The Proceedings of the 30th Annual Child Language Research Forum (1999)

Tone Sandhi as Evidence for Segmentation in Taiwanese

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1 Introduction

A major question in the study of language acquisition concerns how children learn to segment fluent speech into linguistic constituents such as words and syntactic phrases. In this paper, we show how production data can be used as indirect evidence for children's segmentation of fluent speech. Specifically, this paper examines how developmental changes in segmentation are reflected in Taiwanese tone sandhi (TTS).[1]

TTS describes a pattern of tone alternations that are sensitive to the boundaries of prosodic phrases built on syntactic constituents such as NP and VP (see Chen 1987, Lin 1994). Infants and young children just beginning to talk may be able to use TTS alternations in adult speech to learn where the constituent boundaries are (see Tsay, in press). Moreover, the errors that children make in producing tone sandhi alternations provide important evidence about how they are segmenting speech into constituents. TTS is thus an as-yet unexplored tool for researchers to learn more about the development of segmentation in production.

Evidence about the units used in child language production came from the tone errors of two children (2;1-2;9) acquiring Taiwanese. We found that young children sometimes use smaller units than adults (e.g. splitting

[1]This report is part of a longitudinal study still in progress on tone acquisition in Taiwanese funded by National Science Council (Taiwan) grants (NSC87-2411-H-194-019, NSC88-2411-H-194-019) to the first author.

the two constituents of a compound word) and sometimes combine units that would be separate for adults. Moreover, segmentation was sensitive to grammatical factors such as semantic transparency and morphosyntactic structure.

2 Background

In this section, we first introduce the pattern of TTS, with special focus on the interface between the tone alternation domain (tone group) and syntactic structure. We then explain the relevance of TTS to the study of children's segmentation.

2.1 Taiwanese Tone Sandhi

Taiwanese is a dialect of Southern Min Chinese spoken in Taiwan. Except for some function words, each syllable (also a morpheme in most cases) carries one of the seven lexical tones. Moreover, each tone category has two tone values: one occurs in juncture position and the other in context position (to be explained further below). Tone inventory and tone values of the variety we examined (Chia-yi County) are given in Table 1 below, where H, M, and L stand for high, mid, and low pitches, respectively.[2]

Tone category	Tone value	
	Juncture	Context
1	H	M
2	LM	M
3	HL	H
4	L	HL
5	M	L

Table 1 Tone inventory in Taiwanese

For example, as shown in Table 2 below, a Tone 4 morpheme ***si*** meaning "four" has a juncture tone (L) when it appears in the compound "ten-four; fourteen", and a context tone (HL) when it appears in the compound "four-ten; forty".

[2] Tone 6 and Tone 7 only appear in syllables ending with an unreleased -p, -t, -k, or -ʔ. It has been proposed that these two tones can be treated as variants of two of the other five tones (Cheng 1968, Tsay 1989). Furthermore, the acquisition of these tones is confounded by the syllable structure (Tsay and Huang 1998) and thus should be analyzed separately. Therefore, these two tones are not discussed in this paper.

Morpheme	Juncture	Context
si "four"	$tsap^{L}$ $\boldsymbol{si}^{L}$ "fourteen" (lit. "ten-four")	$\boldsymbol{si}^{HL}$ $tsap^{H}$ "forty " (lit. "four-ten")

Table 2 Tone alternation of ***si*** "four"

This tone alternation, called Taiwanese Tone Sandhi (TTS), affects almost all monosyllabic morphemes except for some grammatical morphemes. It is a phrasal phenomenon: juncture position is at the right edge of an XP, and context position is elsewhere (see Chen 1987 and Lin 1994 for details.) This tone sandhi pattern is illustrated schematically in (1) below, where a closing bracket marks the right edge of the tone sandhi domain (called the tone group in the literature), "T_c" represents a context tone, and "T_j" represents a juncture tone.

(1) $T_c\ T_c\ T_j\ ]_{XP}\quad T_c\ T_j\ ]_{XP}\quad T_c\ T_c\ T_j\ ]_{XP}$

TTS is a paradigm example of edge-based prosodification (Selkirk 1986), in which prosodic structure only pays the most minimal attention to syntactic structure. There are only two parameters affecting how prosodic structure is built on syntactic structure. The first parameter is the syntactic level at which prosodic structure is built: either X^{lex} (i.e. the word level) or X^{max} (the phrase level, i.e. XP). The second parameter concerns whether the edges of prosodic constituents align with the left or right edges of syntactic constituents. TTS was in fact the first linguistic pattern to which this model was applied (Chen 1987). As mentioned above, the prosodic constituents that play a role in this pattern are built on the right edge of an X^{max}.

