note that the sonority mainly depends on acoustic intensity (the amount of acoustic energy that is present) (Ladefoged, 2001: 165). Acoustic energy of sounds can be represented by means of 'spectrogram.' A spectrogram is a three-dimensional display of acoustic energy across a range of

[51] Even adult speakers disagree over the number of syllables that contain adjoining vowels such as *mediate, heavier,* and *Neolithic* (Ladefoged, 2001: 226).

frequencies. In the following spectrograms, the vertical axis shows frequency; time runs from left to right (represented in milliseconds (ms)); and the intensity of each component is shown by the darkness (the more intense the energy, the darker the display).

(1) Spectrograms of [i] and [u] (Ladefoged, 2001: 175)



There are continuous bands of relatively tense energy of changing frequency. They represent formants,[52] which result from the acoustic consequences of the mouth and pharynx in terms of the varying frequency values of the resonances (Laver, 1994: 103). The formant with the lowest frequency is denoted by F_1, the second F_2, and the third F_3, each of which is indicated by the arrows in (1). Usually, the first two formants determine the quality of vowels. Table (2) gives the average of F_1, F_2 and the difference between them in eight American English vowels.

(2) Frequencies (Hz) of F_1, F_2, F_3 and F_2–F_1 in eight American English vowels (Ladefoged, 2001: 172)

vowel	F_1	F_2	F_2–F_1	F_3
i	280	2250	1970	2890

[52] Besides the pitch at which a vowel is actually spoken, there are a number of different pitches simultaneously, which we call formants (Ladefoged, 2001: 170). That is, there are a number of formants. The quality of a vowel depends on formants.

ɪ	400	1920	1520	2560
ɛ	550	1770	1220	2490
æ	690	1660	970	2490
ɑ	710	1100	390	2540
ɔ	590	880	290	2540
ʊ	450	1030	580	2380
u	310	870	560	2250

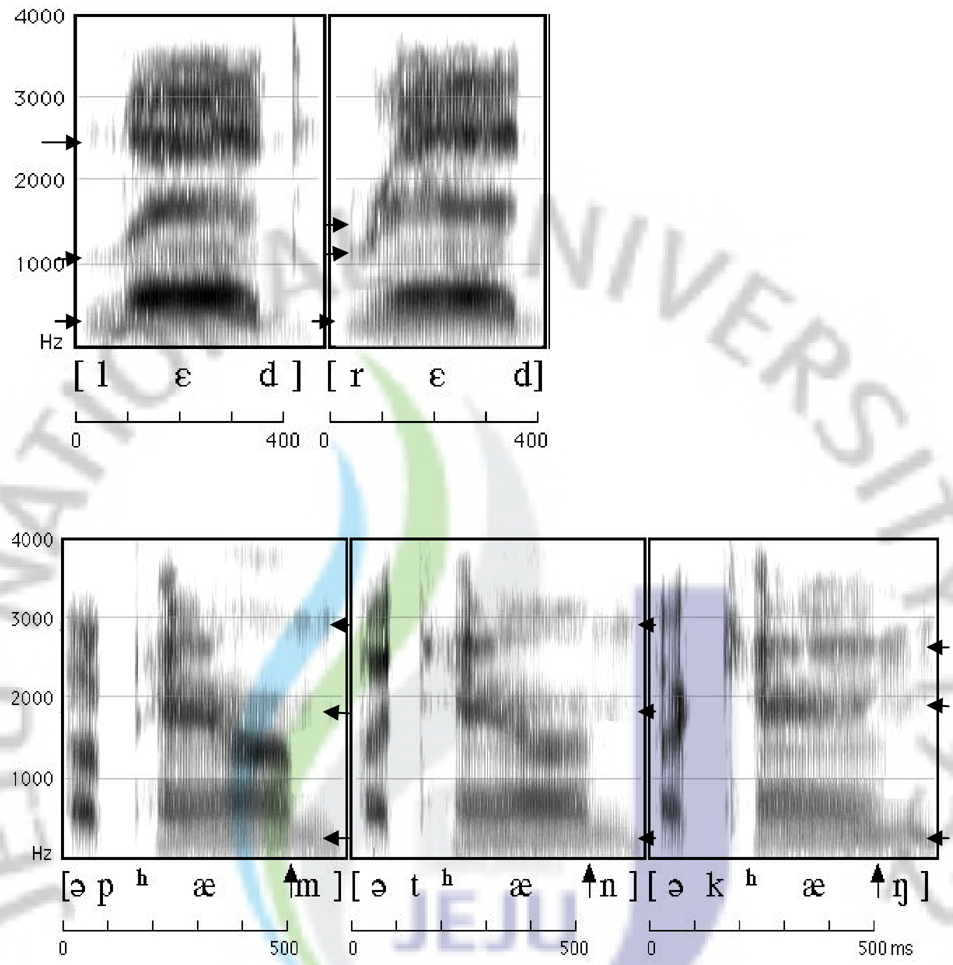
F_1 varies mostly with tongue height. Low vowels like /æ, ɑ/ have a high F_1 frequency, and high vowels like /i, u/ have a low F_1 frequency. F_1 is related to the volume of the oral cavity since it varies with tongue height. If the tongue is lowered, it expands the volume of the oral cavity, which increases resonance. Accordingly, F_1 is inversely related to the degree of resonance. F_2 is affected by both tongue advancement and lip rounding. Back vowels /ɑ, ɔ, ʊ, u/ have a relatively low F_2 and a small F_2-F_1 difference, whereas front vowels /i, ɪ, ɛ, æ/ have a relatively higher F_2 frequency and a large F_2-F_1 difference (Kent and Read, 1992: 92). Table (1) demonstrates that F_2 decreases in order of /i, ɪ, ɛ, æ, ɑ, ʊ, ɔ, u/.

Sonorant consonants also have formant structure similar to that of a vowel. As figure (3) displays, liquids and nasals have distinct formants. In (3a), the bands for the liquids as indicated by arrows, which last for the first 100 ms, are faint, whereas the formants for the following vowel are represented as broader, longer and thicker bands from after 100 ms until about 350 ms in time. The darkness implies that the vowel has more acoustic energy.

(3) Spectrograms of “led” and “red”; “a Pam, a tan, a kang” (Ladefoged, 2001: 181-184)

a.

b.



Nasals also have formant patterns similar to vowels except that they have greatly reduced energy, as illustrated in (3b). The figure gives spectrograms of “a Pam, a tan, a kang.” The arrows at the bottom indicate the oral closures forming the nasal consonants. Formant frequencies are represented by arrows at the right edge of each spectrogram. By contrast, there is no band marking energy distribution for the obstruents: /d/ for (3a) and /p, t, k/ for (3b).

We have thus far shown that liquids and nasals have acoustic energy distribution realized as three (and more) distinct formants. This characteristic is similar to that of vowels and distinguished from obstruents. Now let us look into acoustic resonance of these sounds. We note that F_1 is concerned with the resonance of a sound. Therefore, we compare the F_1 frequency between vowels, liquids and nasals to determine whether liquids and nasals have similarly high levels of resonance to vowels.

Table (4) shows the first formant frequencies of liquids[53] and nasals[54] along with those of high vowels /i, u/. They are higher than those in (3), where F_1 of both liquids and nasals is formed at around 250 Hz. (4) exhibits that the F_1 frequency of liquids and nasals is very close to that of high vowels /i, u/. Therefore, we predict that sonorant consonants have as high acoustic resonance as vowels.

(4) Mean F_1 formant frequencies for high vowels, liquids and nasals

i	u	r	l	nasals
280	310	320	340	300

4.3 Sonority theory

In the previous section we have shown that sonorants and vowels are acoustically similar to each other in the sense that they have formant structure and high degrees of resonance. Based on this finding, I previewed a possible account of TSC with regard to *delicious* [dɪʃəs]. In order to refine the suggestion, I introduce the notion of sonority of a sound and investigate the relation between syllable perception and sonority.

4.3.1 Sonority and the perception of syllables

53 The frequencies for /r/ are the mean value produced by fifteen 17-year-old males; those for /l/ are the average of three authorities' values of formant frequencies in Kent and Read (1992: 139).

54 The frequency for nasals is the one given in Kent and Read (1992: 132).

4.3.1.1 Sonority scale

The sonority of any sound is dependent upon the amount of opening in the vocal tract in producing the sound and its degree of voicing. Thus, sounds with open articulation (e.g., vowels and liquids) are highly sonorous, while sounds with closed articulation (e.g., stops and fricatives) have only a little sonority. As mentioned in the previous section, the sonority among vowels is determined by the height, or the F_1 frequency.

Since the concept of sonority is based on the relative loudness among sounds, in some literature the sonority scale is given to every segment numerically and on a regular basis: Selkirk (1984a: 112), Hogg and McCully (1987: 33) and Katamba (1989: 104). The sonority scale of Hogg and McCully is finer than the other two. Selkirk and Katamba propose the 1-6 sonority scale. These two scales are different in sonority values of obstruents. In Selkirk (1984a), obstruents are divided into two by manner of articulation and sonority values are allocated from 1 to 6 in order of plosives, fricatives/affricates, nasals, liquids, glides and vowels, whereas in Katamba (1989), obstruents are divided into two by voicing and sonority values are given from 1 to 6 in order of voiceless obstruents, voiced obstruents, nasals, liquids, glides and vowels. On the other hand, Hogg and McCully draw up sonority hierarchy with finer gradation from 1 to 10 in degree, with vowels subdivided by tongue height into low, mid and high vowels and obstruents subdivided by manner of articulation and by voicing. The scale is based on the knowledge that sonority is in part correlated with degrees of obstruction of the airstream and voicing as well. According to Hogg and McCully, the highest value 10 is given to low vowels, the lowest sonority value 1 is given to voiceless stops and all the others are ranked in between the two ends at regular intervals as presented in (5).

(5) Sonority scale by Hogg and McCully (1987: 33)

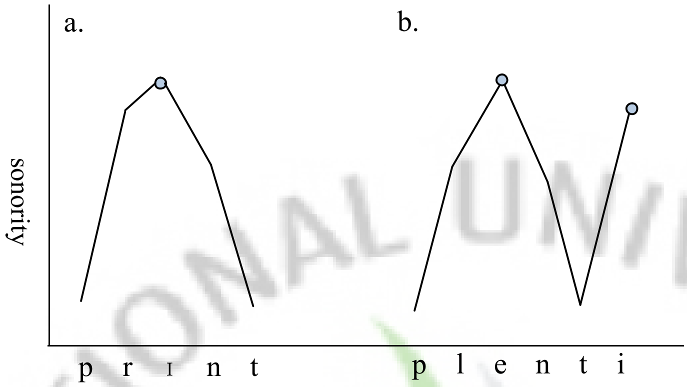
class of sounds	sonority value	examples
low vowels	10	/a, ɑ/
mid vowels	9	/e, o/
high vowels	8	/i, u/
flaps	7	/r/
laterals	6	/l/
nasals	5	/m, n, ŋ/
voiced fricatives	4	/v, ð, z/
voiceless fricatives	3	/f, θ, s/
voiced stops	2	/d, b, g/
voiceless stops	1	/p, t, k/

4.3.1.2 Sonority peak and syllable nucleus

Based on sonority, a syllable can be identified by a locally maximal point or 'peak,' which corresponds to the nucleus, with neighboring sounds having less sonority than the peak. The sonority of a syllable increases from the beginning of the syllable and decreases progressively from the peak onwards, which is what is called a *Sonority Sequencing Generalization* or SSG (Selkirk, 1984a: 116).[55] This principle suggests that phonemes with high sonority values are located towards the center of the syllable, while phonemes with low sonority values are found at the syllable margin (Wyllie-Smith *et al*., 2006: 273). A good example of conforming to SSG is the word *print*. The sequence of sonority values in *print* /prɪnt/ is 1-7-8-5-1 by Hogg and McCully's sonority scale. The vowel /ɪ/ with the highest value 8 becomes the syllable peak, whereas /p/ and /t/ with the least sonority are positioned at the margin. /r/ and /n/ are less sonorous than the vowel and more sonorous than the stops, so located in between the peak and the margin as shown in (6a).

[55] Spencer (1996: 89).

(6) Sonority profiles of *print* and *plenty*



On the other hand, the SSG suggests the word *plenty* in (6b) has two syllables since it has two sonority peaks although the second syllable ends with rising sonority.

Note, however, that sonority peaks do not necessarily represent syllable peaks. There are some exceptions to the SSG. One exception is found in words like *spot, stop, ski, splash, string,* and *skewed*. These words contain the consonant cluster onset starting with /s/ followed by a voiceless stop /p, t, k/ and in some cases, an approximant.[56] In the words, /s/ preceding voiceless stops is greater in sonority value than voiceless stops, leading to the decreasing beginning of the syllable. Take *splash* for example. The sequence of sonority values in it is 3-1-6-10-3 according to Hogg and McCully's sonority scale. Plotting the sonority values on the vertical line we obtain diagram (7a). Even though /s/ marks a local peak of sonority in *splash,* /s/ is not regarded as a syllable peak. That is, such words like *spot, stop, ski and splash, string,* and *skewed* are regarded as exceptional cases to the SSG.[57]

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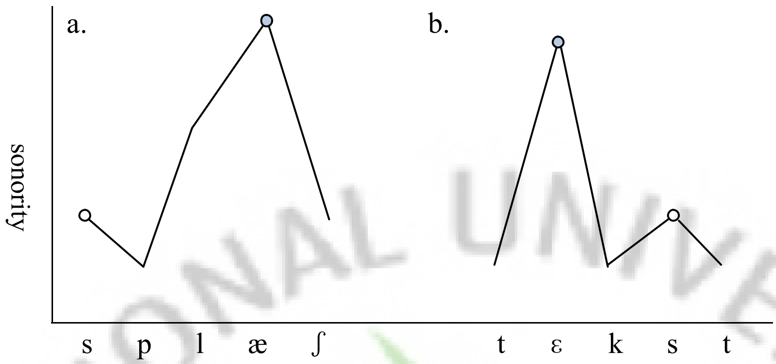
[56] The other consonant clusters in English syllable onsets comply with the SSG. Among examples are those consisting of /s/ plus a nasal/approximant like *snow*, *small*, *sling*, and *swim*; those consisting of a voiceless fricative other than /s/ plus an approximant like *shrimp*, *fly, fry, throw and thwart*; and those consisting of an oral stop plus an approximant like *play, brew, try, dwell, clue*, and *grey*.

[57] Some literature handles the problem in such a way that /s/ behaves exceptionally as an appendix to the basic syllable structure (Giegerich, 1992; Spencer, 1996). Others propose that /sp, st, sk/ should be treated as single

(7) Exception to SSG



Another exception to SSG is found in monosyllabic words like *fox*, *text* and *width* with increasing ends in sonority profiles. As illustrated in (7b), *text* /tɛkst/ has two peaks of sonority at /ɛ/ and at /s/, but for the same reason as onset cluster /sp/ in (7a) /s/ does not become a syllable peak. Nor do /s/ in *fox* and /θ/ in *width.*

By comparison, highly sonorous consonants like liquids and nasals can become a syllable nucleus if they form a sonority peak. Next to vowels, liquids /r, l/ and nasals /n, m, ŋ/ are the most sonorous sounds among consonants. While the least sonorous sounds, oral stops and fricatives cannot become a syllable peak in English, /n, m, r, l/ may become a peak of an unstressed syllable due to their high sonority values. They are found in the second syllables in *button* /bʌtn/, *rhythm* /rɪðm/, *little* /lɪtl/ and (rhotic) *butter* /bʌtr/ (Giegerich, 1992: 166). Such consonants are called *syllabic* consonants.[58] Syllabic consonants can be captured through the SSG. According to Hogg and McCully's sonority scale, the sonority sequence of the second

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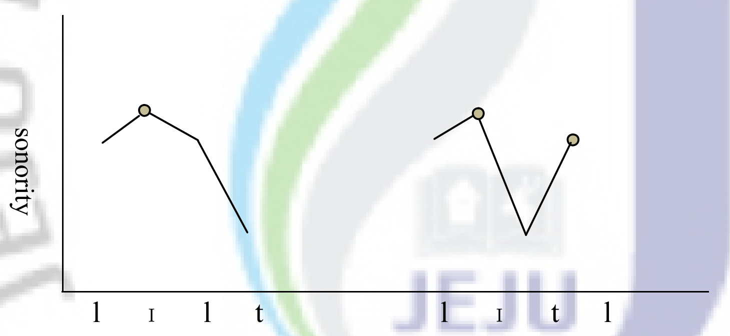
constituents in syllable onsets, given that in Old English alliterative poetry initial consonants alliterated freely (for example, /b/ alliterated with /b/ regardless of the nature of any following consonant, so that /br/ alliterated with /bl/) but /sp, st, sk/ could only alliterate with /sp, st, sk/ respectively, and none of them could alliterate with /s/ alone or with other clusters such as /sw/ (Hogg and McCully, 1987: 48). If that is the case, /sp/ in *splash* will be lower in sonority, no matter what sonority value is attached to it, than the following /l/. In consequence, *splash* conforms to the SSG.

[58] No consonant phonemes other than /r, l, n, m/ may occur in English syllable peaks (Giegerich, 1992: 166).

syllable of each word mentioned above is 1-5 for /tn/, 4-5 for /ðm/, 1-6 for /tl/ and 1-7 for /tr/. Those syllabic consonants are greater in sonority than the preceding obstruents, forming syllable peaks as well as sonority peaks.

In sum, as to the number of syllable in a word, sonority theory assumes that the number of sonority peaks and the number of syllables perceived coincide (Hogg and McCully, 1987: 34; Ladefoged, 2001: 228), except for /sp/, /st/ and /st/. For example, *lilt* and *little* contain the same segments but differ in arrangement, which results in the difference in the number of syllables: *lilt* has one syllable and *little* has two syllables as they differ in the number of sonority peaks, which are marked with gray dots in (8).

(8) Sonority profiles of *lilt* /lɪlt/ and *little* /lɪtl/



We accept the assumption that the number of syllables coincides with the number of sonority peaks except /s/ involved as discussed above.

As Ladefoged (2001: 228) points out, however, there can be disagreements over the number of syllables of some words because the sonority of different sounds may vary quite considerably depending on different speakers. He suggests that 'in a particular circumstance one speaker may pronounce [i] with a greater sonority than [l], whereas another may not.' He further hints that the final /m/ in '*prism*' and /l/ in '*seal*' might or might not constitute distinguishable peaks of sonority, because some speakers may pronounce /m/ and /l/ with greater sonority than

/z/ and /i/, respectively, whereas others may not (Ladefoged, 2001: 228). Such variation might be possible since sonority itself is not an absolute physical quantity; it is a relative concept. Even though Ladefoged hints that the relative sonority of a sound can change compared to other sounds, it does not mean it can occur arbitrarily. Note that there is no disagreement on the number of syllables in such words as “visit, divided, condensation” since “there are clear peaks of sonority.”[59] According to Hogg and McCully’s scale, /v/ and /ɪ/ or /z/ and /ɪ/ in *visit* are separated by four grades (sonority value of /z/, /v/ = 4, / ɪ / = 8), whereas /z/ and /m/ in *prism* are separated by one grade (sonority value of /z/ = 4 and /m/ = 5). Therefore we could infer that if two sounds are in adjacent grades in the sonority scale or their difference in sonority is small, the relative loudness between two sounds might be reversed in terms of auditory perception.

In this line, we will assume relative values of sonority between two sounds might vary for the part of both speakers and listeners when the two sounds are adjacent in the sonority scale, or when the difference in sonority between the two sounds is ‘sufficiently small.’ In particular, when the two sounds are between a nasal and a voiced fricative as seen from ‘prism’ or between a vowel and a liquid /r, l/ as seen from ‘seal,’ one might be confused about the number of syllables of the words, given that /r, l, n, m/ can become a syllable peak phonologically. In the following subsections, I will specifically define what it means by ‘sufficiently small’ in terms of sonority difference between two sounds and attempt to explain the incongruent number of syllables in words like ‘prism.’

4.3.2 Ladefoged’s irregular sonority scale

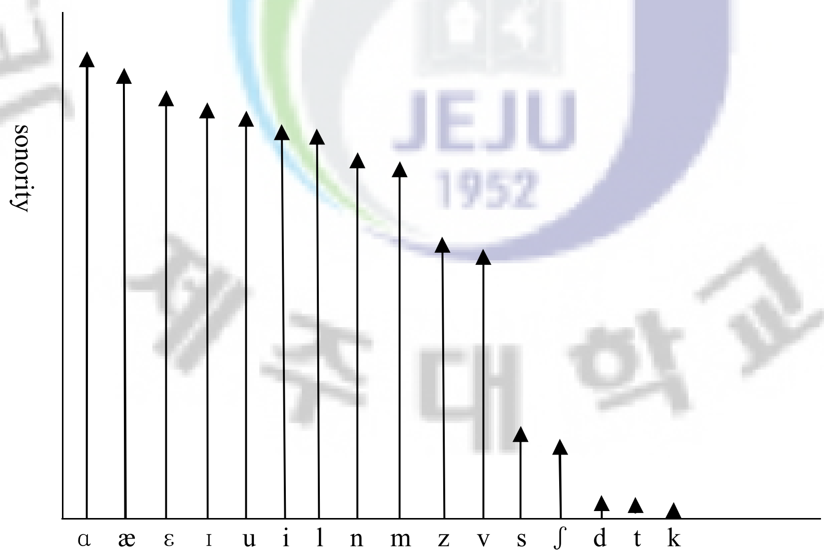
In the previous subsection, we have discussed the perception of the number of syllables based

[59] Ladefoged (2001: 228).

on the sonority scale given in Hogg and McCully (1987). The present subsection will introduce a new numerical sonority scale based on Ladefoged's concept of sonority and I will argue that this new one would be finer and more appropriate for explaining sonority theory, compared with Hogg and McCully's sonority scale.

Ladefoged (2001) provides the bar graph of sonority of English sounds taking into account the acoustic intensity of sounds. As we can see from the graph in (9), the low vowels [ɑ] and [æ] have greater sonority than high vowels [u] and [i], which is similar to Hogg and McCully's scale. It is notable that the liquid [l] has about the same sonority as the high vowel [i]. The nasals [m, n] have slightly less sonority than [i] but greater sonority than a voiced fricative like [z]. Stops, whether voiced or voiceless, have very little sonority. The highly great status of liquids and nasals in sonority is attributable to their similarly low frequency of their first formant as that of the high vowels as mentioned in section 4.2.

(9) Relative Sonority of sounds of English (Ladefoged, 2001: 228)



Ladefoged's sonority scale is not represented numerically. For the sake of convenience in subsequent discussions, I present a numerical version of the sonority scale as provided in (10). I obtained the value of each sound by measuring the height of each bar in the sonority bar graph (9).[60] For a segment whose sonority is not present in the bar graph, I assign the mean value of given sounds that share the natural class with the sound in question. For example, /f/ will be given the sonority 10.5, the mean value of /s/ and /ʃ/ since /f/ belongs to the class of fricatives.

(10) Irregular sonority scale based on Ladefoged's sonority bar graph

class of sounds	sonority value	example
low vowels	60	/a, ɑ/
low-mid vowels	58	/æ/
mid-low vowels	55	/ɛ, ə /
mid-high vowels	54	/ɪ, e/
high vowels	53	/u/
	51	/i/
liquid	50	/l, r/
nasals	48	/m, n/
voiced fricatives	38	/ z/
	36	/v/
voiceless fricatives	11	/s/
	10	/ʃ/
voiced stops	2	/d/
voiceless stops	1	/t, k/

In the sonority scale in (10), vowels are classified into groups according to height since the sonority of vowels varies depending on the vowel height. As to a vowel /ʌ/, the sonority is allotted 56.5, the median value of /æ/ and /ɛ/ because it lies in between the two in terms of vowel height. I rely for vowel height on the vowel chart in Ladefoged (2001), which is provided in Appendix A.

The new sonority scale in (10) is different from Hogg and McCully's scale in several aspects. First, it is finer in the sense that the sonority of individual sounds are given, whereas

[60] The height of each bar is measured in millimeters. I dropped out the unit of millimeters in the numeric version given in (10). For example, the low vowel /ɑ/ is given sonority value 60 since the bar for this vowel in the bar graph in Ladefoged (2001) is 60 *mm* in height.

Hogg and McCully's scale gives the sonority values on the basis of the natural class of sounds. Secondly, while in Hogg and McCully's scale, the sonority score of each class is given at regular intervals from the highest 10 to the lowest 1, the sonority values in (10) are given irregularly between the highest 60 and the lowest 1. Thirdly, while nasals and liquids are placed in the middle between the vowels and the stops in the Hogg and McCully's scale, their sonority values in the new scale are much closer to those of vowels: there is little difference in sonority between /l/ and a high vowel /i/.

We noted that when there are clear peaks of sonority, there is no disagreement on the number of syllables. Conversely, if two sounds are similar in sonority in a word, it could lead to the inconsistent perception of the number of syllables. Then it is required to specify the clear peak of sonority. Note that word-initial syllables starting with an onset, whether it is an obstruent or a sonorant like the first syllables of *visit* and *rabbit*, are easily recognizable as a syllable, and word-medial syllables starting with an obstruent onset like the second syllables of *visit* and *rabbit* exhibit clear peaks of sonority. However, the second 'syllable' of *prism* or a word-internal onsetless syllable immediately after another vowel such as the syllables of *medi**ate**, heavi**er**,* and *Ne**o**lithic* marked in bold might and might not be captured as a syllable of its own. Thus, we predict the misperception of the number of syllables occurs in the non-initial position with sonorous sounds involved.

Let us define the clear peak of sonority (in the word-medial position) in terms of the difference in sonority values. The sonority difference between two adjoining sounds can be represented numerically by using our irregular sonority scale and Hogg and McCully's regular scale (abbreviated to H&M's). We use the notation $|x-y|$ to represent the difference in sonority between two sounds /x/ and /y/. The sonority differences in *mediate* and *prism* are provided in (11).

(11) Sonority difference

Difference	Example	by irregular scale	by H&M's
$\lvert$i–e$\rvert$	/ie/ in ***mediate***	$\lvert 51 - 54 \rvert = 4$	$\lvert 8 - 9 \rvert = 1$
$\lvert$z–m$\rvert$	/zm/ in ***prism***	$\lvert 38 - 48 \rvert = 10$	$\lvert 5 - 4 \rvert = 1$

The sonority difference between adjoining vowels in *mediate* is '4' by the irregular scale and '1' by H&M's. The sonority difference between /z/ and /m/ from *prism* is '10' by the irregular scale and '1' by H&M's. In order to become a clear peak of sonority, the sonority difference between two sounds should be at least higher than '10' by (10) and '1' by H&M's. In fact, for any given obstruent /x/ and any sonorous sound /y/, $\lvert$x–y$\rvert$ takes the minimum value when /x/ is a voiced fricative and /y/ is a nasal. Therefore, we conclude that if $\lvert$x–y$\rvert$ is larger than $\lvert$z–m$\rvert$, /xy/ shows a clear peak of sonority.

Now we will show that the irregular sonority scale is more appropriate in describing perception-based sonority theory than H&M's. We have already mentioned that the local peak in sonority profile does not necessarily become a syllable peak. For example, /s/ in *splash* marks a local peak in sonority but not a syllable peak. The sonority difference between /s/ and /p/ is '10' by the irregular sonority scale and '2' by H & M's. They are exhibited in (12), compared with the difference between /z/ and /m/ in *prism*.

(12) Sonority difference between /s/ and voiceless stops /p, t, k/

Difference	Example	by irregular scale	by H & M's
$\lvert$s–p$\rvert$	/sp/ in *splash*	$\lvert 11 - 1 \rvert = 10$	$\lvert 3 - 1 \rvert = 2$
$\lvert$z–m$\rvert$	/zm/ in *prism*	$\lvert 38 - 48 \rvert = 10$	$\lvert 5 - 4 \rvert = 1$

Since /sp/ does not constitute a single syllable, we can ascertain that any two segments whose sonority difference is 10 in the irregular sonority scale are not sufficient to constitute a syllable. In other words, in order for /xy/ to form a syllable, the sonority difference $\lvert$x–y$\rvert$ must be greater than 10 in terms of the irregular sonority scale provided that they comply with the phonotactics. Meanwhile, if we take H&M's sonority scale, the necessary condition for forming a syllable should be that the sonority difference between two sounds is greater than '1' which amounts to the sonority difference between /z/ and /m/ in *prism*. However, the difference between /s/ and /p/ in *spot* is '2' by H&M's, which leads to a contradictory situation: the sonority difference of two segments /sp/ that cannot constitute a syllable is greater than that of two segments /zm/, which may and may not be perceived as a syllable depending on circumstances. Consequently, our irregular sonority scale is more valid than H&M's in describing the perception of the number of syllables in a word.

There are other factors to disfavor H&M's scale. All the difference between two consecutive grades is indiscriminately '1' in H&M's, which does not take into consideration high sonority of liquids and nasals enough to serve as the syllable peak. On the other hand, Ladefoged's sonority is estimated from measurements of the acoustic intensity of sounds. Considering that acoustic properties affect the perception of sounds and syllables, the acoustic-based sonority scale in Ladefoged (2001) and its numerical version given in (10) are more appropriate. Therefore we will hereafter employ this sonority.

4.4 Account of TSC through sonority theory

4.4.1 Assumptions

We noted in the previous section that the number of syllables in a word is most often determined by the number of sonority peaks. However, in some cases even adult speakers are confusing about the number of syllables. While there is a unanimous agreement on the number of syllable in words like *visit* /vɪ́zət/ and *codify* /kódəfɑɪ/, it is difficult to determine the number of syllables in *prism* and *mediate*. Note that each syllable of the former cases shows contrastive difference in sonority between segments, whereas those between /z/ and /m/ from *pri**sm*** and between /i/ and /e/ from *med**ia**te* are not in stark contrast.

We assume that children's perceptual capacity is not developed fully enough to distinguish one sound from another if the sounds are acoustically similar. Under this assumption, we can claim that children may not perceive the sound sequence of $CVS_{ON}V$[61] as two syllables but one syllable. This is supported by the observation that sonorant consonants are acoustically similar to vowels. To be specific, we suppose that children may not be able to discern between two segments whose difference in sonority is less than '10.' This is the baseline I set for determining whether two sounds can be perceived as a syllable or not, based on what is spelled out on /zm/ and /sp/. In sum, we make the following assumptions to propose an account of TSC.

(13) <u>Assumptions:</u>

a. Children are underdeveloped in perceptual capacity, thus they are less capable of distinguishing one sound from another if their difference in acoustic features is

[61] S_{ON} denotes a sonorant consonant for simplicity's sake.

subtle.

b. Children may not be able to discriminate one sound from another if the difference in sonority value is sufficiently small. 'Sufficiently small' means the sonority difference is no more than '10' in terms of the irregular sonority scale given in (10).

The second assumption can be intensified by the "principle of maximal contrast" (Jacobson, 1968). According to the principle, the first phonological opposition is between a "maximally closed" consonant like /p/ and a "maximally open" vowel like /ɑ/, thus the phonemes that are acquired earliest by children are /p, m, t, ɑ, i, u/ (Edwards and Shriberg 1983: 51). The principle of maximal contrast may imply that a syllable whose elements show maximal contrast is more easily perceived and produced by children than a syllable whose elements show slight contrast. In terms of sonority, it seems that children acquire the CV sequence of the greater difference in sonority earlier.[62]

4.4.2 Sonority profiles of *garage*, *delicious* and *buffalo*

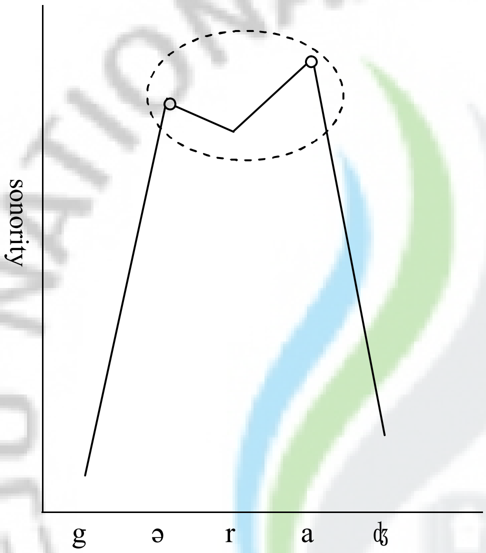
In this section, we draw sonority profiles of target words for TSC to visualize the difference in sonority between an intervocalic sonorant and adjoining vowels.

First, the sonority profile for *garage* /gərɑʤ/ given in (14) shows that there are two peaks of sonority, which would be perceived as two syllables by adults or older children who master their target language. However, the difference between the peaks and the in-between trough is much smaller than the difference between the initial segment and the first peak (or between the second peak and the final segment). The first two segment strings /gə/ has much greater

[62] By way of exception, /nɑ/ and /mɑ/ are acquired as early as /pɑ/, and earlier than /tɑ/ (Edwards and Shriberg, 1983: 133).

difference in sonority as seen in |g−ə|=|2−55|= 53, whereas the sonority differences between /ə/ and /r/ and between /r/ and /a/ are not greater than the baseline 10: they are respectively |ə−r|=|55−50|= 5 and |r−a|=|50−60|= 10.

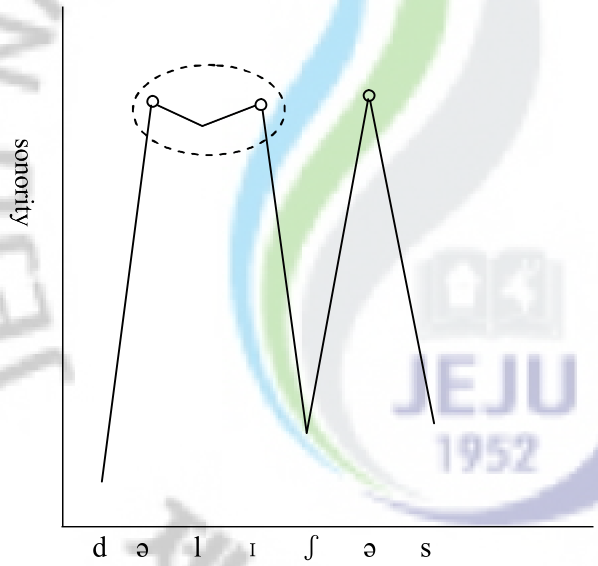
(14) Sonority profile for *garage* /gəraʤ/



Interestingly, the truncations of *garage* by Trevor in our data (See (3) in Chapter 3) reveals that the former output was produced earlier in time (1;10.5−2:0.24) than the latter production (2;3.3-2;3.22). Since consonant clusters are normally avoided in early word production, it may imply that it is a matter of development whether one segment is produced or two segments are produced from the three segments /əra/. If child word truncation takes place simply because children are unable to perceive word-initial weak syllables, *garage* should be produced as /raʤ/, not as [ga：ʤ] or [graʤ]. If /r/ is avoided because of its lateness in acquisition, /r/ should be replaced by a glide like /w/ since liquids are commonly substituted with glides in earlier speech.[63]

Likewise, we can describe the production [dɪʃəs] by Julia (1;11.27) for the target *delicious* /dəlɪ́ʃəs/. The sonority profile of *delicious* /dəlɪ́ʃəs/ is given in Figure (15). The sonority difference between /ə/ and /l/ is '5' and the sonority difference between /l/ and /ɪ/ is '4,' less than the baseline '10.' This is in stark contrast to the sonority difference between /d/ and /ɪ/ (│d−ɪ│=│2−54│= 52). Hence the string /əlɪ/ circumscribed by the dotted circle in (15) might be perceived as one peak by the child.

(15) Sonority profile for *delicious*



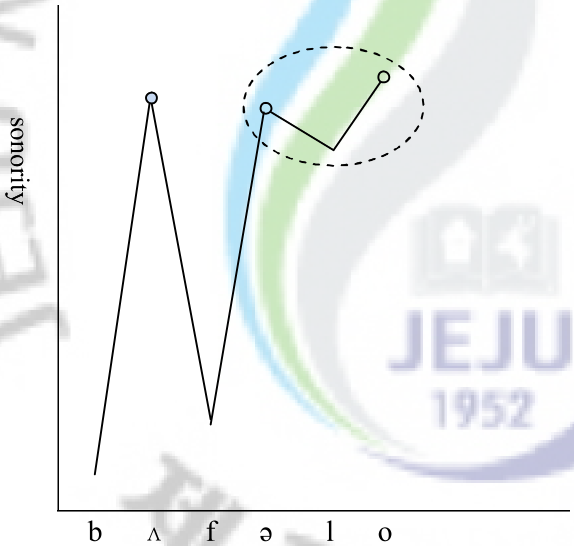
That is, the child produces the target *delicious* as [dɪʃəs]. In terms of the output, we could conclude that the onset of the initial unstressed syllable and the rhyme of the second stressed syllable of the target are combined to constitute the first syllable of the child's production. According to our assumptions, it is because Julia is unable to perceive the syllable starting with

[63] Substitutions of liquids with glides are common in the child word production (Holmes, 1927; Goodluck, 1991; Pater, 1997).

a liquid; she instead perceives the sequence of vowel-liquid-vowel closed by /d/ and /ʃ/ as one rhyme.

By the same token, applying the sonority account to target words whose final syllable starts with a sonorant like *buffalo* and *favorite*, we obtain similar results: children might not perceive the liquid-starting word-final syllable as its own syllable; rather they perceive and produce the two weak syllables as one. Empirically, Julia (2;0.14-2;3.9) produced [bʌfo] for the target *buffalo* and [fevət] for the target *favorite*. The following figure (16) gives sonority profile for *buffalo*.

(16) Sonority profile for *buffalo* /bʌfəlo/



The sonority difference between the intervocalic sonorant and surrounding vowels is less than '10': the difference between /ə/ and /l/ is $|ə−l| = |55−50| = 5$ and the difference between /l/ and /o/ is $|l−o| = |50−54| = 4$. The child might not be aware that the in-between sonorant and the following vowel constitute a syllable, rather consider the sonorant and two vowels before and after it as a single peak, as illustrated by a dotted circle in (16).

In conclusion, most of the words that are truncated by syllable conflation such as *garage*, *delicious* and *buffalo* have a sequence of $VS_{ON}V$ in the word medial position. Children might not perceive a sequence of $S_{ON}V$ as a single syllable if they might not be able to distinguish a sonorant from a vowel. As a result, *garage* is perceived as one syllable and produced as [gaːʤ] or [graʤ]. Similarly, *delicious* is perceived as two syllables and produced as [dɪʃəs]. In most of the children's outputs of TSC, the intervocalic sonorant of the target is not pronounced as shown in *garage* [gaːʤ] and *delicious* [dɪʃəs], but some of the truncations have the sonorant realized, as in *garage* [graʤ] and *police* [plis].

4.4.3 Unresolved issues

We have argued that child productions of TSC are the result of misperception of the number of syllables in the target word. This sonority theoretic approach is based on children's limited perceptual capacity. We assumed that children are not able to perceive an intervocalic sonorant as a syllable onset because the difference in sonority with surrounding vowels is not noticeable to children. In other words, to children, the intervocalic sonorant and surrounding vowels are not distinct. According to this account, the string of $V_1S_{ON}V_2$ are produced either as one vowel (probably, integrated into the second vowel V_2, as in *delicious* [dɪʃəs] and *buffalo* [bʌfo]), or as the sonorant consonant plus a vowel ($S_{ON}V_2$, as seen in [graːʤ] for *garage* and [plis] for *police*).

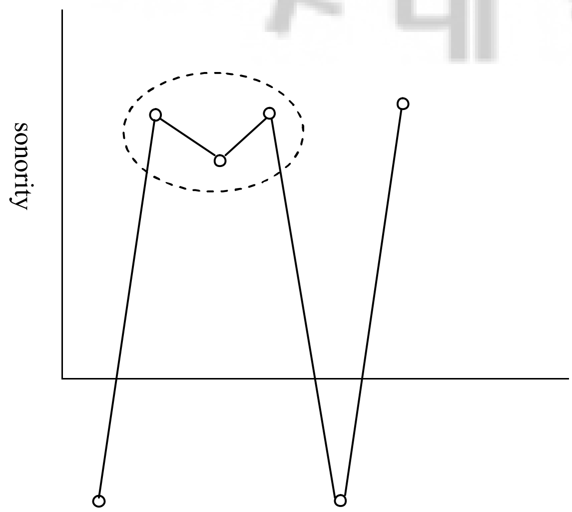
However, it revealed a limitation in the first place. We excluded the TSC of *potato* [pedo] by Julia (2;0.25-2;1.20) from the discussion. Since the intervocalic /t/ has the lowest value of sonority, the difference in sonority with its neighboring vowels is great, far greater than the baseline. Therefore, *potato* should not be subject to TSC. This case may be better explained by

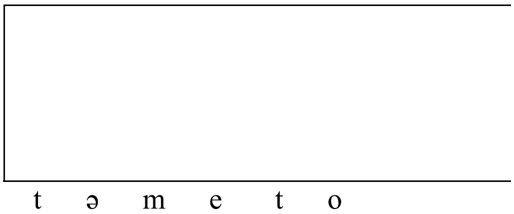
Fikkert's assimilation account; but it entails more complexity since Julia truncated *potato* into [teto] without place assimilation at an older age of 2;5.15. This issue will be resolved through an OT-based approach in the next chapter.

We face other challenges as well. The first is concerned with the production of intervocalic /r/ in [riːsə] for *Theresa*. This target word contains the intervocalic /r/, but /r/ is being produced instead of being omitted like /r/ in *garage* [gaːʤ]. Another problem is concerning the truncation of targets that contain intervocalic /m/. As mentioned earlier, intervocalic sonorant /m/ does not trigger TSC just like other sonorants /r, l, n/. Most of the words containing intervocalic /m/ in our data carry out TSO: [mæmə] for *remember*, [meto] for *tomato*, [mɛnt] for *cement*, [æmʊ] for *animal*, and [gaːmɪn] for *vitamin*.

With respect to the target *tomato*, the sonority difference between /m/ and its neighboring vowels is less than the baseline 10: |ə−m|=|55−48|= 7, |m−e|=|48−54|= 6. Therefore, according to the present account, the sequence /əme/ may be perceived as one peak of a syllable, as illustrated by the dotted circle in the sonority profile in (17) and *tomato* should be perceived and produced as [teto] or [tmeto]. The latter violates the English phonotactics, thus we would obtain [teto], which is contradictory since in effect, *tomato* is truncated into [meto] by TSO. It is certain that /m/ behaves differently from other sonorants /r, l, n/ in child word truncation.

(17) Sonority profile for *tomato* /təmeto/





Among the target words containing intervocalic /m/ in our data, the only case of TSC is *sesame* [sɛsi] produced by Sean (2;5.14), where /m/ is not preserved. By contrast, Derek truncated *sesame* by syllable omission into [sɛ:mə] at 2;2.8 and [semi] at 2;6.26-3;1.28. In fact, *banana* and *company*, the target words containing the other nasal /n/, are also dually truncated: i.e. they are subject to both TSC and TSO. *Banana* is truncated into [bænə] and [nænə]: the former is by Julia (1;11.6-2.5.29) and the latter is by Derek (2;3.0-2;4.0), Sean (1;8.28-1;11.19) and Trevor (0;11.10-1;6.8); *company* is produced not only as [kʌmpi] by Julia (1;11.14) and Sean (2;0.27) but also as [kumni] by Trevor (2;2.23).

A plausible explanation for these variations within the approach in this chapter is that perceptual capabilities differ among children: regarding the target *banana*, Julia (1;11.6-2.5.29) is less developed perceptually so she cannot perceive the intervocalic nasal /n/ in *banana*, whereas the other three children are mature enough to perceive the nasal, and as a result they produce the nasal in [nænə]. This scenario raises a question, however: if the children can perceive intervocalic /n/, what stops them producing the target as three syllables? The production of a disyllabic foot regardless of the segmental content of the output suggests that there are other constraints on the output forms.

Similar to *tomato*, we have shown in Chapter 3 that target words that contain intervocalic obstruents are truncated by syllable omission (e.g. *museum* [zi：ʌm], *dessert* [zɚt] and *abacus* [ækus]). In other words, these truncations are irrelevant to sonority. Thus, this sonority-based approach is not suitable for describing truncation in general including both TSO and TSC. To explain truncation of words that contain intervocalic obstruents or /m/, we need another approach. This will be a constraint-based approach as suggested at the end of the previous chapter.

4.5 Elephant versus octopus

So far we have attempted to explain child word truncation with the sonority theoretic account under the assumption that children's perceptual capabilities are not sufficiently developed to distinguish sonorant consonants from vowels. This attempt was able to give a plausible account of TSC found in WSW, WS and SWW targets (e.g., *delicious* [dɪʃəs], *garage* [ga:ʤ] and *favorite* [fevət]). Although there are unresolved issues in this account, it can provide an account of the segmental effect on truncation found in the contrastive truncation rate between *elephant* and *octopus*. As shown in Chapter 2, words with intervocalic sonorants like *elephant* and *telephone* are much more frequently truncated compared to words with intervocalic obstruents like *octopus* and *crocodile*. For convenience's sake, the truncation rates of the words repeated in (18).

(18) Rates of the truncation in three-syllable target words
(Kehoe and Stoel-Gammon, 1997a: 129)

Target with	SWW		ŚWS	
Intervocalic obstruent	Octopus	20%	Crocodile	24%
			Tinkerbelle	16%
Intervocalic sonorant	Elephant	77%	Telephone	71%
	Animal	64%	Dinosaur	54%

4.5.1 Resyllabification account revisited

As we have noted in Chapter 2, Kehoe and Stoel-Gammon (1997a, 128-129; 1997b, 537-538) argued that the difference in truncation rates between those words is ascribable to different syllabification by children. According to their account, children syllabify an intervocalic sonorant with the preceding stressed syllable, so the syllabification of the words concerned becomes as follows: *din-o-saur, tel-e-phone, an-i-mal, el-e-phant*.[64] The resultant onsetless medial syllables are vulnerable to deletion because they do not fit the CV(C) template proposed by Gerken (1994). Then two-syllable truncations of those targets result. On the contrary, words with intervocalic obstruents like *crocodile, Tinkerbelle,* and *octopus* are syllabified as *cro-co-dile, Tin-ker-bell* and *oc-to-pus*, thus there is no onset-less word-medial syllable. Therefore, those words are less likely to be truncated compared to their counterparts with an intervocalic sonorant.