2.2 TTS and Segmentation

TTS provides a unique opportunity to study how children segment linguistic units in their speech. For example, consider an utterance where there are two tone groups for adults: $T_c\ T_j]_{XP}\ T_j\ ]_{XP}$. If children combine these two domains into one tone group, they would use context tone for the second syllable of the first XP, i.e. $[T_c\ \boldsymbol{T_c}\ T_j]$. However, if children split up the first constituent, they would use a juncture tone for the first syllable: $[\boldsymbol{T_j}]$ $[T_j]$ $[T_j]$. Therefore, by examining such errors in children's productions, we can see under what circumstances children segment speech differently from adults.

Evidence for missegmentation in child speech can come from two types of TTS errors.

(1) TTS errors in context position. If children use smaller prosodic units than adults (e.g. treating words as tone groups and nothing larger), then we should find cases of syllables being produced with juncture tones instead of the context tones used by adults.

(2) TTS errors in juncture position. If children use larger prosodic units than adults (e.g. treating clauses as tone groups and nothing smaller), then we should find that syllables that should have juncture tones are produced with context tones instead.

However, in addition to learning the parameter settings for tone groups, children learning TTS also have to learn the tone categories and the alternants of each tone category, which are arbitrary pairing of tones as shown in Table 1 above. Before these are mastered, children may produce errors where a tone is articulated incorrectly or replaced by another entirely unrelated lexical tone. In this paper we call all such errors "miscellaneous" and will not analyze them.

3 Methods

Data in this paper came from an ongoing three-year project to study the speech productions of fourteen children acquiring Taiwanese as a first language; transcriptions will be available in the CHILDES format (MacWhinney 1995) in the near future.

For this paper, we analyzed two representative children, one female (Jun) and one male (Lin), between the ages of 2;1 and 2;9. Recordings of children at play were made through home visits once every one to two weeks. Each recording, ranging from 30 to 90 minutes in length, was first transcribed in IPA by one linguist (the recorder/observer) and then double-checked by another linguist. There are a total of 21 recordings (1330 minutes) of Jun and 17 recordings (740 minutes) of Lin.

Data was divided into three periods: 2;1-2;3; 2;4-2;6, and 2;7-2;9. All the utterances of the children were first segmented into tone groups according to adult native-speaker intuition. The tone of each syllable in the children's utterances was then checked.[3] If the tone used by the child was different from the target (i.e. adult speech), it was marked as a tone error. Tone errors were classified by position (juncture vs. context) and error type (TTS vs. miscellaneous), as illustrated in Table 3 below:

[3] Syllables that were unclear in tone value were excluded. These included toneless function words and particles, kinship terms that might be Mandarin or loan words, and onomatopoeia.

	Correct	TTS errors	Misc. errors
Target in juncture tsap^{L} ***si***$^{\boldsymbol{L}}$ "fourteen"	si^{L}	*Context form si^{HL}	*Other tones si^{H} , si^{M}, si^{LH}…
Target in context ***si***$^{\boldsymbol{HL}}$ tsap^{H} "forty"	si^{HL}	*Juncture form si^{L}	*Other tones si^{H} , si^{M}, si^{LH}…

Table 3 Classification of tone errors

4 Results and Discussion

Our findings are as follows.

First of all, the overall error rate was low (7-14% for Jun, 8-14% for Lin), as shown in Tables 4 and 5 below. This is consistent with previous studies of tone languages which found that children have good mastery of tone categories by the age of 2;0 (e.g. Li and Thompson 1978, King 1980, Hsu 1989).

Child: Jun	Juncture				Context			
Period	1	2	3	***1-3***	1	2	3	***1-3***
Total errors	98	20	114	***232***	148	23	143	***314***
Total tokens	1238	556	1679	***3473***	759	323	1098	***2180***
Error %	8%	4%	7%	***7%***	19%	7%	13%	***14%***

Table 4 Overall error rate for Jun

Child: Lin	Juncture				Context			
Period	1	2	3	***1-3***	1	2	3	***1-3***
Total errors	87	80	177	***344***	101	125	205	***431***
Total tokens	947	1052	2142	***4141***	664	770	1692	***3126***
Error %	9%	8%	8%	***8%***	15%	16%	12%	***14%***

Table 5 Overall error rate for Lin

Secondly, for both children the error rate was about twice as high in context position as in juncture position. This may seem to indicate that children were segmenting utterances into smaller units than adults. One such example is given below where a compound word (NP) was split into two constituents and as indicated by the use of juncture tone M on the first constituent rather than context tone L.