However, such resyllabification-based approach does not offer an adequate explanation of truncation. Even if the onsetless syllable is deleted, there is no reason for the sonorant syllabified with the preceding stressed syllable to be optionally realized in the child's production, as demonstrated in (19).

(19) Optional production of intervocalic sonorants in child truncations

Target word	Child's production			
	Sonorant deleted	Child[65]	Sonorant produced	Child
animal	[ǽmɑ], [ǽml̩]	28 m3		
	[έ ː mɑ], [έmʊ]	28 f3		
	[amu ː]	T (1;7-2;3)		
	[æmʊ]	D (2;1-3;1)		
elephant	[ɑ́fɪnt]	18 m4	[έlbɪnt]	18 m4
	[ɑ́fɪnt], [ɑfɪt]	22 f1		
	[ɛfɛnt]	S (2;1.19)	[ɛlfɪnt]	S (3;1)
	[έfʌn]	28 m3		

[64] Such syllabifications are supported by experimental evidence that intervocalic sonorants in English are more likely than intervocalic obstruents to be syllabified into the preceding syllable provided that the preceding syllable is stressed (Ishikawa, 2002).

[65] 28 m3 is a 28-month old male participant in Kehoe (1999/2000)'s study and 'T' refers to the child Trevor, 'D' Derek and 'S' Sean in Pater (1997).

	[ɑ́fɪnt]	34 m3		
telephone	[tɑ́fon], [tɛ́ː fòn]	28 m3	[tɛ́rfòn], [tɛ́lfò]	34 f3
	[tɑ́ʊfòn]	28 f3	[tɛ́lfò], [tɛ́lː fòn]	34 f1

One might argue in favor of the resyllabification citing that /l/ in *el-e-phant* could not be realized just because of its late acquisition in the coda position. Unlike /l/, nasals like /n/ in *animal* are among the earliest acquired ones in the coda position (Kehoe and Stoel-Gammon, 2001; Bernhardt and Stemberger, 1998),[66] thus must be frequently preserved. Yet, this is not the case. Indeed, /n/ is very frequently removed from the child's productions as exampled by [æmʊ] and [amuː] in (19).

The resyllabification account is limited to such SWW and ŚWS targets that contain a stressed syllable followed by an unstressed syllable that start with a sonorant (e.g. *élephant*). The account is developed on the assumption that intervocalic sonorants are syllabified with the preceding stressed vowels (e.g. *el-e-phant*). Therefore, it cannot be applied to targets like *delicious*, *favorite* and *buffalo* since the intervocalic sonorant lies between an unstressed syllable and the following stressed syllable for *delícious* and *búffalò* and between two unstressed syllables for *fávorite*. In these cases, it may not be ensured that the sonorant is syllabified with the preceding syllable like *del-i-cious*, *bu-ffal-o* and *fa-vor-ite*. In sum, Kehoe and Stoel-Gammon's approach to truncation is limited to TSO for targets with an intervocalic sonorant between stressed and unstressed syllables, and thus it does not give a general explanation of truncation including TSC like delicious [dɪʃəs] and favorite [fevət].

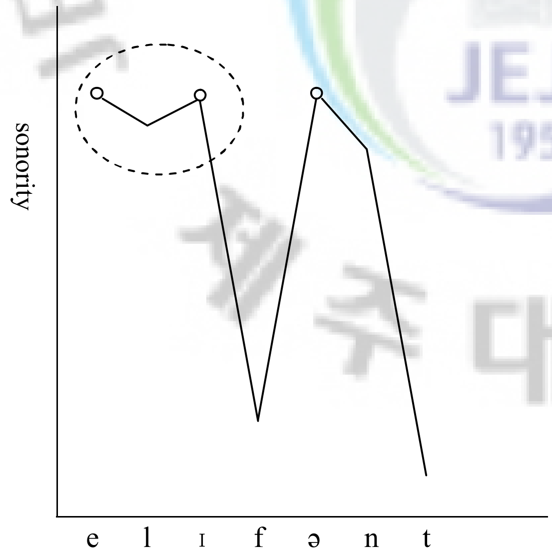
[66] In Bernhardt and Stemberger (1998), the order of coda acquisition is typically voiceless stops and nasals, succeeded by fricatives and voiced stops (428), while the observations of children's coda productions by Kehoe and Stoel-Gammon show that the earliest and most commonly occurring manner class in children's coda inventories is voiceless stops; nasals and voiceless fricatives; voiced obstruents; and the liquid, in order.

4.5.2 Sonority-based account

We discussed the resyllabification account of the issue of *elephant* vs. *octopus* in the above subsection. In this subsection, we will show that the proposed sonority-based account can explain the different truncation rate between *elephant*-type and *octopus*-type words in more effective ways. Under the assumptions given in (13), it is likely that *elephant*-type words are perceived as two syllables, whereas *octopus*-type words are perceived as three syllables.

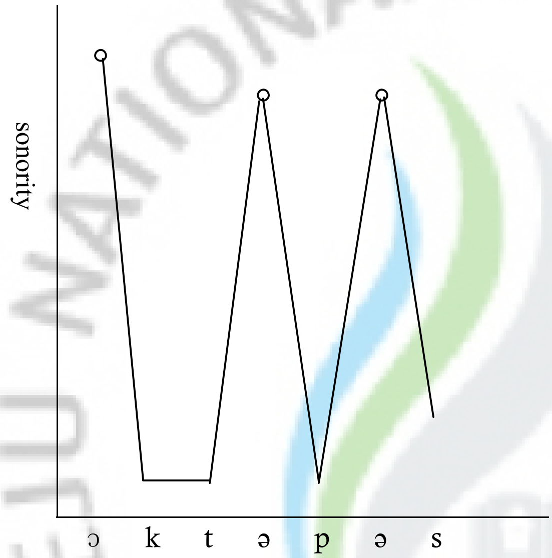
As illustrated in diagram (20), if children would perceive there are two syllable peaks in *elephant* due to the high sonority of /l/, then it would be produced as two syllables: *ele-phant*. The sonority difference between /l/ and each of its neighboring vowels is 4: │e–l│= │54–50│= 4; │l– ɪ │= │50– 54│= 4, smaller than '10.' Therefore, according to our account, the string /elɪ/ is perceived as one syllable; hence *elephant* is produced as two syllables.

(20) Sonority profile for *elephant* /élɪfənt/



By contrast, *octopus* has three distinct peaks as illustrated in the figure (21). In case of *octopus*, the minimal sonority difference between two adjacent segments that constitute a syllable is that of /əs/: $|ə-s| = 55-11 = 44$, much greater than the baseline '10.' That is, *octopus* is perceived as three syllables and thus less likely to be truncated than *elephant*.

(21) Sonority profile for *octopus* /ɑ́ktəpʊs/



In conclusion, *elephant* is likely to be perceived as two syllables by children since it contains a string of $VS_{ON}V$ that is perceived as forming the peak of one syllable. As a result, it is more likely to be produced as two syllables. By contrast, *octopus* with intervocalic obstruent does not contain any intervocalic sonorant. Thus it is perceived as three syllables by children and less likely to be reduced. Therefore, if *octopus* would be truncated into two syllables, it might be due to limitation on production rather than perceptional limitation.

There is another merit in the sonority theoretic approach: it provides an explanation of the optional production of /l/ in the child's productions for *elephant* and *telephone*, which are not accounted for by Kehoe and Stoel-Gammon's resyllabification account. As we see in (22), some children produced /l/ in their two-syllable truncations for *elephant* and *telephone*, whereas others delete /l/ along with the following vowel in their productions. Besides, there is intrapersonal variation in the production of /l/: a child produced both [ˈɛlfɪnt] and [ˈɑfɪnt] at the age of 18 months (Kehoe, 1999/2000: 36). However, Sean produced /l/ in his production for *elephant* when he was over three years old, while he deleted /l/ when he was two years and one month old. Roughly speaking, it seems that older children are able to produce the sonorant in their truncations, which is supported by the productions by Trevor for *garage* and by Julia for *police*. Those productions are provided in (22a).

(22) Optional presence of intervocalic sonorant in truncated productions

	Target	Child's output	Child (age)
a. TSC	garage	[ga：ʤ]	T (1;10.5-2;0.24)
		[graʤ]	T (2;3.3)
	police	[pis]	J (2;1.10-2;5.3)
		[plis]	J (2;6.5)
b. TSO	elephant	[ɛfɛnt]	S (2;1.19)
		[ɛlfɪnt]	S (3;1)

Table (22) clarifies the tendency of the appearance of /r, l/ in productions by children. Of the string $VS_{ON}V$ underlined in the target word, the intervocalic sonorant tends to be produced when the speaker is older, but deleted when the speaker is younger.

According to the account proposed in this chapter, the string of vowel-sonorant consonant-vowel both in *elephant* that is truncated through TSO and in *police* that is subject to TSC would be perceived as a single rhyme and it would be realized as one segment or two due to the size restriction of rhyme. Thus, /ɛlə/ in *elephant* is realized as [ɛ] or [ɛl], just as the productions by Sean in (22b), and /əli/ in *police* is realized as [i] or [li] as the outputs of Julia in (22a).

4.6 Summary and conclusion

In this chapter, it has been argued that children perceive a string of (C)VS_{ON}V as one syllable rather than two syllables since they cannot distinguish an intervocalic sonorant from a vowel. The argument is based on the observation that words with intervocalic sonorants /r, l, n/ tend to be reduced by TSC (e.g. *garage* [gaːʤ], *ballon* [bun], *banana* [bænə]) and that even adults are confusing a sound with another when they are acoustically similar. To construct the argument, we have assumed that children's perceptual capability may not develop sufficiently to distinguish sonorants from vowels since sonorants are acoustically similar. The explanation for TSC of *delicious* according to this approach is that *delicious* /dəlɪ́ʃəs/ is reduced to [dɪʃəs] because the intervocalic /l/ is not perceived as a syllable onset by children.

The sonority-based account proposed in the present chapter is a kind of a perception-based approach. However, it is different from the 'perceptual salience account' in Echols and Newport (1992) and Snow (1998) in several aspects. First, the prior account surmises that children are unable to perceive word-initial unstressed syllables as a whole; thus the word-initial unstressed syllables are prone to omission. According to it, children fail to perceive the onset /b/ of the initial weak syllable from *ballóon* since it is part of an unstressed syllable and thus perceptually non-salient. Hence /b/ should be omitted from the production, resulting in [lun]. However, this is far from any of the real production [bun], [bu] or [bʊn] by children in Pater (1997). On the contrary, our account suggests that children can perceive the onset /b/. It is the intervocalic sonorant that is not perceived. According to the new perception-based account, the string of /əlu/ from *balloon* is perceived as a single peak. Then, the word may be produced as [bun] with the initial consonant kept intact.

As examined in previous chapters, previous accounts of truncation did not account for

TSC in satisfying manners. By contrast, the sonority theoretic approach accounted for TSC. It also proved conducive in explaining the high truncation rate in words with intervocalic sonorants like *elephant* and *animal,* compared to the low truncation rate in words with intervocalic obstruent like *octopus* and *crocodile*. It also leads to give a plausible explanation of the optional presence of the intervocalic sonorants /r, l/ in children's truncations: e.g., [ɛfɛnt] and [ɛlfɪnt] for *elephant,* [pis] and [plis] for *police*.

Note, however, that this sonority-based approach bears some limitations. It suggests no way of accounting for TSO. We observed in Chapter 3 that TSO mostly occurs for target words that contain intervocalic obstruents or /m/: e.g. *together* → [gɛ:dɚ], *museum* → [zi:ʌm] and *abacus* → [ækus]; *tomato* → [meto] and *cement* → [mɛnt]. Furthermore, it did not address the issue of variations between TSO and TSC such as [nænə] & [bænə] for *banana*; [teto] & [pedo] for *potato*; and [kumni] & [kʌmpi] for *company*. These truncations are not caused by the assumed perceptual limitation. Therefore, it seems that there might be constraints on the output.

Looking into the syllables produced by children from our data, children seem to favor a syllable CV such that C and V differ in sonority as greatly as possible rather than CV with a small difference in sonority. For example, /dɪ/ from *delicious* is favored over /lɪ/ because │d−ɪ│ is much greater than │l−ɪ│. Such preference is associated with the maximal contrast principle (Jacobson, 1968): children's early syllable structure is comprised of a maximally closed sound and a maximally open sound (e.g. /pɑ/). It is also related to the emergence of the unmarked (McCarthy and Prince, 1994a) since the less sonorous onset is more unmarked (Gnanadesikan, 1995: 3). In this light, the next chapter will take an approach to word truncation focusing on production constraints.

Chapter 5

Optimality Theoretic Approach to Truncation

5.1 Introduction

In the previous chapter, I suggested that TSC in words containing intervocalic sonorants (most of them are liquids) is ascribable to children's limited perception of sonorant consonants. Word truncation, however, would not be just due to children's perceptual limitation. It has long been argued against the assumption that children's impoverished production is because of their insufficient ability in comprehension of adult targets.[67] We have observed that target words with obstruent onsets are also subject to truncation: e.g. *together* → [gɛ:dɚ] and *cement* → [mɛnt]. These truncations are not related to the perceptual limitation that we assumed to explain TSC. It seems that children's production is constrained structurally so as to take a certain form (Demuth, 1997a). This chapter will approach children's word truncation focusing on constraints on their output forms.

The present approach starts with the assumption that there are constraints on the outputs of child words. As opposed to rule-based,[68] constraint-based approaches place focus on the output forms of children's production. Derivational accounts failed to explain the broad generalization that the same phonological structures which are marked (or disfavored) in adult languages tend also to be avoided in child language (Smolensky, 1996: 720). This issue,

[67] Children who systematically avoid a given structure in their productions can often easily imitate it (Smolensky, 1996: 720).

[68] Rule-based approaches (Smith, 1973; Ingram, 1974) looked upon children word forms as being derived from the adult forms by means of phonological rules. They focused on segmental changes rather than structural well-formedness.

however, is resolved in child grammar formulated under the framework of Optimality Theory (henceforth, OT). In child OT grammar, even children, lean phonological producers, have underlying forms that closely approximate the adult forms, and the constraints in OT grammar are operative in child phonology (Gnanadesikan, 1995; Demuth, 1995). Child words are the optimal form that is left as the only survivor of all candidate forms after filtered by constraints.

This chapter will illustrate how an OT-based approach can give an account of child word truncation including TSC. We will try to explain the following issues of word productions. First, all the target words in the data are produced as a trochaic foot. That is, WS targets are truncated into S; WSW into SW; and SWW and SWS into SW. Second, in terms of truncation content, both stressed and word-final syllables are retained in child words. Third, highly sonorous consonants in the target do not appear on the syllable onset position: intervocalic /r, l/ are easily omitted from child production even though they come on the stressed syllable of the target. Fourth, target words with intervocalic /n, m, t/ undergo TSO as well as TSC depending on children and their age. That is, there is interpersonal and developmental variation in truncation for the same targets. These issues will be addressed with a number of constraints operative in child grammars.

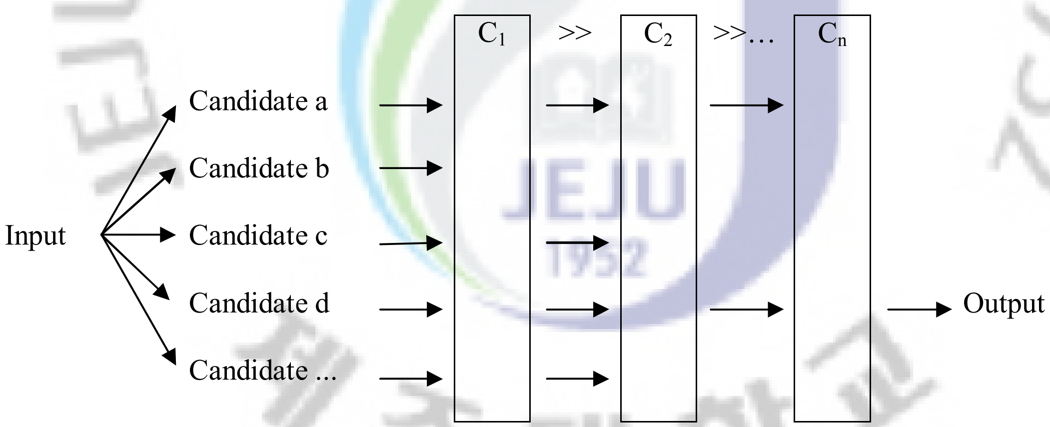
The issues mentioned above will be dealt with in section 5.4 after section 5.2 gives an overview of OT and section 5.3 provides basic notions in child OT grammar.

5.2 Overview of Optimality Theory

This section provides an overview of OT, which will prove useful in discussion of child word truncation. In OT, the phonology of a language is given by the ranking of the set of universal but violable constraints, which is called *constraint hierarchy*, and the constraint hierarchy differs from language to language.

As opposed to generative grammar led by Chomsky and Halle (1968), in which phonological representation is the result of a series of application of ordered rules with one rule's output being the next rule's input, there is no intermediate stage in OT. For a given input, the OT grammar generates (by the mechanism known as GEN (Generator)) and then evaluates (by the mechanism called EVAL (Evaluator)) an infinite set of output candidates, from which the optimal candidates is selected. Evaluation is conducted by a set of hierarchically ranked constraints (C_1 >> C_2 >>…C_n). Going through the evaluation for each constraint filters out candidate outputs until it reaches the point at which only one output candidate survives. This process is schematized as follows in (1).

(1) Mapping of input to output in OT grammar (Kager, 1999: 8)



The optimal candidate, which is the actual output, is the one that is the 'most harmonic' or 'optimal' with respect to the set of ranked constraints. Sorting out less harmonic candidates takes place through the following procedures: violation of a higher-ranked constraint leads to less harmonic status than the violation of a lower-ranked constraint; repeated violation of the same constraint incurs more serious damage to harmony than a single violation of the constraint.

5.2.1 Basic principles

OT makes some fundamental assumptions: an overview of those assumptions will be given below.

(2) Universality: Universal Grammar (UG) provides a set of constraints that are universal and universally present in all grammars.

Universality is essential to the emergence of the unmarked (McCarthy and Prince, 1994a) because structural well-formedness constraints are universal and present in every grammar. But Universality entails Violability and Ranking.

(3) Violability: Constraints are violable; but violation must be minimal.

OT allows violations of any constraints, thus the optimal candidate is in reality not a perfect candidate but the one that 'incurs the least serious violations of a set of constraints' (Kager, 1999: 13). However, no constraint is violated without a compelling reason: avoiding the violation of another higher-ranked constraint. Violability of constraints is an essential property of OT, radically different from derivational models (Kager, 1999: 12). The next tenet of OT is about the ranking of constraints:

(4) Ranking: Constraints 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.

The constraint hierarchy contains all universal constraints (a set called *Con*), but the ranking varies from language to language. A different ranking of the constraint set yields a different grammar, which serves to explain the diversity of interlinguistic variation. The ranking of constraints is only relevant when the constraints are conflicting with each other. The conflicts can be resolved by Domination:

(5) Domination: The higher-ranked of a pair of conflicting constraints takes precedence over the lower-ranked one.

The satisfaction of higher-ranked constraints is given priority at the cost of violation of lower-ranked constraints. The ranking among constraints can be represented by the symbol ">>": $C_1 >> C_2$ means 'Constraint C_1 dominates Constraint C_2,' which in turn implies the violation of C_1 can be more fatal than the violation of C_2.

The ranking of constraints can be also represented by a tableau: constraints are ranked from highest on the left to the lowest on the right along the top row of the tableau. When constraints are indeterminate as to ranking, the dashed line is drawn between the columns concerned. Possible output candidates are represented along the left-hand column with the input form given in the top left cell. Violations of constraints are indicated by the asterisk '*.' If a given constraint is violated more than once, it is added up by the number of violation to the seriousness of the violation. The most serious violations are marked by '!' which excludes the marked one from the optimal candidates. Any candidate that incurs a violation of a higher-ranked constraint is ruled out, regardless of its relative well-formedness with respect to any lower-ranked constraints. Violation of higher-ranked constraints cannot be compensated for by satisfaction of lower-ranked constraints (*strict domination*: Kager, 1999: 22). After exclusion by the highest constraint, the satisfaction or violation of the lower-ranked constraints is irrelevant.

The irrelevance is indicated by shaded cells. The optimal output candidate is indicated by the indicator marker '☞.' A tableau for simple dominance among constraints is represented schematically in (6).

(6) A tableau for simple dominance: $C_1 >> C_2 >> C_3$

input	C_1	C_2	C_3
a. ☞ Candidate A		*	*
b. Candidate B	*!		

Candidate A violates two constraints C_2 and C_3, but it avoids the violation of the highest-ranked constraint C_1; Candidate B violates the highest-ranked constraint, thus becomes less harmonic than Candidate A despite its observance of the other constraints C_2 and C_3.

The final principle to be introduced here is called Parallelism, which is concerning Evaluation:

(7) Parallelism: Best-satisfaction of the constraint hierarchy is a compound of the whole hierarchy and the whole candidate set. There is no serial derivation.

In OT, the true output is not produced in a step-by-step manner; that is, the evaluation is implemented in parallel with reference to all the relevant constraints and all potential candidate outputs. Therefore, there is no intermediary level between input and output in OT. This is the major difference from rule-based theory.

5.2.2 Interactions of markedness and faithfulness

In OT, a grammar consists of two conflicting sets of constraints: Markedness constraints and Faithfulness constraints. Markedness constraints are to yield unmarked forms and faithfulness constraints require that outputs preserve the properties of their inputs. While markedness constraints focus on the well-formedness of the output, faithfulness constraints take into account both the input and the output. That is to say, markedness constraints concern the output alone; faithfulness constraints concern the relation between the input and output. The interaction between these two types of constraints gives birth to the optimal form as an output.

5.2.2.1 Markedness

Markedness is based on the fact that certain types of structure - segments or prosodic structures - are universally favored over others. Those favored are unmarked structures, and marked structures are avoided cross-linguistically. Markedness is a relative notion. The unmarked structure that obeys a constraint C is guaranteed to be unmarked with respect to C itself; it can be marked with respect to other constraints. Such a relative markedness can be represented by a hierarchy of constraints. For example, since coronals are universally considered less marked than labials, we get the hierarchy of constraints governing place of articulation: *[lab] >> *[cor], which means the constraint disfavoring labial sounds is ranked high than the constraint disfavoring coronal sounds (Kager, 1999: 44). Furthermore, the relative strength of the individual markedness factors varies from language to language.

In addition to featural markedness constraints like *[cor], there are prosodic markedness constraints like ONSET, No-Coda and FTBIN. As to syllable structure, syllables that have an onset are cross-linguistically preferred over syllables that lack an onset, and syllables that avoid the coda are more widely present in languages than the ones that must have codas. Those structural well-formedness constraints are expressed as follows:

(8) ONSET: Syllables must have onsets.

No-Coda: Syllables must be open, that is, have no codas.

These constraints are instantiated by the observation that the core syllable CV is present in all languages. A powerful cross-linguistic preference of regular alternation of strong and weak syllables yields foot binarity or FTBIN, which requires that feet be binary (Prince and Smolensky, 1993; McCarthy and Prince, 1994a).

(9) **FTBIN** Feet are binary at the level of syllable or the mora.

A key function of FTBIN is to exclude degenerate feet, which contain a single light syllable and this constraint will play a key role in explaining child prosodic structures.

5.2.2.2 Faithfulness

Faithfulness constraints are to pursue the identity between the input and output, thus they entail the mapping between the input and the output. The output element that is corresponded to an input element is called the 'correspondent.' Among the faithfulness constraints are Max-IO, Dep-IO and IDENT-IO(F) (McCarthy and Prince, 1995: 16). Max-IO requires that the input is maximally represented in the output, and thus is violated if a segment of the input is deleted. Dep-IO requires that each segment in the output form has a corresponding segment in the input, and thus prohibits the insertion of segments. IDENT-IO(F) requires no featural changes between the input and output.

(10) **Max-IO**: Every segment of the input has a correspondent in the output.

Dep-IO: Every segment of the output has a correspondent in the input.

IDENT-IO(F): Correspondent segments are identical in feature F.

Such correspondence between the input and output is well established in *correspondence theory* by McCarthy and Prince (1995). McCarthy and Prince introduced the correspondence theory with the aim to account for base-reduplicant relations, which has been extended to encompass not only the input-output relations but also relations between any two structures (McCarthy and Prince, 1995: 14). Correspondence can be formally defined as follows:

(11) **Correspondence**

Given two strings S_1 and S_2, correspondence is a relation *R* from the elements of S_1 to those of S_2. Elements $\alpha \in S_1$ and $\beta \in S_2$ are referred to as correspondents of one another when $\alpha\ R\ \beta$.

To put it simply, in the input-output relation, S_1 is the set of elements in the input and S_2 is the set of elements in the output. For a given element in the input, if there is an element in the output corresponding to the input element, the faithfulness is observed. Faithfulness of the output to the input is explained by means of constraints requiring identity between elements in the input and output like those constraints given (10).

Among other correspondence constraints are *linearity*, *contiguity*, *anchoring* or *alignment*, *uniformity* and *integrity* (McCarthy and Prince, 1995: 123-124; Kager, 1999: 250-252). These constraints will be introduced, when necessary in the later part of this chapter. In particular, *contiguity* constraints that militate against medial deletion or epenthesis and *alignment* constraints that require corresponding elements in the input and output both stand at an edge will prove useful in our discussion.

5.3 Child OT grammar

OT-based approaches to child phonology have assumed that children have the same constraints in their grammar as those of adult phonology (Gnanadesikan, 1995; Demuth, 1995, 1997a, 1997b; Kehoe, 1999/2000; Jusczyk *et al.*, 2006). They argue that the hierarchy of constraints differs among children and changes over time, just as every language prioritizes the same set of constraint differently. We expect from different rankings of constraints different outputs for a given input. The present study also accepts this notion. It is the key notion in an account of variation in word truncation among children and across ages. We also assume the ‘continuity’ between child grammar and adult grammar, hypothesizing child phonology has the same substance as adult phonology (Fikkert, 2007).

In the OT mechanism of child phonology, the ‘input’ form is the adult target word and the ‘output’ form is the child word production. The initial state of a child’s phonology has markedness constraints ranked higher than faithfulness constraints (Demuth 1995, 1996c). The process of acquisition is performed by gradually promoting faithfulness constraints and producing more and more marked forms faithful to the adult forms.

Let us see a brief illustration of the relation between markedness and faithfulness. In the word productions of the four children in Pater (1997), a word takes a form of a trochaic foot: all the targets are produced as S or SW. They violate faithfulness to the input in order to have unmarked forms of prosodic words. McCarthy and Prince (1994a) propose Align (Ft, L, PrWd, L), which requires the left edge of every foot to be aligned with the left edge of the prosodic word. If this constraint is satisfied, every foot is positioned initially in the prosodic word. The tableau (12) of *tomato* → [meto] (by Julia aged 2;0.11-2.10.30) illustrates how the ranking of Align (Ft, L, PrWd, L) above Max-IO forces violation of faithfulness.

(12) Align (Ft, L, PrWd, L) >> Max-IO

	/təméto/	Align (Ft, L, PrWd, L)	Max-IO
a. ☞	[(meto)$_F$]		**
b.	[tə(meto)$_F$]	*!	

The attempt by candidate (12b) to retain the initial unstressed syllable leads to the violation of the higher ranked Align (Ft, L, PrWd, L), so (12b) is ruled out. On the other hand, candidate (12a) avoids the violation of the higher-ranked constraint at the cost of the deletion of the initial unstressed syllable, which means the violation of Max-IO. The violation of the lower ranked constraint is irrelevant, as illustrated by the shaded cells. As a result, we obtain the optimal output form [meto] for the input /təméto/.

It should be noted, however, that the production of a trochaic foot requires more complex set of constraints than tableau (12) illustrates. Align (Ft, L, PrWd, L) simply requires that "every foot stand in initial position in the prosodic word." Since for a given input all possible outputs should be compared against a set of constraints, candidates like [(təmeto)$_F$] consisting of a trisyllabic foot or [(təme)$_F$to)] composed of a disyllabic foot plus an unfooted syllable satisfy Align (Ft, L, PrWd, L) as well as Max-IO. This issue is discussed in the next subsection.

5.3.1 Trochaic-foot production

Truncation requires target words to be reduced in size by definition. Therefore, the faithfulness constraint Max-IO is violated, which will make Max-IO ranked low in the child grammar. Truncated forms that show an intense tendency to take a trochaic form S(W) are captured by employing three constraints: PARSE-σ, FTBIN and Align (Ft, L, PrWd, L) (Pater 1997: 209).

(13) **ALIGNLEFT** Align (Ft, L, PrWd, L): Align the left edge of every foot with the left edge of the prosodic word.

PARSE-σ Every syllable must belong to a foot.

The alignment constraint ALIGNLEFT, or Align (Ft, L, PrWd, L), ensures the prosodic word beginning with a foot and that there is only one foot with additional unfooted syllables because if there were more than one foot, the right-side foot could never be aligned with the left edge of the prosodic word. Since English has a trochaic foot system, the high ranking of ALIGNLEFT will bring on a possibility of a word starting with a stressed syllable to be more optimal. Secondly, the constraint PARSE-σ penalizes unfooted syllables. So, if PARSE-σ is ranked high, a word containing an unfooted syllable like *banana* will be less optimal than its truncated forms [nænə]. The third constraint FTBIN requires a foot to be binary either at the moraic or syllabic level, as specified by the *foot binarity* (McCarthy and Prince, 1994b). This constraint disfavors a monomoraic foot or a foot consisting of more than two syllables like a dactylic foot (SWW). If those three constraints are satisfied, we will have a prosodic word consisting of a single trochaic foot as illustrated in (14).

(14) ALIGNLEFT, PARSE-σ, FTBIN

		ALIGNLEFT	PARSE-σ	FTBIN
a.	☞ [(σσ)][69]			
b.	[(σσ) σ]		*	
c.	[σ(σσ)]	*	*	
d.	[(σσσ)]			*
e.	[(σσ)(σσ)]	*		

Candidate (14a) is a single foot composed of two syllables. Thus it is self-evident that candidate (14a) complies with all the three constraints. Candidate (14b) fulfills ALIGNLEFT since it has only one foot word-initially. Its compliance with FTBIN is attributable to the fact that the only foot is disyllabic. Candidate (14b), however, violates PARSE-σ since the third syllable is not footed. Candidate (14c) consisting of an unfooted syllable and a following disyllabic foot violates not only PARSE-σ but also ALIGNLEFT since the unfooted first syllable intervenes between the left edge of the prosodic word and the left edge of the foot. Candidate (14d) obeys PARSE-σ since all the syllables are organized into a foot. Candidate (14d) satisfies ALIGNLEFT, but it violates FTBIN since the foot exceeds two syllables. Lastly, candidate (14e) fulfills both FTBIN and PARSE-σ since it is composed of two disyllabic feet with no other unfooted syllable, but it fails on ALIGNLEFT because of the second foot whose left edge never coincides with the left edge of the prosodic word.

The evaluation of candidates in (14) shows that a disyllabic foot is optimal with respect to the three constraints, ALIGNLEFT, PARSE-σ and FTBIN. Note that a prosodic word consisting of a bimoraic monosyllabic foot [$\sigma_{\mu\mu}$] also satisfies all the three constraints. In consequence, we

[69] A foot will be represented by a parenthesis ( ) and a prosodic word will be denoted with a bracket [ ] when needed. So [σ(σσ)] refers to a prosodic word consisting of an unfooted syllable and a disyllabic foot. However, we will omit the parenthesis as long as there is no confusion, for example, when representing a prosodic word consisting only of a single foot: [σσ] refers to a prosodic word consisting of a disyllabic foot. Furthermore, since English is trochaic, we know a word consisting of WSW constitutes an unfooted syllable plus a trochaic foot to be denoted as [W(SW)]. Thus, for simplicity's sake, we will write [WSW] for [W(SW)] for English words.

conclude that a prosodic word consisting of a single trochaic foot SW or S[70] fulfills all the three constraints. For convenience's sake, the three constraints combined are referred to as WordSize borrowing the term used in Pater (1997: 231). WordSize is violated if any of the three constraints (ALIGNLEFT, PARSE-σ, FTBIN) is violated. Thus, in order to obtain a prosodic word consisting of a trochaic foot, the constraint WordSize should be ranked higher than Max-IO.

5.3.2 Retention of the stressed and the word-final syllables

In this subsection we will discuss how to account for the preservation of both stressed and word-final syllables in OT. Note that WordSize is not sufficient to explain the truncation of WSW targets into SW and SWW targets into SW_2, since a bimoraic monosyllabic foot also satisfies WordSize. In order to ensure that the stressed syllable and word-final syllable are retained, we need two constraints concerning the correspondence between the input and the output: STRESS-FAITH, which ensures the preservation of stressed elements (Demuth, 1996a; Pater, 1997) and ANCHOR-RIGHTI-O (McCarthy and Prince, 1994a, 1995), which calls for right edge correspondence.

(15)	**STRESS-FAITH**	A stress bearing element in the Input must have a correspondent in the Output.
	ANCHOR-RIGHTIO	Elements at the right edge of the Input word and the Output word stand in correspondence.

We assume that the elements in the two constraints in (15) temporarily refer to

[70] In English, lexical words have at least one stressed syllable, so a monosyllabic lexical word should consist of a single stressed syllable, just denoted by 'S' (Giegerich, 1992). That is, all English monosyllabic lexical word should be bimoraic.

'syllable.'[71] Then, STRESS-FAITH is violated when a stressed syllable in the input is not produced in the output or loses stress. ANCHOR-RIGHTIO is violated if the right-most syllable of the input is not produced in the output. The correspondence in these constraints is different from that of Max-IO in the sense that segmental change including segment deletion does not matter as long as it preserves the syllable status. To clarify the difference, let us consider a few possible candidates for the input *elephant* /ɛ́ləfənt/ and evaluate whether they observe or violate these three faithfulness constraints. In (16), the violation of each constraint is marked with the asterisk. Regarding Max-IO, asterisk marks will be added according to the number of segments in the input that are deleted from the output. The blank cell indicates there is no violation of the given constraint. The correspondence relation of segments is represented by the subscript integers.

(16) Violation of STRESS-FAITH, ANCHOR-RIGHTIO, Max-IO

Input /$\acute{\varepsilon}_1 l_2 ə_3 f_4 ə_5 n_6 t_7$/	STRESS-FAITH	ANCHOR-RIGHTIO	Max-IO
a. [$\acute{\varepsilon}_1 w_2 f_4 ə_5 n_6$]			**
b. [$\varepsilon_1 w_2 f_4 \acute{ə}_5 n_6$]	*		**
c. [$\acute{\varepsilon}_1 w_2 ə_3$]		*	****
d. [$f_4 \acute{ɪ}_5 n_6$]	*		****
e. [$\acute{\varepsilon}_1 w_2$]		*	*****
f. [$\acute{\varepsilon}_1 l_2 ə_3 f_4 ə_5 n_6 t_7$]			

Candidate (16a) does preserve the stressed syllable and the right-most syllable although /ɛ́l/ is substituted with [ɛ́w] and the final syllable /fənt/ is reduced to [fən]. That is, it observes both constraints, whereas it violates Max-IO because two segments (number 3 and number 7) are deleted. By contrast, candidate (16b) with the same segment construction as that of (16a) violates STRESS-FAITH since the stressed syllable of the input loses its stress. Candidate (16c)

[71] McCarthy and Prince (1995: 14) states the elements in Correspondence can refer to segments or any other higher prosodic units such as mora, syllable, feet, and so forth.

made up of the first and the second syllables of the input preserves the stress syllable, but ANCHOR-RIGHTIO is violated since it does not contain any correspondent of the segments of the final syllable. On the other hand, candidate (16d) satisfies ANCHOR-RIGHTIO, but violates STRESS-FAITH since there is no correspondence to the stressed syllable of the input. It violates Max-IO four times since there is no correspondent to four segments of the input (number 1, 2, 3 and 7). Candidate (16e) preserves the first stressed syllable, but it does not contain any correspondent of the final syllable of the input, thus violates ANCHOR-RIGHTIO, not to mention the violation of Max-IO. Finally, candidate (16f) satisfies all the constraints. It implies that this candidate will be chosen as the optimal candidate with respect to these constraints regardless of the ranking between them.

Note that the most faithful candidate (16f) violates WordSize since it is comprised of three syllables. The higher ranking of this structural constraint relative to any of the faithfulness constraints in (16) will rule out it. Accordingly, in order to obtain a truncated form as an optimal candidate, Max-IO should be dominated. Now let us consider tableau (17) with the same set of candidates as (16).

(17) STRESS-FAITH, ANCHOR-RIGHTIO>> Max-IO

/ɛ́ləfənt/	WordSize	STRESS-FAITH	ANCHOR-RIGHTIO	Max-IO
a. ☞ [ɛ́wfən]				**
b. [ɛwfə́n]	*!	*		**
c. [ɛ́wə]			*!	****
d. [fɪ́n]		*!		****
e. [ɛ́w]			*!	*****
f. [ɛ́ləfənt]	*!			

Regardless of the rankings among WordSize, STRESS-FAITH and ANCHOR-RIGHTIO, candidate

(17a) becomes optimal. Therefore, the truncation of SWW into SW_2 is explained by the higher ranking of the three constraints. Note that we observed in Chapter 2, the higher production rate of SW_2 compared to SW_1 for SWW target words. The constraint hierarchy in (17) suffices for the account.

For a longer target word like SWS(W), we have a different hierarchy of constraints in order to account for the retention of stressed syllables and word-final syllables in child word production. We observed in Chapter 2 that SWS targets are mostly truncated to SS and SWSW targets are predominantly produced as SSW. In order to ensure the presence of both stressed and word-final syllables, STRESS-FAITH and ANCHOR-RIGHTIO should be ranked high. As SSW is preferred over a trochaic disyllabic foot SW, WordSize should be ranked lower than these faithfulness constraints.

Tableau (18) considers five candidates for the input SWSW:

(18) STRESS-FAITH, ANCHOR-RIGHTIO>> WordSize

$S_1W_1S_2W_2$	STRESS-FAITH	ANCHOR-RIGHTIO	WordSize
a. ☞ $[S_1S_2W_2]$			*
b. $[S_1W_1S_2]$		*!	*
c. $[S_1S_2]$		*!	*
d. $[S_2W_2]$	*!		
e. $[S_1W_1]$	*!	*	

Candidate (18a) and candidate (18b) consist of two stressed syllables and one unstressed syllable: the former with the word-final unstressed syllable and the latter with the word-medial unstressed syllable, which leads to the violation of ANCHOR-RIGHTIO. Candidate (18c) is composed with the two stressed syllable. It also violates ANCHOR-RIGHTIO. All of the top three candidates violate WordSize since they form two feet. By contrast, the bottom two candidates are a disyllabic trochaic foot, conforming to WordSize. Candidate (18d) amounts to the right-most foot, whereas candidate (18e) consists of the left-most trochaic foot. Both violate Stress-Faith since one of the two stressed syllables is deleted in them. Candidate (18e) has an additional violation mark for Anchor-RightIO by its constitution. Consequently, candidate (18a) is chosen as an optimal one since it fulfills two higher constraints. Its violation of the lowest-ranked WordSize is irrelevant. The mutual ranking between Anchor-RightIO and Stress-Faith remain indeterminate because it is not important to the outcome. Accordingly, the ranking in (18) accounts for the production of SSW for the SWSW targets.

Meanwhile, if the right-most trochaic foot is to be chosen as an optimal output for the input SWS(W) as seen in the production of [fɔm] by Robin (1;10-2;1) for the target *tèlefóon* (Fikkert, 1994), WordSize should be ranked higher than the faithfulness constraints. It is illustrated in tableau (19).

(19) WordSize >> Anchor-RightIO, Stress-Faith

tèlefóon	WordSize	Anchor-RightIO	Stress-Faith
a. [tèləfón]	*!		
b. [tèfón]	*!		
c. ☞ [fɔm]			*
d. [tèlə]		*!	*

The top two candidates in (19) violate WordSize since they consist of two feet, whereas the bottom two candidates observe the structural well-formedness constraint. Although both candidate (19a) and (19b) fulfill Anchor-RightIO and Stress-Faith, they fail to become optimal due to their violation of a higher-ranked constraint. Of the two candidates forming a trochaic foot, (19d) is ruled out since it violates both of the faithfulness constraints. By contrast, candidate (19c) has one violation mark, thus it becomes an optimal candidate.

It should be mentioned that Robin produced a two-foot word [té ː ləfò ː m] at an older age (2;1.7) while shifting the stress pattern (Fikkert, 1994: 221). In order to yield [té ː ləfò ː m] as an optimal output candidate, the ranking of (19) should be reversed. In sum, the preservation of stressed and word-final syllables requires two faithfulness constraints: STRESS-FAITH and ANCHOR-RIGHTIO. The ranking of WordSize relative to the stress and word-final position faithfulness constraints accounts for the production of the right-most foot [fɔm] of *tèlefóon* as well as the two-foot production [té ː ləfò ː m].

We now turn to our data extracted from Pater (1997). As we have already seen in tableau (17), the above-mentioned constraints will bring us to an explanation of the high retention of both stressed and word-final syllables. For convenience's sake, some examples discussed in Chapter 3 are repeated here.

(20) a. Examples of TSO

Stress type	Adult Target	Children's Output	
WS	dessert	[zɚt]	J (2;8.7-2;9.24)
	machine	[ʃɪ]	T (1;8.26-2;4.13)
	alone	[won]	D (2;6.24)
	Michele	[ʃɛ:u]	T (1;6.25-2;5.26)
WSW	banana	[nænə]	D (2;3.0-2;4.0),
	potato	[teto]	J (2;5.15)
	remember	[mæmə]	J (1;10.8-3;0.1)
	Theresa	[ri ː sə]	T (2;11.10)
	tomato	[meto]	J (2;0.11-2.10.30)
SWW	abacus	[ækus]	T (1;9.2-2;0.8)
	company	[kumni]	T (2;2.23)
	dominoes	[da ː nouz]	T (2;2.23)
	elephant	[ɛwfən]	D (2;9.7-2;10.7)
		[ɛfɛnt]	S (2;1.19)
		[ɛlfɪnt]	S (3;1.18-3;1.27)
		[ɛ ː fɪnt]	T (1;11.14-2;6.15)
	sesame	[sɛ ː mə]	D (2;2.8)
		[semi]	D (2;6.26-3;1.28)

b. Examples of TSC

Stress type	Adult Target	Child Output	Child (age)
WS	balloon	[bun]	D (2;2.25-2;4.26)
	garage	[ga：ʤ]	T (1;10.5-2;0.24)
		[graʤ]	T (2;3.3)
	police	[pis]	J (2;1.10-2;5.3)
		[plis]	J (2;6.5)
WSW	banana	[bænə]	J (1;11.6-2.5.29)
	delicious	[dɪʃəs]	J (1;11.27)
	maracas	[ma：kas]	T (2;0.27)
	piano	[pæ：no]	T (1;11.9-2;2.23)
	potato	[pedo]	J (2;0.25-2;1.20)
SWW	broccoli	[baki]	J (1;7.6-2;0.19)
	buffalo	[bʌfo]	J (2;0.14-2;3.9)
	company	[kʌmpi]	J (1;11.14), S (2;0.27)
	favorite	[fevət]	J (2;0.25-2;6.1)
	sesame	[sɛsi]	S (2;5.14)

Those truncations take place by omitting non-final unstressed syllables, while stressed syllables and word-final unstressed syllables are preserved. It shows that STRESS-FAITH and ANCHOR-RIGHTIO are at play in the child productions. Tableau (21) considers four candidates for the input *tomato*, for example. The high ranking of WordSize, STRESS-FAITH and ANCHOR-RIGHTIO ensures the production of a foot as well as the preservation of stressed syllables and word-final syllables.

(21) WordSize, STRESS-FAITH, ANCHOR-RIGHTIO >> Max-IO

tomato /təméto/	WordSize	ANCHOR-RIGHTIO	STRESS-FAITH	Max-IO
a. [tə(me)]	*!	*		**
b. ☞ [meto]				**
c. [me]		*		**
d. [tə(meto)]	*!			

Candidate (21a) consists of the initial unstressed and stressed syllables, which violates WordSize as well as ANCHOR-RIGHTIO. Candidate (21b) is the right-most trochaic foot, which violates the lowest-ranked Max-IO. Candidate (21c) is made of a single syllable corresponding to the stressed syllable. Since /e/ is a tense vowel in English, this candidate forms a bimoraic foot, so it satisfies not only STRESS-FAITH but also WordSize. However, it is ruled out due to its violation of ANCHOR-RIGHTIO. Consequently, candidate (21b) that avoids the violation of the high-ranked constraints is chosen as optimal. Although it violates Max-IO, it is not fatal since the constraint is least dominant.

In sum, in the grammars of the four children in Pater (1997), the structural well-formedness constraints (ALIGNLEFT, PARSE-σ and FTBIN, altogether called WordSize) and the prosodic faithfulness constraints (stress faithfulness STRESS-FAITH and word-final position faithfulness ANCHOR-RIGHTIO) are ranked high. However, it is difficult to determine the ranking between the two sets of well-formedness and faithfulness constraint since there is no target containing more than one foot like SWS and SWSW in our data. As we have seen in (18) and (19) for longer targets with two feet, WordSize is initially ranked above STRESS-FAITH and ANCHOR-RIGHTIO and later the ranking is reversed. Truncations of WSW targets into SW, WS into S and SWW into SW_2 seem to be straightforwardly captured by the high ranking of WordSize, STRESS-FAITH and ANCHOR-RIGHTIO.

It is problematic, however, that those constraints do not lead us to explicit accounts of TSC in (20b) such as [dɪʃəs] for *delicious* /dəlɪ́ʃəs/ and [bəfo] for *buffalo* /bʌ́fəlò/. It is unclear whether [dɪ] in [dɪʃəs] is the correspondent of the word-initial unstressed syllable or the stressed syllable of the input *delicious*; whether [fo] in [bəfo] is the correspondent to the word-medial or word-final syllable of the input *buffalo*.