(2) Target: ***ten***$^{\boldsymbol{L}}$ ue^{M}]$_{NP}$ la^{L}
Lin: ***tji***əŋ$^{\boldsymbol{M}}$] ue^{M}]$_{NP}$ ia^{L} (2;3.26)

electricity speech (particle)
"telephone"

However, if we examine the error types shown in Tables 6 and 7, Jun showed no difference in the proportion of TTS errors in juncture position (35%) vs. context position (36%), while Lin showed a difference opposite to that expected, having more TTS errors in juncture position (72%) than in context position (45%).

Child: Jun	Juncture				Context			
Period	1	2	3	***1-3***	1	2	3	***1-3***
TTS errors	32	9	40	***81***	28	4	82	***114***
Misc. errors	66	11	74	***151***	122	19	61	***200***
Total errors	98	20	114	***232***	148	23	143	***314***
TTS error %	33%	45%	35%	***35%***	19%	17%	57%	***36%***

Table 6 TTS error rate for Jun

Child: Lin	Juncture				Context			
Period	1	2	3	***1-3***	1	2	3	***1-3***
TTS errors	53	61	132	***246***	43	59	91	***193***
Misc. errors	34	19	45	***98***	58	66	114	***238***
Total errors	87	80	177	***344***	101	125	205	***431***
TTS error %	61%	76%	75%	***72%***	43%	47%	44%	***45%***

Table 7 TTS error rate for Lin

These observations imply that children do not start with a default parameter setting of "X^{lex}". However, the children did sometimes split up words as the above example in (2) shows. Moreover, using the same data discussed in this paper, Chen (1999) found effects of semantic transparency and morphosyntax on the rate of TTS errors in context position. Semantically transparent disyllabic compounds were more likely to have TTS errors in context position than semantically opaque words. The children also made more TTS errors in context position in verb phrases than in nominal compounds.

Errors made in juncture position also provide information about missegmentation. For example, the following error is a TTS error occurring in juncture position, indicating that the child was combining two tone groups into one.

(3) Target: t'i^{M} ***ti***ŋ^{***HL***}]$_{NP}$ pue^{H}]$_{VP}$, t'i^{M} tiŋ^{M}]$_{NP}$
Lin: te^{M} ***tji***əŋ^{***H***} pe^{H}], la^{M} tjiəŋ^{HL}] (2;3.12)
sky top fly sky top

"(An object) is flying in the sky, the sky."

Importantly, the TTS error rate was higher in juncture position if the target was not utterance-final. For example, Table 8 shows the juncture TTS error rates for Lin in Period 1 (2;1-2;3) in final vs. non-final positions.

Lin (Period 1)	Final	Non-final
TTS errors	9	46
Misc. errors	14	15
Total Errors	23	61
TTS error %	39%	75%

Table 8 Juncture TTS errors in utterance final vs. non-final positions

This observation implies that children do have a tendency to merge tone groups. However, given that they also have a tendency to split up tone groups as we saw above, we cannot conclude that the initial parameter setting is "X^{max}". Further work is needed to explore precisely what factors (phonological, semantic, pragmatic, lexical, distributional, as well as syntactic) trigger merging of tone groups.

5 Conclusion

In this paper, we have shown how the tone errors produced by young children acquiring Taiwanese tone sandhi can be used to study how fluent speech is segmented during early stages of language acquisition. While research using this new source of data is still in its beginning stages, some basic conclusions can already be drawn. First, tone sandhi errors reveal that children often split up prosodic constituents into units smaller than those used by adults. In particular, they often decompose semantically transparent compounds into the component morphemes and also put the component words in VPs into separate prosodic domains. Second, at the same time they build prosodic constituents larger than those used by adults, though the conditions triggering this are less clear. The fact that children both split up and merge prosodic constituents during the same developmental stages implies that the acquisition of sentential prosodic structure does not simply involve testing alternative parameter settings (i.e. X^{lex} vs. X^{max}), but rather is more complex and in need of further study.

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