In order to clarify the correspondence relations, we revisit the correspondence theory by McCarthy and Prince (1995). The correspondence theory is to capture the faithfulness of the output form to the input form. It is explained by means of constraints requiring identity between elements in the input and output. In child word truncation, correspondence is the relation between the set of elements in the adult target and the set of elements of children's real production. Of truncated productions, syllable conflation found in *delicious* [dɪʃəs] and *favorite* [fevət] may involve more complexity in correspondence relations. Suppose that two syllables, each of which consists of CV, are coalesced into one as follows:

(22) Input Output

$(C_1V_1)_\sigma\ (C_2V_2)_\sigma \rightarrow (C_1V_2)_\sigma$

Then, at the level of segments, V_1 and C_2 of the input do not have their correspondents in the output. However, at the level of syllable we will assume that both syllables in the input share the correspondent in the output, given that correspondence can sometimes be one-to-many relations (McCarthy and Prince, 1995: 14). In other words, even if only part of a syllable in the input appears on the output, it is regarded as the syllable of the input having its correspondent in the output.

For truncations where initial weak syllables are entirely omitted, for example *banana* [nænə], the weak syllable of the input is viewed as having no correspondent in the output. The correspondence relations are illustrated in (23), in which the solid line represents that there is a correspondence relation between two syllables involved and the dotted line indicates there is no correspondent for the given syllable.

(23) Correspondence diagram at the level of syllable

	a. One-to-one	b. One-to-many	
Input	bə nǽ nə	bə nǽ nə	dɔ́g

Output   nǽ nə   bǽ nə   dɔ́ gɪ

In (23a), there is no correspondent in the output [nǽnə] for the initial syllable of the input /bənǽnə/. On the other hand, the first syllable of the output [bǽnə] in (23b) serves as a double correspondent of both the first and second syllables of the input since it contains part of each syllable. Similarly, in the two-syllable production [dɔ́gɪ] for the monosyllabic input *dog* /dɔ́g/, one element (here, syllable) in the input corresponds to two elements in the output simultaneously.

Correspondence relations at the level of segment are different from those at the level of syllable; there is only one-to-one correspondence permitted as displayed in (24).

(24) Correspondence diagram at the level of segment

	a.	b.	c.
Input	b ə n ǽ n ə	b ə n ǽ n ə	d ɔ g
Output	n ǽ n ə	b ǽ n ə	d ɔ́ g ɪ

At the segmental level, no element from the input is associated with two elements or more of the output and vice versa. Whether the output for the input *banana* is [nǽnə] in (24a) or [bǽnə] in (24b), the input *banana* contains elements (here, segments) that have no correspondent in the output. However, segments that have no output correspondent vary depending on the output. In (24a), the first two elements /b/ and /ə/ in the input have no correspondent in the output [nǽnə], whereas the second and third elements /ə/ and /n/ of the input have no correspondent in the output [bǽnə] in (24b). In case of the output [dɔ́gɪ] in (24c), its final element /ɪ/ does not have its correspondent in the input.

As we have observed in Chapter 3, it is the stressed and the word-final vowels of the targets that are invariably retained, regardless of TSC and TSO. As shown in *mach<u>í</u>ne* [ʃ<u>ɪ</u>], *<u>e</u>leph<u>a</u>nt* [<u>ɛ</u>wf<u>ə</u>n], *ball<u>óo</u>n* [b<u>u</u>n] and *f<u>á</u>vor<u>i</u>te* [f<u>e</u>v<u>ə</u>t], where the preserved elements are underlined, both stressed and word-final vowels are preserved but word-final consonants may and may not be deleted.[72] If the segment is the very element in correspondence relations, [ɛwfən] for *élephant* gets to violate ANCHOR-RIGHTIO since the word-final segment /t/ is not preserved as shown in (25a). On the other hand, if the syllable is the element in correspondence relations it observes ANCHOR-RIGHTIO, as illustrated in (25).

(25) Correspondnece with respect to *elephant* /ɛ́ ləfənt/→ [ɛwfən]

	a. Segmental correspondence	b. Syllabic correspondence
<u>Input</u>	ɛ́ l ə f ə n t	ɛ́ lə fənt
<u>Output</u>	ɛ w f ə n	ɛ w fən

Therefore, we assume that the element in STRESS-FAITH and ANCHOR-RIGHTIO refers to the syllable and that one-to-many correspondence relations are allowed between syllables.

Next, we will illustrate the preservation of both stressed and word-final syllables in TSC. Unfortunately, the constraint hierarchy employed to account for TSO in tableau (17) of *elephant* [ɛwfən] and tableau (21) of *tomato* [meto] does not give an explicit explanation for TSC. Take the input *delicious*, for example. Tableau (26) illustrates that the set of ranked constraints given in (21) produce two optimal candidates of the input /dəlɪ́ʃəs/.

[72] Note that word-final consonants are prone to deletion in child phonology (Goodluck, 1991: 25).

(26) WordSize, STRESS-FAITH, ANCHOR-RIGHTI-O >> Max-IO

delicious /dəlɪ́ʃəs/	WordSize	ANCHOR-RIGHTIO	STRESS-FAITH	Max-IO
a. ☞ [lɪʃəs]				**
b. ☞ [dɪʃəs]				**
c. [dəlɪʃəs]	*!			

Candidate (26a) is a truncated form via the omission of the initial syllable, and candidate (26b) stems from the conflation of the first two syllables of the input. Despite its faithfulness to the input, candidate (26c) is ruled out because it violates WordSize. The two disyllabic candidates (26a) and (26b) satisfy all the three undominated constraints. They obey STRESS-FAITH, since /dɪ/ in (26b) as well as /lɪ/ in (26a) corresponds to the stressed syllable of the input according to the correspondence relation (23). Their compliance with ANCHOR-RIGHTIO is ensured by the preservation of the final syllable of the input. Although candidate (26a) and (26b) violate Max-IO, the constraint is ranked lowest, thus it is not relevant. Consequently, we get two optimal candidates with the constraint hierarchy given in tableau (26), which is not allowed under OT grammar, where only one candidate must be left after going through evaluation by a set of ranked constraints.

Tableau (27) evaluates candidates for the input *fávorite*, only to have similar results.

(27) WordSize, STRESS-FAITH, ANCHOR-RIGHTI-O >> Max-IO

favorite /févərɪt/	WordSize	ANCHOR-RIGHTIO	STRESS-FAITH	Max-IO
a. [fevə]		*!		***
b. ☞ [fevət]				**
c. ☞ [ferɪt]				**
d. [févərɪt]	*!			

Candidate (27a), which consists of the first and second syllables of the input, violates ANCHOR-RIGHTIO since it does not contain the syllable corresponding to the final syllable of the input. Thus, it is ruled out. Candidate (27d) violates WordSize, which fails its optimality. However, both candidate (27b) and candidate (27c) fulfill ANCHOR-RIGHTI-O because each of their final syllables contains the segment corresponding to the final segment of the input. As a result, we come to get two optimal candidates (27b) and (27c) for the input *favorite*, which is contradictory in the OT grammar.

In conclusion, the constraint hierarchy we employ in explaining TSO ([meto] for *tomato* in (21) and [ɛfɪnt] for *elephant* in (17)) does not work properly in explaining TSC. For the same reasoning, we fall into fallacy in accounting for TSC like *tomato* [meto], *museum* [ziːʌm] and *abacus* [ækus]. According to the reasoning of (26) and (27), both [meto] and [teto] can become optimal candidates for *tomato* since both fulfill STRESS-FAITH and ANCHOR-RIGHTI-O. So can both [miːʌm] and [ziːʌm] for *museum*; both [ækus] and [æbus] for *abacus*.

In the end, the given constraint hierarchy (WordSize, STRESS-FAITH, ANCHOR-RIGHTI-O >> Max-IO) gives rise to absurd results: two optimal candidates for a given input. In order to avoid such results, we need constraints to serve to penalize [lɪʃəs] for *delicious*; [ferɪt] for favorite; [teto] for *tomato,* [miːʌm] for *museum* and [æbus] for *abacus*. On the one hand, we need onset markedness constraints that disfavor certain sounds in the onset position: for example *L-ONS which is violated when the onset is a liquid. If this constraint is ranked high, [dɪʃəs] is favored over [lɪʃəs]. On the other hand, we require a contiguity constraint that militates against, broadly speaking, word-medial deletion. If the contiguity constraint is ranked high, candidate [meto] for the input *tomato* is favored over [teto] which does not satisfy the contiguity.

5.4 Analysis of the onset choice

5.4.1 Introduction

Word truncation for WS(W) target words in the data (Pater, 1997) preserves the stressed vowel[73] of the target, regardless of whether it is syllable omission or syllable conflation. However, it is unclear whether the onset of the stressed syllable of the target is preserved or not. For the target *balloon*, all the four children in Pater (1997) produce the onset consonant of the initial weak syllable in the truncations [bu], [bʊn], [bun] or [bum]. By contrast, the onset consonant of the initial unstressed syllable of the target *tomato* does not survive in its truncations: [meto] by Julia (2;0.11-2.10.30) and [meːdo] by Trevor (2;0.27). It seems that the onset of the truncation word forms is chosen from the two consonants before the stressed vowel of the target. As to *balloon*, /b/ is chosen between /b/ and /l/, and /m/ is selected between /t/ and /m/ in *tomato*. Then what are the factors to determine which consonant survives? Even though we discussed in the previous section the necessity for contiguity and onset markedness constraints, we take time to contemplate possible factors in determining the onset in child word production.

Bernhardt and Stemberger (1998: 459) identified four possible factors that could influence the onset choice: sonority, position in the word, contiguity to the stressed syllable and possibility of faithful production. When it comes to sonority, an onset of low sonority is favored just as it holds for the reduction of the onset cluster /bl/ into /b/. If sonority would be an important factor, /b/ would be favored over /l/ in *balloon*, and /t/ over /m/ in *tomato*. The second factor would prefer the left-most consonant of the word. If the word position would play a decisive role, /b/ would be chosen in *balloon*, and /t/ would be chosen in *tomato*. Thirdly,

[73] Children may make substitutions for the vowels: the stressed vowel in [gʌːwa] for the target *gorilla* /gərɪ́lə/.

contiguity favors the consonant that is contiguous to the stressed vowel. If contiguity would work on the onset choice, /l/ and /m/ would be chosen respectively for the targets *balloon* and *tomato*. The fourth factor takes into account children's ability to pronounce a certain consonant faithfully. Liquids are invariably regarded as acquired later, thus less likely to be produced, while stops and nasals are among early acquired ones and thus more likely to survive. If the fourth factor would be more relevant, /b/ would be favored over /l/ in *balloon*.

Among the four possible factors, the second and fourth appear little relevant. As we observed, the word-initial weak syllables as a whole are much more likely to be omitted, which means the word-initial onset consonant is also subject to omission. In our data given in Appendices B-C, about 62% of truncations for WS(W) target words delete the initial syllable as a whole and 27% of truncations retain the consonant of the initial syllable of the target. Thus, it is not much convincing that left-most consonants are favored.

Production faithfulness seems less relevant to child word truncation since children tend to substitute earlier-acquired sounds for later-acquired sounds rather than omit those late sounds (Edwards and Shriberg, 1983; Locke, 1993). Besides we easily see marked sounds beating unmarked sound in truncations like *pajamas* [ʤaːmas] produced by Trevor (1;7.26-2;2.10) and *museum* [ziːʌm] by Trevor (2;2.27). /p/ in *pajamas* and /m/ in *museum* are considered to be acquired earlier than /ʤ/ and /z/, respectively (Edwards and Shriberg, 1983), but they fail to be chosen in the child's truncated word forms.

Consequently, we will have sonority and contiguity left to take into account. For WS(W) target words, sonority will be compared between the two onset consonants before the stressed vowel and contiguity refers to the contiguity to the stressed syllable. Concerning SWW target words, sonority will involve comparing the two onset consonants from the two unstressed syllables and contiguity refers to the contiguity to the word-final syllable.

5.4.2 Onset markedness constraints

In this subsection, we will introduce onset markedness constraints, both in structure (e.g. ONSET, *COMPLEX) and in feature (e.g. *L-ONS) as well as a contiguity constraint (I-CONTIG-σ). The interaction among those constraints will provide accounts of TSC as well as TSO in terms of onset choice.

5.4.2.1 ONSET and *COMPLEX

All children produce onset consonants: that is, there is no report of a child who completely lacked onsets at any age (Bernhardt and Stemberger, 1998: 370). Onsets are not necessarily obligatory in child phonology. It is not difficult to find examples of onsetless syllables in children's speech such as *apple* [aː] and *hop* [ap];[74] *up* [ʌp] and *eye* [æʔ].[75] However, child English shows a strong tendency to avoid onset-less syllables although English allows onset-less syllables. In order to avoid being onsetless, an onset consonant could be inserted like the production [laɪ.dən] for *lion* /laɪ.ən/,[76] or the vowel in the onsetless syllable could be deleted like productions [gɛn] for *again* and [waɪ] for *away* by Trevor in Pater (1997).

(28) Strategies to avoid being onsetless

Target	Productions	Strategy
lion /laɪ.ən/	[laɪ.dən]	consonant epenthesis
again /əgɛn/	[gɛn]	deletion of onsetless vowel
away /əwe/	[waɪ]	

Such a tendency to avoid being onsetless can be captured by the constraint ONSET (Prince and

74 Bernhardt and Stemberger (1998).
75 Kehoe and Stoel-Gammon (2001).
76 Bernhardt and Stemberger (1998: 374).

Smolensky, 1993; Kager, 1999) that requires a syllable to have an onset. Onsets are part of the well-formed syllable in the speech of children (Bernhardt and Stemberger, 1998: 375), so ONSET should be ranked high in child grammar. Tableau (29) demonstrates how the higher ranking of ONSET than faithfulness constraints, Max-IO and Dep-IO can explain the production [laɪ.dən] for the target *lion*.

(29) ONSET >> Max-IO, Dep-IO

lion /laɪ.ən/	ONSET	Max-IO	Dep-IO
a. [laɪ]		**!	
b. ☞ [laɪdən]			*
c. [laɪ.ən]	*!		

Candidate (29a) is missing two segment correspondents of the input, thus violating Max-IO. The non-epenthetic (fully faithful) candidate (29c) is ruled out the undominated ONSET. The epenthetic candidate (28b) is chosen as an optimal candidate since it avoids violating higher-ranked constraints.

Another markedness constraint on syllable onset is *COMPLEX, which forbids complex onsets:[77]

(30) ***COMPLEX** Onsets must be simple.

Some children develop some clusters as early as 1;4 although there is variation in the onset time, but there has been no report that children have consonant clusters in their first words (Bernhardt and Stemberger, 1998: 383).[78] When the onset in the adult target word is more complex than a

[77] *COMPLEX refers to the constraint that does not allow complex syllable margins, both onset and coda (Kager, 1999). For convenience's sake, we use it with onsets.
[78] French's (1989) son produced his first word containing a consonant cluster at age 1;10, when he said [bv] for /br/

single consonant, children produce only one consonant at earlier ages (Ingram, 1989; Gnanadesikan, 1995; Wyllie-Smith *et al.*, 2006). For example, Gitanjali (Gnanadesikan, 1995) reduced complex onsets to a single segment aged between 2;3 and 2;9 as given in (31).

(31) Cluster reduction by Gitanjali (Gnanadesikan, 1995)

Target	Productions	Target	Productions
clean	[kin]	skin	[gɪn]
draw	[dɔː]	spoon	[bun]
please	[piz]	slip	[sɪp]
friend	[fɛn]	snookie	[suki]

With the ranking *COMPLEX >> Max-IO, we can easily capture cluster reduction as illustrated in tableau (32) of *clean* [kin].

(32) *COMPLEX >> Max-IO

clean/klin/	*COMPLEX	Max-IO
a. ☞ [kin]		*
b. [klin]	*	

In (32), we consider only two candidates, the fully faithful candidate [klin] and [kin] where /l/ is lost. *COMPLEX requires simply that the onset contain maximally one segment, either /k/ or /l/. The account of which segment is selected from the cluster requires more constraints. From the examples given in (31), we can tentatively conclude that the less sonorous of the consonant cluster is present in the child's production.[79] In order to exclude more sonorous onsets, we need

(McLeod, van Doorn and Reed, 2001a). Children in Watson and Skucanec (1997) begin to produce /pw/ and /bw/ at 2;6 and /st/, /sp/, /pl/, /pw/, /bw/ at age 3. On the other hand, the children in Shriberg (1993) begin to produce consonant cluster containing alveolar nasal at age 3.

[79] It is not always the less sonorous consonant that is produced in the cluster reduction. The reduction of /sl/ to /l/, /sm/ to /m/ and /sn/ to /n/ is found among children aged between 2;0 – 2;11 (Wyllie-Smith *et al.*, 2006), for example

onset markedness constraints that ensure more sonorous onsets are more marked onsets. The necessity of onset markedness constraints in cluster reduction is consistent with the need for constraints to penalize sonorous onsets in syllable conflation, that is, to penalize [lɪʃəs] in favor of [dɪʃəs] for the target *delicious*.

5.4.2.2 Onset markedness hierarchy

Markedness is a relative notion (Kager, 1999: 44), thus markedness of segments in the onset position can be built on the comparison between the segments. It seems that the preferences of [dɪʃəs] over [lɪʃəs] for *delicious* and [bʌfo] over [bʌlo] for *buffalo* are associated with the choice of the onset of the output form. It is not simply a matter of the retention of stressed and word-final syllables, but a matter of the markedness of the onset. As to the child production for *delicious*, /d/ is favored as a syllable onset over /l/; the same is true of /f/ over /l/ in the production of *buffalo*.

The relative markedness of onsets can be captured on the ground that the higher the sonority of the consonant, the more marked onset it can be (Prince and Smolensky, 1993; Gnanadesikan, 1995). According to the Margin Hierarchy[80], it is more marked for a segment with higher sonority to come on the onset position. In this light, we obtain the onset markedness hierarchy, which may be revised version of the Margin Hierarchy.

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smoke [moʊk]. Strikingly, the children reduce /sm/ to /m/ 100% of the time; in the majority cases of other types of /s+sonorant/ cluster, the less sonorous /s/ is deleted (/sw/→/w/ (90%), /sn/ →/n/ (84%)). However, other consonant clusters like /sp/, /tr/, /br/, /gr/, /pr/, /kr/, /fr/, /pl/ and /fl/ are reduced to the least sonorous consonant 100% of the time, and others like /sk/, /st/, /dr/, /kl/, /bl/ and /tw/ are almost always reduced to the least sonorous consonant.

[80] The Margin Hierarchy (*M/*a* >> *M/*i* >> *M/*r* >> … >> *M/*d* >> *M/*t*) states that it is less harmonic to parse *a* as a margin than to parse *i* as margin, less harmonic to parse *i* as a margin than *r*, and so on down the sonority ordering (Prince and Smolensky, 2002: 141).

(33) Onset markedness hierarchy

*V- ONS >> *L-ONS >> *N-ONS >> *F-ONS >> *P-ONS

*V-ONS refers to a constraint that militates against a vocalic (glide) onset; *L-ONS against liquid onsets; *N-ONS against nasal onset; *F-ONS against fricative onsets; and *P-ONS against plosive onsets.

The onset markedness hierarchy can address the selection of the less sonorous consonant from the complex onset. Tableau (34) displays a ranking to select the less sonorous consonant of the cluster /kl/ for the target *clean*.

(34) *COMPLEX, *A-ONS >> *P-ONS, Max-IO

clean/klin/	*COMPLEX	*L-ONS	*P-ONS	Max-IO
a. ☞ [kin]			*	*
b. [lin]		*!		*
c. [klin]	*!	*	*	

Candidate (34c) is ruled out by *COMPLEX. Of the remaining candidates, (34b) violates *L-ONS, thus being ruled out. As a result, candidate (34a) is chosen as optimal since it avoids violations of the higher-ranked constraints. In a similar way, the removal of /s/ from /sk/ cluster can be captured with the onset markedness hierarchy:

(35) *COMPLEX, *F-ONS >> *P-ONS, Max-IO

skin /skin/	*COMPLEX	*F-ONS	*P-ONS	Max-IO
a. ☞ [gin]			*	*
b. [sin]		*!		*
c. [skin]	*!	*	*	

Candidate (35c), the fully faithful candidate, fatally violates *COMPLEX. Candidate (35a) and (35b) both satisfy *COMPLEX, and each holds one violation mark for onset markedness constraints. However, candidate (35a) becomes optimal since it violates the lower-ranked onset markedness constraint, *P-ONS.

Next we will look into how onset markedness constraints work on the account of syllable conflation. We will undertake a slight revision of the hierarchy given in (33) before applying the hierarchy to our data from Pater (1997). Children tend to realize liquids as glides (e.g. around → [waun] by Trevor at 2;0.8) (Holmes, 1927; Pater, 1997), thus *V-ONS and *L-ONS can be merged into *A-ONS (*Approximant-ONS), which penalizes approximant onsets. As a result, the preference for [dɪʃəs] over [lɪʃəs] as to the input *delicious* can be grasped in terms of *A-ONS. As to the onset markedness constraints concerning obstruent onsets, we find no stronger effect of *F-ONS than that of *P-ONS from our data. For example, *desert* is produced as [zɚt] not as [dɚt]. Thus, we put fricatives and plosives into one class of obstruents and assume a markedness constraint *Ob-ONS (*Obstruent-ONSET) exerts the weakest influence in the grammars of the children. As a result, we obtain a revised hierarchy of onset markedness constraints as follows:

(36) Onset markedness hierarchy (abridged)

*A-ONS >> *N-ONS >> *Ob-ONS

According to the onset markedness hierarchy, the choice of [dɪʃəs] as an optimal candidate for the input *delicious* rather than [lɪʃəs] can be resolved by the ranking *A-ONS >> *Ob-ONS as shown in (37).

(37) *A-ONS >> *Ob-ONS

delicious /dəlɪ́ʃəs/	*A-ONS	*Ob-ONS
a. ☞ [dɪʃəs]		**
b. [lɪʃəs]	*!	*

Two fricative onsets in candidate (37a) results in two violation marks for *Ob-ONS, but is becomes optimal compared to its competitor. Candidate (37b) fatally violates the higher-ranked *A-ONS.

Thus far we have seen that the onset markedness constraints we discussed elucidate the selection of less sonorous onset and the deletion of more sonorous onset in child word productions (in syllable conflation as well as cluster reduction). However, we know it is not always the less sonorous consonant that survives in child word productions. The target word *tomato* is produced as [meto] by Julia (2;0.11-2.10.30), as opposed to our expectation. According to the onset markedness hierarchy, [teto] should be optimal compared to [meto] as illustrated in (38).

(38) *N-ONS >> *Ob-ONS

tomato/təméto/	*N-ONS	*Ob-ONS
a. [meto]	*	*
b. ☞ [teto]		**

Consequently, we require a constraint that has stronger effect so as to reject [teto]. A contiguity constraint that militates against the deletion of segments from different syllables serves this function. Note that all the TSC violate the contiguity among segments, whereas all the TSO cling to the contiguity.

5.4.3 Contiguity constraint, I-CONTIG-σ

We have noted the necessity for a constraint that penalizes word-medial deletion found in [teto] for *tomato*/təméto/. McCarthy and Prince (1994a: 9) present contiguity constraints as follows:

(39) **I-CONTIG** ('No skipping') The portion of the input string standing in correspondence forms a contiguous string.

O-CONTIG ('No intrusion') The portion of the output string standing in correspondence forms a contiguous string.

The map xyz → xz violates I-CONTIG because xz is not a contiguous string in the input; the map xz → xyz violates O-CONTIG but xy → xyz does not (McCarthy and Prince, 1995: 123). Truncations do not involve epenthesis or 'intrusion' at all, thus O-CONTIG is irrelevant to our discussion. Only I-CONTIG is of interest to us.

We know that the candidate [teto] for the input *tomato* violates I-CONTIG since there is a two-syllable gap between /t/ and /e/. Therefore, if ranked high, this contiguity constraint will explain the ruling out of [teto] for the input *tomato*. Note, however, that any kind of truncations of SWW targets entail word-medial deletion, leading to the violation of I-CONTIG. That is, the constraints cannot discriminate between TSC and TSO for SWW targets. For example, in *abacus* [ækus], a TSO, there is two-segment skipping between the correspondents of /æ/ and /k/. That is, the portion of the input string does not form a contiguous string. As to *buffalo* [bʌfo], a TSC, there is a gap by one segment between the correspondents of /f/ and /o/. In other words, both TSO and TSC violate the contiguity with respect to SWW targets.

In order to bring in the effect to discriminate TSO from TSC for SWW targets, we employ a revised version of I-CONTIG: contiguity is considered relative to the syllable as given below

(Pater, 1997):

(40) **I-Contig-σ** The portion of the input string standing in correspondence with the segments of a syllable of the output forms a contiguous string.

I-Contig-σ requires that the segments within a given syllable of the output must be taken from a contiguous string within the input. The following hypothetical candidates in (41) illustrate the ill-formed candidate and the optimal candidate as respects the constraint, I-Contig-σ. In the diagram, syllable boundaries in the output forms are marked with square brackets:

(41) Well-formedness with respect to I-Contig-σ

	a. well-formed	b. ill-formed
Input	b ə n æ n ə	b ə n æ n ə
Output	[n æ][n ə]	[b æ] [nə]

In (41a), all the elements within each syllable of the output are from a contiguous string in the input, whereas the elements in the first syllable of the output in (41b) are not from a contiguous string but there is a gap. That is to say, (41a) observes I-Contig-σ; (41b) violates I-Contig-σ. The observance of I-Contig-σ will raise the possibility of candidate [nænə] for the input *banana* becoming optimal if the contiguity constraint is undominated.

Truncations of syllable omission like *tomato* [meto], *museum* [ziːʌm] and *abacus* [ækus] conform to I-Contig-σ. Hence in order to account for those productions, the contiguity constraint should be undominated. Conversely truncations of syllable conflation like *delicious* [dɪʃəs], *balloon* [bun] and *favorite* [fevət] are in violation of I-Contig-σ. That is, in order for two syllables to be conflated into one syllable, I-Contig-σ should be dominated or its effect should be weakened. As we observed in Chapter 3, most syllable conflations occur when the targets contain intervocalic sonorant segments. Tableau (42) and (43) display the interaction between the two conflicting constraints: onset markedness constraint and I-CONTIG-σ. Tableau (42) shows how the ranking of *A-ONS above I-CONTIG-σ explain TSC for the input *delicious*.

(42) *A-ONS >> I-CONTIG-σ

delicious /dəlɪˊʃəs/	*A-ONS	I-CONTIG-σ
a. ☞ [dɪʃəs]		*
b. [lɪʃəs]	*!	

Candidate (42a) violates I-CONTIG-σ and candidate (42b) violates *A-ONS, but the ranking of *A-ONS >> I-CONTIG-σ makes (42a) an optimal candidate.

On the contrary, the tableau of [meto] for the input *tomato* requires placing I-CONTIG-σ ranked above *N-ONS as illustrated in (43).

(43) I-CONTIG-σ >>*N-ONS

tomato /təméto/	I-CONTIG-σ	*N-ONS
a. ☞ [meto]		*
b. [teto]	*!	

Tableau (43) considers two output candidates. Candidate (43a), which contains /m/ as on onset, violates *N-ONS while avoiding discontiguity among segments. Candidate (43b) fatally violates I-CONTIG-σ while all of its onsets are the least marked, satisfying *N-ONS.

We have so far introduced relevant constraints to account for our data of truncations. We saw in (42) and (43) two different types of truncation (TSC and TSO, respectively) can be explained with the interaction between onset markedness constraints and the input contiguity constraint. We have already illustrated that when WS(W) targets are reduced into S(W), whether it is TSC like (42) or TSO like (43), the stressed vowel is always retained and between the two onsets before the vowel, one is chosen as the onset of the child word. In the next section we will look into TSC and TSO in terms of the onset choice.

5.4.4 Onset choice between two consonants

5.4.4.1 WS(W) targets

We have observed that when WS(W) is truncated into S(W), the stressed rhyme is always retained and the onset of the stressed syllable of the child word is chosen between the two onsets before the stressed vowel of the input. For example, for the input *balloon*, /b/ and /l/ compete and for *potato*, /p/ and the first /t/ enter into the competition.

The onset choice can be made considering two aspects: contiguity and onset markedness concerning manner of articulation. In TSC of WSW targets, of the two onsets before the stressed syllables, the one that is discontiguous to the stressed vowel is chosen as the onset of the child production(e.g. between /d/ and /l/ in *delicious* in (42), /d/ is selected). On the other hand, in case of TSO, of the two onsets before the stressed vowel, the one that is contiguous to the vowel is chosen as the onset of the child word (e.g. between /t/ and /m/ in *tomato* in (43), /m/ is chosen).

The examination of the onset choice in terms of onset markedness is more complicated since, unlike the binary contiguity, onset markedness can be ternary as given in (36) or quinary as given in (33), or even further subdivided if we consider markedness of separate segments like */m/-ONS. To investigate the onset choice in terms of onset markedness, I classify truncations according to the manner of articulation of onset candidates: liquids, nasals, obstruent. Plosives and fricatives are classified into obstruent since there is no different behavior found in our children's truncations.

Liquids vs. obstruents

Table (44) lists the targets and their truncations where an obstruent and a liquid compete for the onset position of the child words. All but one (*Theresa* [riːsə]) truncations choose the obstruent as the onset. In the production for *Theresa*, the onset /r/ of the stressed syllable is preserved as the onset of the truncated form. By contrast, the other liquids including those that are the onset of the stressed syllable (e.g. /l/ in *delicious*) give way to their obstruent competitors.

(44) Onset choice between Obstruent and Liquid

Stress type	Target	Truncation	Child (Age)	Onset candidates	Chosen onset
WSW	delicious	[dɪʃəs]	J (1;11.27)	d, l	d
	gorilla	[gʌːwa]	T (1;11.14)	g, r	g
	Theresa	[riːsə]	T (2;11.10)	t, r	r
WS	balloon	[bun]	D (2;2.25-2;4.26)	b, l	b
	belong	[bɔŋ]	J (1;11.27-2;0.26)	b, l	b
	garage	[gaːʤ]	T (1;10.5-2;0.24)	g, r	g

With regard to the truncations in (44) except for *Theresa* [riːsə], the consonant of low sonority is chosen as the onset in the child's word and the contiguity to the stressed vowel does not have any effect on the onset choice. Thus, the grammar should put *A-ONS in a higher ranking than I-CONTIG-σ as illustrated in (45):

(45) *A-ONS >> I-CONTIG-σ

delicious /dəlɪ́ʃəs/	*A-ONS	I-CONTIG-σ
a. [lɪʃəs]	*!	

b. ☞ [dɪʃəs]		*

<u>Nasal vs. obstruent</u>

Next, we will look into the onset choice between an obstruent and a nasal. Unlike the choice between an obstruent and a liquid, it reveals inconsistent results as demonstrated in (46).

(46) Onset choice between Obstruent and Nasal

Stress type	Target	Truncation	Child (Age)	Onset candidates	Chosen onset
WS	Denise	[dis]	T (1;1.17-2;2.15)	d, n	d
	cement	[mɛnt]	D (2;11.27)	s, m	m
	machine	[ʃɪ]	T (1;8.26-2;4.13)	m, ʃ	ʃ
	Merced	[sɛd]	T(1;11.12-2.11.10)	m, s	s
WSW	banana*	[nænə]	D (2;3.0-2;4.0)	b, n	n
	banana*	[bænə]	J (1;11.6-2.5.29)	b, n	b
	Modesto	[dɛsto]	T (2;8.15)	m, d	d
	museum	[ziːʌm]	T (2;2.27)	m, z	z
	tomato	[meto]	J (2;0.11-2.10.30)	t, m	m
	tomorrow	[mowo]	J (1;7.16-2;.0.17)	t, m	m

First, when /m/ is involved in the onset competition, sonority does not exert any effect. For example, regarding the production of *cement*, if the consonant of low sonority is favored as the onset, /s/ should be chosen; in fact, /m/ is chosen, instead. Contiguity to the stressed vowel seems to be in operation. The consonant that is contiguous to the stressed vowel, regardless of sonority, is chosen as the onset. This relation is illustrated in tableau (47):

(47) I-CONTIG-σ >> *N-ONS

cement	I-CONTIG-σ	*N-ONS

a. [sɛnt]	*!	
b. ☞ [mɛnt]		*

In (47) each of the two candidates for the input *cement* violates one of the two given constraints. Since candidate (47b) avoids the violation of the higher-ranked constraint, it is chosen as optimal. The ranking in (47) explains all the cases of TSO in (46) including *banana* [nænə]. However, it cannot account for TSC in (46): *banana* [bænə] and *Denise* [dis]. In fact, they are the only target words in our data that /n/ concerns. In their truncated forms, sonority appears to influence. The illustration of the ranking of *N-Ons above I-Contig-σ is provided in (48), where two candidates are considered.

(48) *N-Ons >> I-Contig-σ

banana	*N-Ons	I-Contig-σ
a. ☞ [bænə]	*	*
b. [nænə]	**!	

Candidate (48a) violates both constraints, whereas candidate (48b) violates one constraint. Since the latter violates the higher-ranked *N-Ons twice, it is more fatal. Thus it is excluded and consequently candidate (48a) is chosen as an optimal candidate with respect to the given ranking.

Although it might be difficult to determine which constraint is operating more powerfully due to lack of the data, one plausible account of the discrepancy in truncation for the same target *banana* is that different ranking might operate depending on children and at different stages of development, which will be dealt with later.

<u>Nasal vs. liquid</u>

Thirdly, we will look into the onset choice between a liquid and a nasal. As the table in (49) exhibits, regardless of the contiguity to the stressed vowel, the nasal, here /m/, is favored over the liquid. That is, sonority is more relevant to truncation rather than contiguity.

(49) Onset choice between Liquid and Nasal

Stress type	Target	Truncation	Child (Age)	Onset candidates	Chosen onset
WSW	maracas	[maːkas]	T (2;0.27)	m, r	m
	remember	[mæmbə]	J (2;1.18-2.7.29)	r, m	m
WS	Marie	[mi]	T (1;6.17-1;9.2)	m, r	m

The productions in (49) can be captured with the ranking of constraints: A-Ons >> *N-Ons, I-Contig-σ, as illustrated in (50) and (51).

(50) *A-Ons >> *N-Ons, I-Contig-σ

marácas	*A-Ons	*N-Ons	I-Contig-σ
a. [raːkas]	*!		
b. ☞ [maːkas]		*	*

(51) *A-Ons >> *N-Ons, I-Contig-σ

remémber	*A-Ons	*N-Ons	I-Contig-σ
a. [ræmbə]	*!		*
b. ☞ [mæmbə]		*	

Of the two output candidates for the input *maracas*, candidate (50a) violates the highest ranked constraints. By contrast, although it violates the other two constraints, candidate (50b) avoids the violation of *A-Ons. That is why (50a) becomes optimal. Similarly, of the two candidates for the input *remember*, candidate (51a) is ruled out since it violates *A-Ons. Thus, (51b) is chosen as an optimal candidate.

Obstruent vs. obstruent

Table (52) shows the state of onset choice between two obstruents. Although plosives have lower sonority than fricatives (and affricates) and can be more unmarked onsets, there is no case within our data that favors a plosive onset over a fricative (or affricate). In this case, the onset seems to be determined by the contiguity to the stressed vowel. Thus, when an obstruent is vying with another obstruent, contiguity is more actively engaged in truncation, and the onset markedness constraint that disfavors fricative or plosive onsets is virtually switched off. We obtain the constraint hierarchy: I-CONTIG-σ >> *Ob-ONS.

(52) Onset choice between two Obstruents

Stress type	Target	Truncation	Child (Age)	Onset candidates	Chosen onset
WSW	pajamas	[daməs]	J (1;8.27-2;0.2)	p, ʤ	d[81]
		[ʤæməʃ]	S (1;11.15-2;0.23)	p, ʤ	ʤ
	potato*	[teto]	J (2;5.15)	p, t	t
		[teː to]	T (1;919-1.10.5)	p, t	t
	potato*	[pedo]	J (2;0.25-2;1.20)	p, t	p
	together	[gɛː dɚ]	T (1;9.27-2;0.27)	t, g	g
	vagina	[ʤaiː nə]	T (2;11.10)	v, ʤ	ʤ
WS	dessert	[zɚt]	J (2;8.7-2;9.24)	d, z	z
	today	[de]	D (2;8.19-3;2.0)	t, d	d

Note that there is an exceptional case in (52): *potato* is produced as [pedo] by Julia aged 2;0.25-2;1.20, in which neither sonority nor contiguity is involved. More notably, Julia produced both [teto] and [pedo] at varying times: [pedo] predates [teto]. This may imply that in

81 It would be reasonable to say that /ʤ/ is survived in the competition with /p/ and then replaced by /d/ since /d/ shares more features (e.g. [Place]) with /ʤ/ than /p/.

Julia's word production, the constraint of the contiguity to the stressed vowel comes into effect later in time and that there would a preference for /p/ over /t/ in the child's earlier production.

As to the onset choice between /p/ and /t/ from the first and second syllables of *potato*, we resort to markedness constraints governing place of articulation since it is no longer concerning markedness about manner of articulation or sonority. Universally, coronals are presumed to be less marked than labials, and thus the constraint that prohibits labials in the output outranks the constraint that prohibits coronals (Prince and Smolensky, 2002: 198; Kager, 1999: 44). In child language, neither [labial] nor [coronal] is strongly confirmed as universal default place or articulation (Bernhardt and Stemberger, 1998: 291) since the relative frequencies between coronals and labials vary across children and language. In child English, however, we take [labial] as more unmarked place since labials /p, b/ are normally acquired earlier than coronals /t, d/ (Edwards and Shriberg, 1983: 133, 169; Dodd *et al*., 2003). Moreover [labial] is the more common place feature than [coronal] in child language, both in inventory and substitutions (Bernhardt and Stemberger, 1998: 292). Therefore, *[cor] is higher-ranked than *[lab] as far as early child English is concerned.

Tableau (53) and (54) illustrate the ranking of these place markedness constraints with respect to I-CONTIG-σ.

(53) *[cor] >> *[lab], I-CONTIG-σ

potato /pətéto/	*[cor]	*[lab]	I-CONTIG-σ
a. ☞ [peto]	*	*	*
b. [teto]	**!		

For the given ranking, candidate [peto] becomes optimal despite its violation of all the constraints since the other candidate (53b) violates the highest constraint *[cor] twice, which is more fatal. On the other hand, if I-CONTIG-σ dominates *[cor], [peto] is ruled out because it violates the highest constraint as illustrated in (54). As a result, we get to obtain the optimal output [teto] for the input *potato*.

(54) I-CONTIG-σ >> *[cor] >> *[lab]

potato /pəteto/	I-CONTIG-σ	*[cor]	*[lab]
a. [peto]	*!	*	*
b. ☞ [teto]		**	

The two tableaux show that the different ranking of constraints accounts for the different production for the same target at different ages.

<u>Onsetless vs. onsetful</u>

It has been noted that syllables beginning with a consonant are preferred to those beginning with a vowel and syllables with consonant onset are regarded as well-formed (Kager, 1999: 93). In an attempt to avoid being onsetless, word-initial onsetless unstressed syllables in (55a) are omitted; the onsetless stressed syllable of *piáno* in (55b) adopts /p/ of the preceding unstressed syllable as its onset by deleting the medial unstressed vowel /ɪ/.

(55) Truncations of word containing onset-less syllables

	Target	Truncation	Child (Age)
a.	again	[gɛn]	J (1;10.1-2;1.24)
	alone	[won]	D (2;6.24)
	apart	[part]	T (1;9.29)
	away	[we]	D (2;2.30)
	away	[waɪ]	J (1;8.24-2;0.19)
	eleven	[jɛvən]	J (2;2.24)
	enough	[nʌf]	T (1;10.5-1;11.25)

	excuse	[ku ː zə]	T (2;2.10-2;6.6)
	umbrella	[bɛla]	S (2;0.1)
	umbrella	[bre ː wa]	T (1;11.5)
b.	piano	[pæ ː no]	T (1;11.9-2;2.23)
	piano	[pæno]	J (1;9.19-2;4.17)

We can consider those cases of onsetless syllables in line with the above-mentioned onset choice. There is only one consonant before the stressed vowel of the target words: both in *again* and in *piano*. Thus, the consonant takes the onset position of the first syllable of the child's production. As opposed to the onset choice between two consonants, sonority and contiguity to the stressed vowel do not have any bearing here. Instead, syllable well-formedness that requires a syllable to begin with a consonant plays a role.

Tableau (56) captures the effect of Onset for the input *again*: Onset, which is in conflict with Max-IO as to the output candidates of the input *again*, should be ranked higher to produce the optimal production [gɛn].

(56) Onset >> Max-IO

again	Onset	Max-IO
a. [gɛn]		*
b. ☞ [əgɛn]	*!	

Candidate (56b) is ruled out because it violates the higher ranked Onset. Candidate (56a) violates Max-IO due to the deletion of the initial vowel /ə/ but fulfills the outranking constraint Onset, thus chosen as an optimal candidate.

Avoidance of onsetless syllables in the target *piano* takes a different strategy from the common strategy like the deletion of the onsetless syllable in (55a) or the insertion of a consonant like [laɪ.dən] for *lion* /laɪ.ən/ in (28). If we follow those common strategies, we will obtain [pɪno] as a result of the deletion of the onsetless syllable or [pɪʔæno] by epenthesizing a glottal consonant before the onsetless syllable. Let us consider these productions as output candidates along with Julia's production [pæno] and the adult form [pɪæno]. ONSET serves to exclude the adult form containing an onsetless syllable and WordSize rules out tri-syllabic productions. Note that STRESS-FAITH and WordSize are undominated in the grammars of the four children in our data as elaborated in previous sections. Their ranking above ONSET is motivated by our observation that some child words contain onsetless syllable: for example, *alone* → [ioː n] and *around* → [ound]. Finally, to select [pæno] as an optimal candidate, I-CONTIG-σ should be dominated. The illustration of the ranking of the constraints is offered in tabeau (57).

(57) STRESS-FAITH, WordSize >> ONSET >> I-CONTIG-σ

/pɪǽno/	STRESS-FAITH	WordSize	ONSET	I-CONTIG-σ
a. ☞ [pæno]				*
b. [pɪno]	*!			
c. [pɪʔæno]		*!		
d. [pɪæno]		*!	*	

5.4.4.2 SWW and ŚWS target words

In regard to SWW and ŚWS target words in our data, their truncations yield SW forms. As we have shown before in section 3.2 of Chapter 3, the primarily stressed syllable of the target is unquestionably retained. Concerning the rightmost two syllables, either they are conflated into one (e.g., *buffalo* →[bʌfo]) or the word-medial unstressed syllable is omitted (e.g., *abacus* →[ækus]). In either case, the word-final rhyme is preserved although the onset of the word-final syllable is not guaranteed to be retained. As another example, the truncation [fevət] for *favorite* by Julia (2;0.25-2;6.1) shows that the onset of the word-final syllable is omitted but the rhyme is retained.

There are some obscure examples such as [kæmʌ] by Sean (2;0.13), [kæmə] by Trevor (1;5.6-1;11.25) and [kæmɚ] by Trevor (2;0.3) for the target *camera*. [82] In those truncated forms, we cannot definitely confirm that the word-final vowels are preserved. However, we assume their retention of the final vowel considering that /ə/ appears in both the medial and the final syllable of the targets and vowels are highly subject to substitution in child speech. Then, we could say that the onset of the second syllable of the child word is chosen from the consonant onsets of the two right-most syllables of SWW/ŚWS targets. Just as in the truncation of WS(W) target words, we could look into the onset choice in terms of sonority and contiguity, the sonority of the onset consonants from the two weak syllables and the contiguity of each consonant to the word-final vowel.

As shown in (58), between an obstruent and a liquid, an obstruent is chosen as the onset. So, sonority is taken into account more than the contiguity to the word-final vowel.

(58) Onset choice between Obstruent and Liquid

Target	Truncation	Child (Age)	Onset candidates	Chosen onset
broccoli[83]	[baki]	J (1;7.6-2;0.19)	k, l	k
buffalo	[bʌfo]	J (2;0.14-2;3.9)	f, l	k
favorite	[fevət]	J (2;0.25-2;6.1)	v, r	v

That is, I-CONTIG-σ, a contiguity constraint that favors a consonant adjacent to the word-final

[82] Note that in Chapter 3 we classified those truncations as the case of TSO where the final syllable as a whole is omitted.

[83] The initial stressed syllable of the target *broccoli* is produced as [ba] by reducing the onset cluster /br/ into /b/, a consonant of low sonority. Such a reduction is commonly found in children’s word productions (Gnanadesikan, 1995; Wyllie-Smith *et al*., 2006).

vowel of the input, dominates *A-ONS, as illustrated in (59) for the truncation of *buffalo*.

(59) *A-ONS >> I-CONTIG-σ

	búffalo	*A-ONS	I-CONTIG-σ
a.	☞ [bʌfo]		*
b.	[bʌlo]	*!	

Candidate (59b), which consists of the stressed syllable and the word-final syllable from the input, violates the undominated *A-ONS, thus it is ruled out. On the other hand, candidate (59a), where the rightmost two syllables of the input are conflated, avoids violating *A-ONS although it does not conform to the contiguity constraint.

When an obstruent and a nasal are vying for the onset position, we encounter conflicting results for the same target words. As displayed in (60), where two competing consonants of each target word are represented in bold face, *company* is produced as [kʌmpi] by Julia and *sesame* as [sɛsi] by Sean, which implies sonority is more relevant than contiguity, or the ranking would be: *N-ONS >> I-CONTIG-σ. On the contrary, the production of [kumni] for *company* by Trevor and [semi] for *sesame* by Derek suggests that contiguity is more relevant to the onset choice than sonority or the ranking should be: I-CONTIG-σ >> *N-ONS.

(60) Onset choice between Obstruent and Nasal

Target	Truncation	Child (Age)	Onset candidates	Chosen onset
com**p**a**n**y	[kʌmpi]	J (1;11.14)	p, n	p
	[kumni]	T (2;2.23)	p, n	n
se**s**a**m**e	[sɛsi]	S (2;5.14)	s, m	s
	[semi]	D (2;6.26-3;1.28)	s, m	m

As opposed to truncations of WS(W) words given in (46), */m/-ONS is not invariably dominated by I-CONTIG-σ regarding the input *sesame*. However, we could draw the same conclusion as the truncation of *banana* in (46) that the ranking of constraints (here, I-CONTIG-σ and *N-ONS) can vary among children.

(61) Onset choice between obstruent and nasal by child

Stress type	Target	Truncation	Child (Age)	Onset candidates	Chosen onset
WSW	banana	[nænə]	D (2;3.0-2;4.0)	b, n	n
SWW	sesame	[semi]	D (2;6.26-3;1.28)	s, m	m
WSW	banana	[bænə]	J (1;11.6-2.5.29)	b, n	b
SWW	company	[kʌmpi]	J (1;11.14)	p, n	p

For example, as presented in (61), the contiguity constraint outranks *N-ONS in Derek's production, whereas sonority is more relevant than contiguity in Julia's productions; that is, I-CONTIG-σ is dominated by *N-ONS in Julia's grammar.

Next, we will examine the onset choice between two nasals or between two obstruents in SWW and ŚWS target words. Since there is only one case of the competition between a liquid and a nasal- when the target is *camera*, we exclude it from discussion. Like truncations of WS(W) targets, when an obstruent is vying with another obstruent in the targets with the word-initial stressed syllable (see table (62)), contiguity is actively engaged in truncation.

(62) Onset choice between Obstruents

Target	Truncation	Child (Age)	Onset candidates	Chosen onset
abacus	[ækus]	T (1;9.2-2;0.8)	b, k	k
bicycle	[baɪko]	J (1;8.4-1;10.13)	s, k	k
medicine	[mɛsɪn]	J (2;0.25-2;6.1)	d, s	s

The same holds true for the onset choice between nasals as shown in (63).

(63) Onset choice between Nasals

Target	Truncation	Child (Age)	Onset candidates	Chosen onset
animal	[æmʊ]	D (2;1.14-3;1.24)	n, m	m
cinnamon	[sɪmɛn]	J (1;11.15)	n, m	m
dominoes	[daːnouz]	T (2;2.23)	m, n	n

For each input word in (62) and (63), the consonant contiguous to the word-final vowel is chosen as the onset of the weak syllable of the child output. Thus, the outputs require the constraint I-CONTIG-σ to be undominated.

5.4.5 Rankings of constraints in truncation

Thus far we have discovered the subrankings of constraints operating in the grammar of the children in Pater (1997):

(i) The structural constraints ALIGNLEFT, PARSE-σ and FTBIN and prosodic faithfulness constraints STRESS-FAITH and ANCHOR-RIGHTIO are undominated and ranked higher than Max-IO. Their high ranking is motivated by the observations that children's truncated outputs preserve both stressed and word-final syllables of the targets, and as a result they stick to the trochaic form of S or SW.

(ii) (45), (57) and (59) show that onset markedness constraints ONSET and *A-ONS are dominated by the set of constraints mentioned in (i), but they dominate I-CONTIG-σ: ONSET, *A-ONS >> I-CONTIG-σ. This accounts for TSC of targets containing intervocalic liquids.

(iii) As seen in (50) and (62), *Ob-ONS is virtually switched off and I-CONTIG-σ exercises the stronger effect on the output: I-CONTIG-σ >> *Ob-ONS. This explains TSO of targets with intervocalic obstruents.

(iv) The ranking of I-CONTIG-σ with respect to *N-ONS is difficult to determine. Some truncations (in fact, TSO) require the ranking of I-CONTIG-σ >> *N-ONS; others (TSC) call for the reversed ranking *N-ONS >> I-CONTIG-σ, as illustrated in table (64). The different rankings between the two constraints give birth to variation of TSC and TSO for the same target, which are marked by an asterisk in (64).

(64) The ranking between I-CONTIG-σ and *N-ONS

Ranking	Input	Output	Child (Age)
I-CONTIG-σ	cement	[mɛnt]	D (2;11.27)
>> *N-ONS	machine	[ʃɪ]	T (1;8.26-2;4.13)
	Merced	[sɛd]	T(1;11.12-2.11.10)
	banana*	[nænə]	S (1;8.28-1;11.19)
	Modesto	[dɛsto]	T (2;8.15)
	museum	[ziːʌm]	T (2;2.27)
	tomato	[meto]	J (2;0.11-2.10.30)
	tomorrow	[mowo]	J (1;7.16-2;.0.17)
	company*	[kumni]	T (2;2.23)
	sesame*	[semi]	D (2;6.26-3;1.28)
*N-ONS >>	Denise	[dis]	T (1;1.17-2;2.15)
I-CONTIG-σ	banana*	[bænə]	J (1;11.6-2.5.29)
	company*	[kʌmpi]	J (1;11.14)
	sesame*	[sɛsi]	S (2;5.14)

(v) In addition to the ranking in (iv), the ranking between *[cor] and I-CONTIG-σ is also indeterminate in Julia's production of *potato*. It seems to vary across ages of children.

5.4.6 Interpersonal and developmental variations

In the previous subsection, we noted that the ranking between I-CONTIG-σ and *N-ONS is indeterminate. More problematically, the input words represented by the upper script '*' in (64) yield the opposite outputs. It would not be possible to know whether the ranking varies from word to word (Pater, 1997: 227). However, it would be possible that different children have different rankings of constraints. In this view, we will explore the output variations among children and intrapersonal differences over time, and try to account for these variations in terms of different rankings of constraints.

5.4.6.1 Interpersonal variations

First, we will look into how output words vary among individual children. The following table (65) summarizes the variant outputs for the inputs *banana*, *company* and *sesame* depending on children.

(65) Variant truncations for *banana*, *company* and *sesame* by child

Child	Target	Truncation	Age
Trevor	banana	[nænə]	0;11.10-1;6.8
		[nænæ]	1;0.9-3;1.8
	company	[kumniː]	2;2.23
Derek	banana	[nænə]	2;3.0-2;4.0
	sesame	[sɛːmə]	2;2.8
		[sɛːmi]	2;6.26-3;1.28
Julia	banana	[bænə]	1;11.6-2.5.29
	company	[kʌmpi]	1;11.14
Sean	banana	[nænə]	1;8.28-1;11.19
	sesame	[sɛsi]	2;5.14
	company	[kʌmpi]	2;0.27

The productions by Trevor and Derek in (65) require their grammars to set I-CONTIG-σ higher than *N-ONS, whereas Julia's productions induce the dominance of *N-ONS over I-CONTIG-σ. The three children's rankings of onset markedness constraints with respect to the contiguity constraints are as follows:

(66) Constraint hierarchy by child

Child	Hierarchy
Trevor	*A-ONS >> I-CONTIG-σ >> *N-ONS >>*Ob-ONS
Derek	*A-ONS >> I-CONTIG-σ >> *N-ONS >>*Ob-ONS
Julia	*A-ONS >>*N-ONS >> I-CONTIG-σ >>*Ob-ONS

Contrary to those three children, Sean's productions appear to be rather tricky: the truncation of *banana* adheres to the ranking I-CONTIG-σ >> *N-ONS, while the truncations of *sesame* and *company* are consistent with the ranking *N-ONS >> I-CONTIG-σ. Therefore, the ranking between *N-ONS and I-CONTIG-σ appears to be difficult to determine at least for Sean's grammar. Such intrapersonal variation can be captured by means of constraint re-rankings over time. We will deal with it in the next subsection in more detail.

5.4.6.2 Developmental variation

One possible approach to Sean's variation in word production can be derived from the observation that different rankings of constraints appear at different times of his life, although the time lapse is not so distinct. The production [nænə] is produced rather earlier (1;8.28-1;11.19) than the productions of [sɛsi] (2;5.14) and [kʌmpi] (2;0.27). It implies that Sean has *N-ONS overruled by I-CONTIG-σ at first and then later the ranking is reversed. That is, the hierarchy of the two constraints varied over time as demonstrated in (67).

(67) Sean's re-ranking between I-CONTIG-σ and *N-ONS over time

Input	Output	Time	Hierarchy
banana	[nænə]	1;8.28-1;11.19	I-CONTIG-σ >> *N-ONS
sesame	[sɛsi]	2;5.14	*N-ONS >> I-CONTIG-σ
company	[kʌmpi]	2;0.27	

The re-ranking process of constraints over time has been used as a general way to account for child development (Demuth, 1995, 1996b, 1996c). This way can be evidenced further by another data of word variations. We observed that Julia's outputs of *potato* are different depending on the time of production: she produced [pedo] earlier and [teto] later in time. As we have already seen in (53) and (54), Julia's variation in production for the target *potato* is explained via re-ranking between the input contiguity constraint (I-CONTIG-σ) and place markedness constraints (*[cor], *[lab]), as repeated in (68).

(68) Julia's re-ranking between I-CONTIG-σ and *[cor] over time

Input	Output	Time	Hierarchy
potato	[pedo]	2;0.25-2;1.20	*[cor] >> *[lab], I-CONTIG-σ
	[teto]	2;5.15	I-CONTIG-σ >> *[cor] >> *[lab]

The productions of *potato* can serve as evidence to support the claim that children initially pursue unmarked forms and gradually proceed to marked ones (McCarthy and Prince, 1994a; Demuth, 1995; Gnanadesikan, 1995). /p/ in [pedo] is regarded as more unmarked than /t/ in [teto] in child language since it is acquired earlier.

The transfer from unmarked to marked forms can be also found in the productions of onset complex. The reduction of complex onset into simple onset is one of the universal characteristics of early child word (Gnanadesikan, 1995). The children in our data also reduce complex onsets into simple ones as presented in (69).

(69) Complex onset

Child	Input	Output	Age
Trevor	spatula	[bæ ː ʧʌ]	1;11.23
Julia	broccoli	[bɑki]	1;7.6-2;0.19
	pretend	[tɛnd]	2;1.20-2;3.30

Interestingly, some of the target words that do not have any complex onset are produced as words having complex onsets, as illustrated in (70). It shows that the production of complex onset is preceded by that of simple onset for the targets *garage* and *police*.

(70) From simple onset to complex onset

Child	Input	Output	Age
Trevor	garage	[ga ː ʤ]	1;10.5-2;0.24
		[graʤ]	2;3.3
Julia	police	[pis]	2;1.10-2;5.3
		[plis]	2;6.5
	banana	[bænə]	1;11.6-2;5.29
		[blæna]	2;3.20-2;4.5

Regarding the outputs of *banana* by Julia, however, we cannot draw a clear line between simple onset and complex onset production time: there is an overlapping period when two forms coexist. Even though many researchers identify discrete stages of language development including Demuth (1996b) and Fikkert (1994), it does not mean children move from one stage to another overnight. In this light, we will allow leeway for the overlapping.

The shift from simple toward complex onset requires their grammar to contain *COMPLEX, a markedness constraint that forbids complex onsets and allows the constraint to be obeyed initially and then violated later. Tableau (71) and (72) illustrate how the ranking between *COMPLEX and Max-IO leads one candidate to exclude the other. The ranking of *COMPLEX above Max-IO is illustrated in tableau (71) and the reversed ranking is depicted in (72). We will evaluate two candidates [pis] and [plis] with respect to the two constraints. Each of the both candidates has two violation marks: candidate [pis] has two marks for Max-IO, and [plis] has one for *COMPLEX and one for Max-IO. Since the violation of a lower ranked constraint is irrelevant in OT, we judge by the violation marks in unshaded cells.

(71) *COMPLEX >> Max-IO

police	*COMPLEX	Max-IO
a. ☞ [pis]		**
b. [plis]	*!	*

Candidate (71a) is chosen as an optimal candidate despite its double violation of Max-IO since it observes the higher ranked constraint *COMPLEX, whereas candidate (71b) violates it. By contrast, the ranking of Max-IO above *COMPLEX prevents [pis] from becoming optimal as illustrated in (72). Candidate (72a) violates the higher ranked constraints twice, whereas candidate (72b) violates one time. Since the more violation marks adds up the fatalness, (72b) is selected.

(72) Max-IO >> *COMPLEX

police	Max-IO	*COMPLEX
a. [pis]	**!	
b. ☞ [plis]	*	*

In conclusion, Trevor and Julia's grammars get *COMPLEX, which yields unmarked simple onset, initially ranked higher than the faithfulness constraint Max-IO, but the constraints are re-ranked over time towards pursuing faithfulness.

5.5 Conclusion

Thus far we have seen how an OT-based approach explains truncations of WS, WSW, SWW and ŚWS targets by the four children (Pater, 1997). We regarded the target word that a child aims to produce as the 'input' and the real production by the child as the 'output' in order to apply the principles of OT to our data. It has been argued that in the children's grammars, markedness constraints are ranked higher than the faithfulness constraint Max-IO: markedness constraints include prosodic markedness constraints (PARSE-σ, FTBIN, ONSET and *COMPLEX) and featural markedness constraints (*A-ONS and *[cor]).

ONSET and *COMPLEX require the child words to start with a single consonant onset. PARSE-σ and FTBIN along with another structural constraint ALIGNLEFT should be ordered above Max-IO in order to illuminate children's production of a trochaic foot. We called the combination of these three constraints 'WordSize.' If it this combined constraint is undominated, a word form should be a disyllabic foot or a bimoraic monosyllabic foot. We noted, however, that the preservation of both stressed and word-final syllables in trisyllabic targets are not simply captured by the undominated WordSize because the stressed syllable alone can constitute a well-formed foot (e.g. [el] for *elephant* is also a trochaic foot). Therefore, we needed the high ranking of faithfulness constraints, STRESS-FAITH and ANCHOR-RIGHTI-O to ensure the retention of both stressed and word-final syllables. It is notable that these prosodic faithfulness constraints are dominant in the children's grammars whereas the segmental faithfulness Max-IO is dominated by them and WordSize. We noted that the ranking of these constraints relative to the well-formedness constraints 'WordSize' is difficult to determine.

One of the most important issues in the present study is how to account for TSC as well as TSO in a systemic way. TSC was virtually an intractable problem unsatisfactorily dealt with by other previous accounts. It was resolved here by the interaction between I-CONTIG-σ and the onset markedness constraints (*A-ONS and *N-ONS). More specifically, since the targets containing intervocalic liquids are almost always subject to TSC, the ranking of *A-ONS is higher than I-CONTIG-σ. Regarding truncation of the target word containing intervocalic nasals /n, m/, children show variations: some truncate via TSO and others through TSC. Such interpersonal variation was explained by the different ranking of I-CONTIG-σ with respect to *N-ONS.

We have also discussed an intra-personal variation in truncation according to the age. The target *potato* initially undergoes TSC (*potato* → [pedo]), and later TSO (*potato* → [teto]). Such developmental was resolved by the assumption that early child grammar changes the ranking of constraints over time: *[cor] >> I-CONTIG-σ → I-CONTIG-σ >> *[cor]. In the discussion regarding developmental variation, it has been noted that children initially pursue unmarked forms (both segmentally and prosodically) and gradually proceed to marked ones. For example, in terms of onset markedness, more unmarked simple onset (e.g. *police* [pis]) is produced earlier in time than complex onset (e.g. *police* [plis]) as we have illustrated in (71) and (72).

In conclusion, the children's word productions are restricted by the same constraints on the output forms as required for adult languages. The observation that their words are different from adult words (especially their aptness to truncate multisyllabic words) is explained by a difference in constraint rankings between child and adult languages. It has been demonstrated in this chapter that in child language, markedness constraints that yield unmarked prosodic structures (like a trochaic foot) are ranked above the faithfulness constraint that approximates the adult target forms. Variability in truncation depending on children and across ages was analyzed using the OT model of child phonology.

Chapter 6

Summary and Conclusion

6.1 Summary

In this dissertation, we have discussed child word truncation with special interest in truncation of syllable conflation. I have sought ways to explain truncation in general and variations among children by employing Optimality Theory. Before drawing the conclusions of the present study, this chapter will provide summaries of each chapter.

Chapter 1 briefly introduced the concept of child word truncation. We noted that word truncation has long been identified with syllable omission and syllable conflation and variations in truncation among children were not dealt with seriously in previous studies.

In Chapter 2, we reviewed previous findings on patterns of child word truncation and previous approaches to child word truncation. In regard to the content of truncation, we found that children show a high probability of retaining stressed syllables and word-final syllables, while deleting nonfinal unstressed syllables.

In terms of the stress patterns, it seemed that WSW targets are most likely to be truncated; SWW targets are more likely to be truncated than SWS targets (Kehoe and Stoel-Gammon, 1997a). However, the solid connection across ages is left questionable since one age group truncate SWW targets more often than other types. Kehoe and Stoel-Gammon (1997a, 1997b) demonstrated segmental effect on truncation: targets containing intervocalic sonorants like *elephant* and *telephone* are more prone to truncation than those with intervocalic obstruents like *octopus* and *crocodile*.

We reviewed three major approaches to child words. The trochaic template approach (Gerken, 1994, 1996; Fikkert, 1994) claimed that English-speaking children's early word productions are controlled by the trochaic template S(W) and the materials that do not fit the template are omitted from their production. The prosodic structure accounts (Demuth and Jane, 1995; Demuth, 1996b, 1996c, 2003; Demuth *et al*., 2006) identified developmental stages according to the acquisition of prosodic structures. They argued child word shapes are initially limited to lower level units of prosodic structure such as 'core syllable' and 'minimal word' and over time become more sophisticated towards higher prosodic structures such as 'feet' and 'prosodic words'. The perceptual salience accounts (Echols and Newport, 1992; Echols, 1993; Snow, 1998) are based on children's perceptual limitations. They assumed that children extract perceptually salient syllables (i.e. stressed and word-final syllables) from the stream of speech, and thus they only produce those salient syllables, while omitting relatively less prominent syllables.

Those approaches could explain the general tendency of truncation including the vulnerability of word-initial unstressed syllables. However, they all failed to provide clear accounts of syllable conflation as well as variation between TSC and TSO (e.g. *banana* → [bænə], [nænə]), nor could they explain the segmental effects on truncations found in *elephant* vs. *octopus*.

In Chapter 3, we investigated the truncated forms by children in Pater (1997) in order to explore TSC. We found out that although TSO was predominant in truncation (62%), TSC also occurred with not modest frequency (27%). It was noted that children stick to the onset-rhyme structure of syllable, i.e. the onset from the first syllable and the rhyme from the second syllable are merged into a syllable (e.g. favorite → [fevət]) and structural well-formedness when truncating words (e.g. *garage* was truncated into 'grage,' police into 'plice,' *banana* into 'blana'; but there were no production like 'bnana,' for *banana* or 'dlicious' for *delicious*). The target words that are subject to TSC contained a liquid /r, l/ (83% of all TSC) or a nasal /n/ (6%) or m/ (2%) or a coronal stop /t/ (8%). In other words, those segments rarely appeared on child words.

In Chapter 4, I proposed a sonority-theoretic approach to child word truncation. This approach was motivated by the observation that target words containing intervocalic sonorants such as *banána* and *delícious* are truncated into [bænə] and [dɪʃəs], where the liquid and nasal onsets are not produced. They are different from the general prediction of [nænə] and [lɪʃəs], which can result from the omission of the word-initial unstressed syllable. We assumed that children's perceptual capability may not develop enough to distinguish sonorants from vowels. The assumption is based on the knowledge that sonorant consonants and vowels have similarly high sonority, which is attributable to their acoustic similarity, and that acoustic features are closely related to auditory perception. According to the assumption, the intervocalic /l/ in *delicious* /dəlɪʃəs/ may not be perceived as a syllable onset; rather the sequence /dəlɪ/ is perceived as having one peak, resulting in the reduced production of [dɪʃəs].

This perception-based approach seemed to explain not only syllable conflation but also the segmental effects on truncation found in *elephant* vs. *octopus*. However, there was no way of explaining truncations of target words containing no intervocalic sonorants like *museum* [ziː ʌm] and *abacus* [ækus], nor did it explain truncation of the words containing intervocalic /m/ such as *tomato* [meto] and *cement* [mɛnt]. We noted that unlike other sonorant consonants /n, r, l/, intervocalic /m/ rarely triggered syllable conflation. Moreover, the variability in truncation (e.g. [bænə] and [bænə] for *banana*) was not clarified.

Chapter 5 provided OT-based accounts of word truncation. This approach resolved the issue of TSC and the variability in truncation among children. Taking the adult target word as the input and the child word as the output, the same universal, violable constraints as adult OT grammars were employed to account for the truncated word forms. The production of a trochaic foot (for example, a trisyllabic word WSW is reduced into SW) was explained by placing WordSize (ALIGNLEFT, PARSE-σ and FTBIN) ranked higher than Max-IO. An account of the preservation of stressed syllables and word-final syllables required STRESS-FAITH and ANCHOR-RIGHTIO to be undominated.

Regarding the issue of TSC vs. TSO, we employed I-CONTIG-σ that disallows skipping from the input syllable string and the onset markedness constraints *A-ONS and *N-ONS, which militate against approximant onsets and nasal onsets, respectively. The ranking of I-CONTIG-σ with respect to *A-ONS and *N-ONS explicate both types of truncation. We concluded that *A-ONS is ranked higher than I-CONTIG-σ in the grammars of the four children. As a result, targets containing intervocalic liquids are subject to TSC (e.g. *delicious* [dɪʃəs], *garage* [ga:ʤ]). The ranking of *N-ONS with respect to I-CONTIG-σ varied among children. For example, Trevor's grammar has *N-ONS ranked below I-CONTIG-σ, which leads to TSO of *banana* [nænə]. In Julia's grammar [bænə], by contrast, *N-ONS is ranked above I-CONTIG-σ, hence resulting in TSC of *banana* [bænə].

Accordingly, the issue of interpersonal variation in truncation came down to the relative ranking of the same set of constraints. In other words, we captured this issue drawing on one of the major notions in child OT that constraint hierarchy differs from child to child. Intrapersonal, developmental variation was also understood under the assumption that a child grammar changes the ranking of constraints over time: Sean's production of [nænə] for *banana* (a TSO) at 1;8.28-1;11.19 and [sɛsi] for *sesame* (a TSC) at 2;5.14 is illustrated by the varying ranking over time: I-CONTIG-σ >> *N-ONS at earlier ages and *N-ONS >> I-CONTIG-σ later.

6.2 Conclusion

We have noted that previous studies on child word truncation have focused on TSO and TSC like *banana* [bænə] has been overlooked as minor or deviant from the so-called normal pattern of TSO. As a result, there has been neither a principled study on truncation patterns nor satisfying accounts of TSC. The current study, however, has explored TSC in line of child word truncation in general and presented principled accounts of both TSO and TSC by drawing on Optimality Theory.

It has been observed in the earlier part of this dissertation that TSC occurs frequently and in many English learning children's productions. Moreover, it is also found in other languages like Dutch, the southern Bantu language Sesotho and Korean. In Sesotho, for example, the preverbal subject marker *ke*- and the future tense marker -*tla*- frequently surface as one syllable *ka*-. In Dutch, there is an early word [míkRon] for *microfoon* 'microphone' (Demuth, 1996c: 6), and we can find in Fikkert (1994) examples of TSC like *konijn* /koːnέɪn/ → [kɛɪn]; *ballon* /bɑlɔ́n/ → [bɔn]; and *banana* /baːnáːn/ → [paːn]. In case of Korean, there is a report that infants produce [bæŋ.gi] for /bi.hæŋ.gi/ 'airplane' and [kəm.mɑ] for /kɨn.əm.mɑ/ 'aunt' (Lee, 1989). Given the frequency and distribution among languages, syllable conflation deserves to be studied.

More importantly, TSC has some implications for children's phonological development. First, it lends support to the claim that children have some knowledge of the correct adult forms (Smith, 1973; Ingram, 1974; Goodluck, 1991: 26). As opposed to the argument of Echols and Newport (1992), TSC demonstrates that children perceive non-final, unstressed syllables as well since the onset consonant of those syllables are produced (e.g. /b/ in *banana* [bænə]). Secondly, it suggests that children are sensitive to the prosodic well-formedness. As we noted in this research, children's truncated outputs cling to the onset-rhyme structure of syllable (i.e. the onset of one syllable and the rhyme of the other syllable of the target are combined to form a syllable of the child word). Furthermore, only well-formed onset clusters are produced (e.g. [graʤ] for *garage* and [plis] for *police*). By contrast, ill-formed onset clusters are either absent from child productions (e.g. *[dlɪʃəs] for *delicious*) or substituted by well-formed ones (e.g. *[bnæna] → [blæna] for *banana*). In other words, the transition toward the adult-like production allows for phonological well-formedness.

It has long been noted that child languages are characterized by variability: variation among children and within an individual child. Such variability has made it difficult to explain early word production in consistent ways. This research approaches those variations from the Optimality Theoretic perspective. In OT model of child phonology, child grammars are composed of the same universal, violable constraints as those of adult grammars. The rankings of constraints differ from child to child. In this study, interpersonal choices between TSC and TSO for the same target are accounted for by the different rankings of the same set of constraints among children. Furthermore, the constraints are reranked over time: at an initial stage of development, structural constraints that yield unmarked forms are ranked high, but they are gradually demoted over time and faithfulness constraints are promoted instead. Even though we have not discussed enough data to confirm this developmental change in the constraint hierarchy, it provides an explanation of intra-personal variation. It should be recognized that the data discussed in the current study fall short of consistently ascertaining the initial outranking of the markedness constraints over the faithfulness constraints and the change in ranking over time.

There are other limitations regarding the present study. First, since we resorted to secondary data from Pater (1997), we only dealt with limited corpora of children's word productions and did not consider the whole repertoire during the period of data collection. As a result, we had difficulty reaching the rankings of the constraints operative in the children's grammars. We just suggested subrankings of constraints concerned with truncation. Secondly, the OT-based account itself is limited to the content of production. The issue of why some targets are more likely to be truncated by children than others remains unresolved (Note that *elephant* is much more likely to be truncated than *octopus*). Therefore we need to further explore this issue in future research. Despite its limitations, this research provided principled explanations for various patterns of child word truncation and shed new light on truncation of syllable conflation that has been overlooked.

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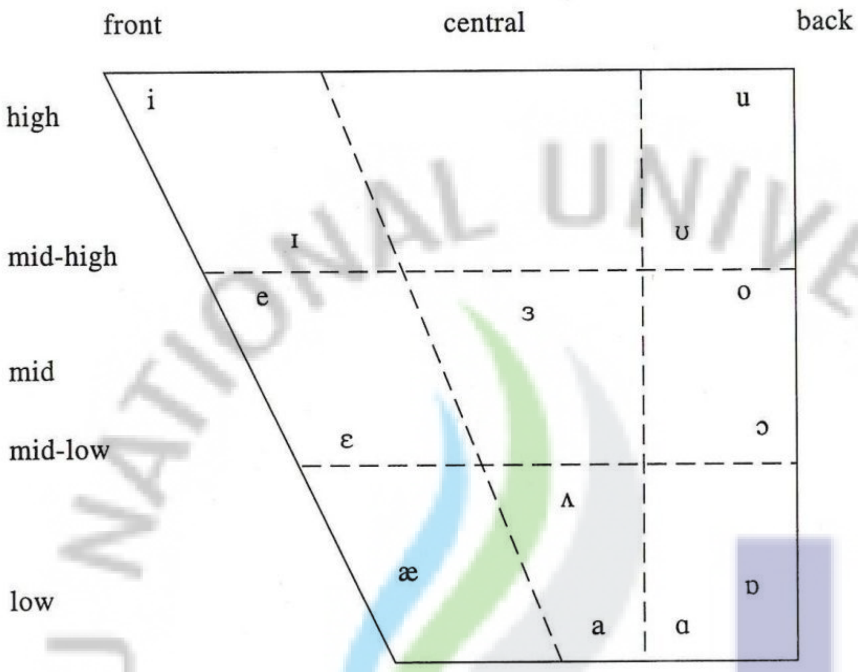
Appendix A: The English Vowel Chart (Ladefoged, 2001: 36)



Appendix B: Truncations of WSW targets (Pater, 1997: 216-

TABLE 1
Truncations of σ′σσ Targets

another		
Derek	[nʌdɝ]	2;2.23 ~ 2;5.11
Julia	[jəwo]	1;10.12
	[jə]	1;11.4
Sean	[ənə]	1;9.15
	[əʊ]	1;10.11
	[nʌdɚ]	2;4.2
	[ʌə]	2;4.22
	[anʌ]	2;4.24
	[nʌθɝ]	2;10.13
Trevor	[nʌ:ɚ]	2;5.17
	[nʌ:dɚ]	2;5.17
	[ənɚ]	3;2.0
banana		
Derek	[nænə]	2;3.0 ~ 2;4.0
Julia	[mænə]	1;7.16 ~ 1;10.8
	[bænə]	1;11.6 ~ 2;5.29
	[blæna]	2;3.20 ~ 2;4.5
Sean	[nænə]	1;8.28 ~ 1;11.19
Trevor	[nænə]	0;11.10 ~ 1;6.8
	[nænæ]	1;0.9 ~ 3;1.8
gorilla		
Julia	[graʊwə]	2;2.21
Trevor	[go:wæ]	1;11.12
	[wʌ:ga:]	1;11.14
	[gʌ:wa]	1;11.14
Modesto		
Trevor	[dɛsto]	2;8.15
Nathaniel		
Trevor	[fæfue]	2;1.0
	[fæ:ŋo]	2;1.17
	[fæŋo:s]	2;2.23
piano		
Julia	[pæno]	1;9.19 ~ 2;4.17
Trevor	[pæ:no]	1;11.9 ~ 2;2.23
remember		
Julia	[mɛmə]	1;10.8 ~ 3;0.1
	[mɛmbə]	2;1.18 ~ 2;7.29
apartment		
Julia	[partmɛnt]	2;3.14 ~ 2;5.16
baloney		
Derek	[bwoni]	2;7.18 ~ 2;10.2
delicious		
Julia	[dɪʃəs]	1;11.27
eleven		
Julia	[dɛbən]	1;9.10
	[jɛbən]	1;9.15
	[jɛmɪn]	1;9.20 ~ 1;10.7
	[jɛvən]	2;2.24
maracas		
Trevor	[ma:kas]	2;0.27
museum		
Trevor	[zi:ʌm]	2;7.27
pajamas		
Julia	[daməs]	1;8.27 ~ 2;0.2
Sean	[dʒæməʃ]	1;11.15 ~ 2;0.23
Trevor	[da:məs]	1;7.11
	[dʒa:mas]	1;7.26 ~ 2;2.10
potato		
Julia	[pedo]	2;0.25 ~ 2;1.20
	[teto]	2;5.16
Trevor	[te:to]	1;9.19 ~ 1;10.5
salami		
Trevor	[ma:mi]	1;6.25 ~ 2;1.0

7)

spaghetti		
Julia	[dɪbi]	1;9.7
	[gɛbi]	1;10.8
	[skɛbi]	1;11.19 ~ 2;3.8
	[sketi]	2;0.29
Trevor	[gɛdi]	1;4.27 ~ 1;9.2
together		
Trevor	[gɛ:dɚ]	1;9.27 ~ 2;0.27
tomorrow		
Julia	[mowo]	1;7.16 ~ 2;0.17
Trevor	[moro]	1;8.12 ~ 2;1.14
vagina		
Trevor	[dʒai:nə]	2;11.10
Theresa		
Trevor	[ri:sə]	2;11.10
tomato		
Julia	[meno]	1;9.22 ~ 1;10.27
	[meto]	2;0.11 ~ 2;10.30
Trevor	[me:do]	2;0.27
umbrella		
Derek	[bwɛa]	1;11.30
Sean	[bɛla]	2;0.1
Trevor	[brʌ:gæ]	1;11.1
	[bre:wa]	1;11.5
	[bʌwə]	1;11.5
	[bwɛ:wəz]	2;1.0 ~ 2;1.14

Appendix C: Truncations of WS targets (Pater, 1997: 217-

TABLE 2
Truncations of σ′σ Targets

again				*alone*		
Julia	[gɛn]	1;10.1 ~ 2;1.24		Derek	[won]	2;6.24
Sean	[gɛ]	2;5.21		Trevor	[io:n]	2;1.26
	[gɛn]	2;7.11				
Trevor	[gɛ]	0;10.28 ~ 1;0.8				
	[gɛn]	1;6.17 ~ 2;3.3				
apart				*around*		
Trevor	[part]	1;9.29		Sean	[ound]	1;11.12
				Trevor	[wau:n]	2;0.8
away				*balloon*		
Derek	[we]	2;2.30		Derek	[bu]	1;11.6 ~ 2;2.1
Julia	[waɪ]	1;8.24 ~ 2;0.19			[bun]	2;2.25 ~ 2;4.26
Sean	[we]	2;1.25 ~ 2;8.23		Julia	[bu]	1;5.28
					[bʊn]	1;9.18 ~ 1;10.23
				Sean	[bʌ]	1;3.21
					[bu]	1;4 ~ 1;7.18
					[bum]	1;11.0
				Trevor	[bu]	1;4.19 ~ 1;4.27
					[bu:m]	1;4.27 ~ 1;6.25
					[bu:n]	1;9.29 ~ 1;11.14
behind				*belong*		
Derek	[haind]	2;3.24		Julia	[bɔŋ]	1;11.27 ~ 2;0.26
Trevor	[hai:n]	2;0.8 ~ 2;2.15		Trevor	[ɔ:ŋ]	2;1.5
caboose				*cement*		
Trevor	[gu:s]	2;4.24 ~ 2;11.17		Derek	[mɛnt]	2;11.27
Denise				*dessert*		
Trevor	[dis]	1;1.17 ~ 2;2.15		Julia	[zɚt]	2;8.7 ~ 2;9.24
enough				*excuse*		
Trevor	[nʌf]	1;10.5 ~ 1;11.25		Trevor	[ku::zə mi] (excuse me)	2;2.10 ~ 2;6.6

8)

garage				*giraffe*		
Julia	[gwa:dz]	2;8.25		Julia	[dʒwæf]	2;2.7
Trevor	[ga:dʒ]	1;10.5 ~ 2;0.24			[dræf]	2;2.17 ~ 2;6.10
	[gardʒ]	2;1.5 ~ 2;1.26			[dwæf]	2;2.22
	[gradʒ]	2;3.3		Trevor	[wæ:f]	1;9.1 ~ 1;11.14
	[gra:dʒ]	2;3.22				
guitar				*machine*		
Sean	[tar]	2;2.12		Trevor	[ʃɪʃɪm] (sewing machine)	1;8.26 ~ 2;4.13
Trevor	[gi]	1;1.13 ~ 1;3.11			[o: ʃi:n] (sewing machine)	2;4.24
	[ga]	1;1.19 ~ 1;6.17			[so:ə ʃi::m] (sewing machine)	2;8.5
	[ga:r]	1;7.20 ~ 2;1.5				

Marie			*Merced*		
Trevor	[mi]	1;6.17 ~ 1;9.2	Trevor	[sɛd]	1;11.12 ~ 2;11.10
Michele			*police*		
Trevor	[ʃɛ:u]	1;6.25 ~ 2;5.26	Julia	[pismæn] (policeman)	2;1.10 ~ 2;5.3
				[plis]	2;6.5
			Trevor	[pi:smæn] (policeman)	2;4.13
pretend			*surprise*		
Julia	[tɛnd]	2;1.20 ~ 2;3.30	Derek	[pwaɪz]	2;7.7
today					
Derek	[de]	2;8.19 ~ 3;2.0			

Appendix D: Truncations of SWW targets (Pater, 1997: 221)

TABLE 3
Truncations of ˈσσσ Targets

abacus			*Allison*		
Trevor	[æ:ʃɪʃ]	1;8.7	Trevor	[ai:]	1;3.5
	[æ:tʃus]	1;9.2		[aijə]	1;3.10 ~ 2;2.7
	[ækus]	1;9.2 ~ 2;0.8		[æ:sʌn]	2;0.8 ~ 2;2.3
	[æ:ʃʌʃ]	1;9.2			
animal			*bicycle*		
Derek	[æmʊ]	2;1.14 ~ 3;1.24	Julia	[baɪko]	1;8.4 ~ 1;10.13
Julia	[amo]	1;9.8 ~ 2;1.2		[baisko:]	2;0.14 ~ 2;5.7
Trevor	[nɔno]	1;5.13	Trevor	[gaiki]	1;5.5
	[amu:]	1;7.20 ~ 2;3.4			
broccoli			*buffalo*		
Julia	[baki]	1;7.6 ~ 2;0.19	Julia	[bʌfo]	2;0.14 ~ 2;3.9
camera			*cinnamon*		
Sean	[kæmʌ]	2;0.13	Julia	[sɪmɛn]	1;11.15
	[kæmrʌ]	2;0.13 ~ 2;10.9			
Trevor	[kæ:mə]	1;5.6 ~ 1;11.25			
	[kæ:mɚ]	2;0.3			
company			*dominoes*		
Julia	[kʌmpi]	1;11.14	Trevor	[da::nouz]	2;2.23
Sean	[kʌ́mpi]	2;0.27		[da:mno:θ]	2;4.3
Trevor	[kumni:]	2;2.23			
dungarees			*elephant*		
Trevor	[gʌŋgi:z]	1;10.1	Derek	[ɛwfən]	2;9.7 ~ 2;10.7
			Julia	[ɔwo]	1;8.0
				[apɛn]	1;10.4
				[aʊfənts]	1;10.27 ~ 2;0.13
			Sean	[adi]	1;6.1
				[ɛfɛnt]	2;1.19
				[ɛlfɪnt]	3;1.18 ~ 3;1.27
			Trevor	[ɛ:fɪnt]	1;11.14 ~ 2;6.15
				[ɛ:tʌnt]	1;11.14
favorite			*gallopey*		
Julia	[fevət]	2;0.25 ~ 2;6.1	Julia	[gabi]	1;9.14
Sean	[fevrɪt]	3;2.12			
medicine			*sesame*		
Julia	[mɛsɪn]	1;11.12	Derek	[sɛmə]	2;2.8
Sean	[wapi]	1;7.14		[semi]	2;6.26 ~ 3;1.28
Trevor	[mɛ::sɪn]	2;1.26	Sean	[diduit]	1;10.6
	[mɛ:sɪn]	2;11.10		(Sesame Street)	
				[do dwit]	1;10.17
				(Sesame Street)	
				[sɛsi stwit]	2;5.14
				(Sesame Street)	

spatula			*tricycle*		
Trevor	[bæ:tʃʌ]	1;11.23	Derek	[twaɪkl]	2;8.18 ~ 2;10.4
vitamin					
Trevor	[ga:mɪn]	1;5.30			
	[bai:mi:ʃ]	1;6.9			

Appendix E: Onset Choice in Truncations

(i) Truncation of syllable omission

Type	Target	Truncation	Child (Age)	Competitors for Onset	Chosen onset
WSW	banana*	[nænə]	D (2;3.0-2;4.0)	b, n	n
		[nænə]	S (1;8.28-1;11.19)		
		[nænə]	T (0;11.10-1;6.8)		
	eleven	[jɛbən]	J (1;9.15)	Φ**, l	l→j
		[jɛvən]	J (2;2.24)		
	Modesto	[dɛsto]	T (2;8.15)	m, d	d
	museum	[ziːʌm]	T (2;2.27)	m, z	z
	pajamas	[daməs]	J (1;8.27-2;0.2)	p, ʤ	ʤ→d
		[ʤæməʃ]	S (1;11.15-2;0.23)		ʤ
		[daːməs]	T (1;7.11)		ʤ→d
		[ʤaːmas]	T (1;7.26-2;2.10)		ʤ
	potato	[teto]	J (2;5.15)	p, t	t
		[teːto]	T (1;919-1.10.5)		
	pretend	[tɛnd]	J (2;1.20-2;3.30)	pr, t	t
	remember	[mæmə]	J (1;10.8-3;0.1)	r, m	m
		[mæmbə]	J (2;1.18-2.7.29)		
	spaghetti	[gɛbi]	J (1;10.8)	sp, g	g
		[gɛdi]	T (1;4.27-1;9.2)		
		[skɛbi]	J (1;11.10-2;3.8)	sp, g	sk*
		[sketi]	J (2;0.29)		
	Theresa	[riːsə]	T (2;11.10)	t, r	r
	together	[gɛːdɚ]	T (1;9.27-2;0.27)	t, g	g
		[gɛːdɚ]	T (1;9.27-2;0.27)		
	tomato	[meno]	J (1;9.22-1;10.27)	t, m	m
		[meto]	J (2;0.11-2.10.30)		
		[meːdo]	T (2;0.27)		
	tomorrow	[mowo]	J (1;7.16-2;.0.17)	t, m	m
		[moro]	T (1;8.12-2.1.14)		
	umbrella	[bwɛa]	D (1;11.30)	Φ, br	br→bw
		[bɛla]	S (2;0.1)		br→b
		[breːwa]	T (1;11.5)		

	vagina	[ʤai ː nə]	T (2;11.10)	v, ʤ	ʤ
WS	again	[gɛn]	J (1;10.1-2;1.24)	Φ, g	g
		[gɛ]	S (2;5.21)		
		[gɛn]	S (2;7.11)		
		[gɛ]	T (0;10.28-1;0.8)		
		[gɛn]	T (1;6.17-2;3.3)		
	alone	[won]	D (2;6.24)	Φ, l	l
		[io ː n]	T (2;1.26)		
	apart	[part]	T (1;9.29)	Φ, p	p
	around	[ound]	S (1;11.12)	Φ, r	r
		[wau ː n]	T (2;0.8)		
	away	[we]	D (2;2.30)	Φ, w	w
		[waɪ]	J (1;8.24-2;0.19)		
		[we]	S (2;1.25-2;8.23)		
	cement	[mɛnt]	D (2;11.27)	s, m	m
	dessert	[zɚt]	J (2;8.7-2;9.24)	d, z	z
	enough	[nʌf]	T (1;10.5-1;11.25)	Φ, n	n
	machine	[ʃɪ]	T (1;8.26-2;4.13)	m, ʃ	ʃ
	Merced	[sɛd]	T(1;11.12-2.11.10)	m, s	s
	Michele	[ʃɛ ː u]	T (1;6.25-2;5.26)	m, ʃ	ʃ
	today	[de]	D (2;8.19-3;2.0)	t, d	d
SWW	abacus	[ækus]	T (1;9.2-2;0.8)	b, k	k
	Allison	[æ ː sʌn]	T (2;0.8-2;2.3)	l, s	s
	animal	[æmʊ]	D (2;1.14-3;1.24)	n, m	m
		[amu ː]	T (1;7.20-2;3.4)		
	bicycle	[baɪko]	J (1;8.4-1;10.13)	s, k	k
		[baisko]	J (2;0.14-2;5.7)		
	camera	[kæmʌ]	S (2;0.13)	m, r	m
		[kæmə]	T (1;5.6-1;11.25)		m
		[kæmɚ]	T (2;0.3)		m
	cinnamon	[sɪmɛn]	J (1;11.15)	n, m	m
	company*	[kumni]	T (2;2.23)	p, n	n
	elephant	[ɛwfən]	D (2;9.7-2;10.7)	l, f	f
		[ɛfɛnt]	S (2;1.19)		

		[ɛlfɪnt]	S (3;1.18-3;1.27)		
		[ɛːfɪnt]	T (1;11.14-2;6.15)		
	gallopey	[gabi]	J (1;9.14)	l, p	p → b
	medicine	[mɛsɪn]	J (2;0.25-2;6.1)	d, s	s
		[mɛːsɪn]	T (2;11.10)		
	sesame*	[sɛːmə]	D (2;2.8)	s, m	m
		[semi]	D (2;6.26-3;1.28)		
	tricycle	[twaɪkl]	D (2;8.18-2;10.4)	s, k	k
	vitamin	[gaːmɪn]	T (1;5.30)	t, m	m
ŚWS	dominoes	[daːnouz]	T (2;2.23)	m, n	n

(ii) Truncation of syllable conflation

Type	Target	Truncation	Child (Age)	Competitors for onset	Chosen onset
WSW	banana*	[bænə]	J (1;11.6-2.5.29)	b, n	b
		[blæna]	J (2;3.20-2;4.5)		bl
	delicious	[dɪʃəs]	J (1;11.27)	d, l	d
	gorilla	[gʌːwa]	T (1;11.14)	g, r	g
		[graʊwə]	J (2;2.21)		gr
	maracas	[maːkas]	T (2;0.27)	m, r	m
	piano	[pæːno]	T (1;11.9-2;2.23)	p, Φ	p
		[pæno]	J (1;9.19-2;4.17)		
	potato*	[pedo]	J (2;0.25-2;1.20)	p, t	p
WS	balloon	[bu]	D (1;11.6-2.2.1)	b, l	b
		[bun]	D (2;2.25-2;4.26)		
		[bʊn]	J (1;9.18-1;10.23)		
		[bu]	J (1;5.28)		
		[bum]	S (1;11.0)		
		[bʌ]	S (1;3.21)		
		[bu]	S (1;4-1;7.18)		
		[bu]	T (1;4.19-1;4.27)		
		[buːm]	T (1;4.27-1;6.25)		
		[buːn]	T (1;9.19-1;11.14)		
	belong	[bɔŋ]	J (1;11.27-2;0.26)	b, l	b
	Denise	[dis]	T (1;1.17-2;2.15)	d, n	d
	garage	[gwaːdz]	J (2;8.25)	g, r	g
		[gaːʤ]	T (1;10.5-2;0.24)		

		[garʤ]	T (2;1.5-2;1.26)		
		[graʤ]	T (2;3.3)		
		[graːʤ]	T (2;3.22)		
	guitar	[gi]	T (1;1.13-1;2.11)	g, t	g
		[ga]	T (1;1.19-1;6.17)		
		[gaːr]	T (1;7.20-2;1.5)		
	giraffe	[ʤwæf]	J (2;2.7)	g, r	g
		[dræf]	J (2;2.17-2;6.10)		
		[dwæf]	J (2;2.20)		
	Marie	[mi]	T (1;6.17-1;9.2)	m, r	m
	police	[pis]	J (2;1.10-2;5.3)	p, l	p
		[plis]	J (2;6.5)		
		[piːs]	T (2;4.13)		
SWW	broccoli	[baki]	J (1;7.6-2;0.19)	k, l	k
	camera	[kæmrʌ]	S (2;0.13-2;10.9)	m, r	r
	company*	[kʌmpi]	J (1;11.14)	p, n	p
		[kʌmpi]	S (2;0.27)		
	dungarees	[gʌŋgiːz]	T (1;10.1)	g, r	g
	favorite	[fevət]	J (2;0.25-2;6.1)	v, r	v
	sesame*	[sɛsi]	S (2;5.14)	s, m	s
	spatula	[bæːʧʌ]	T (1;11.23)	ʧ, l	ʧ
ŚWS	buffalo	[bʌfo]	J (2;0.14-2;3.9)	f, l	f

* *Banana, potato, company* and *sesame* are truncated both by omission and by conflation.
** Φ denotes the syllable has no onset consonant.

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