Children's Use of Orthographic Cues in Language Processing

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Abstract

Rendaku, or sequential voicing, is a morphophonemic process in Japanese in which the voiceless word-initial consonant of the second element (=E2) of a compound word becomes voiced (e.g., ori + **k**ami →ori**g**ami, 'folding' + 'paper' → 'paper folding', /k/ becomes /g/). In adult grammar, *rendaku* is subject to two conditions: It applies if and only if (a) E2 is a *Yamato* word (native vocabulary) in the lexicon and (b) it contains no voiced consonant (e.g., b, d, & g). Recent psycholinguistic studies have revealed that Japanese-speaking preschoolers do not follow adult's grammar; they develop their original prosodically-based *rendaku* processing strategy (preschooler-specific *rendaku* strategy). Their strategies qualitatively change in the early middle childhood to be adult-like *rendaku*, creating a discontinuity in children's word-processing strategies. This study investigated factors responsible for this developmental discontinuity. We conducted an experiment using cross-modal linguistic stimuli (prosody & orthography) to see whether children's orthographic knowledge affects their *rendaku* strategy or not. Our results showed that orthographic cues affected literate children's *rendaku* processing. They were aware the correspondence between types of orthography and word categories in Japanese.

Keywords: preschoolers; *rendaku*; orthography; word category; pitch accent;

Introduction

Rendaku is a morphophonemic process in Japanese that the initial voiceless consonant of the second element (E2) of a compound becomes voiced (Vance, 2015).

(1) Compound Word Formation and *Rendaku*

E1	+	**E2**	→	Compound Word	
ori	+	**k**ami	→	ori**g**ami	**/k/ →/g/**
'folding'		'paper'		'paper folding'	

Rendaku has long been studied based on the data from adult subjects (Labrune, 2013). Neuropsychological studies have shown that *rendaku* is not just a matter of pronunciation such as English consonantal assimilation (e.g., tran**s**cript [s] vs. tran**s**action /s/→[z]); *rendaku* has functions of signaling the syntactic (grammatical), semantic (=meaning) aspects of E2 within a compound (Ogata, E., Hayshi, R., Imaizumi, S., Hirata, N., & Mori, K., 2000).

Thus, studying children's *rendaku* acquisition should lead to our deeper and comprehensive understanding of language development and cultural influences on our language faculty.

In adult grammar, *rendaku* is generally subject to 2 conditions (Ito & Mester, 1986, 1995, Fukuda & Fukuda, 1999, Fukuda, 2002) [1]:

(2) *Rendaku* conditions
Rendaku applies if
(a) E2 is a *Yamato* morpheme (native vocabulary)
and
(b) E2 contains no voiced obstruent in it (Lyman's Law).

The *rendaku* conditions seems complex and difficult for children to acquire since in order to be able to apply *rendaku* properly, children must know the lexical strata and Lyman's Law. Lexical strata are word categories stratified in the Japanese lexicon: *Yamato*, Sino-Japanese, foreign loans, and onomatopoeia (Ito & Mester, 1995, McCawley, 1968). Lyman's Law (Ito & Mester, 1995, Vance, 2015, and many others), which prohibits more than one voiced consonant within a morpheme (an element or unit of a word), is active only in the native vocabulary. This means that children must know which word belongs to the native vocabulary.

Children also have to parse the E2 and decide the applicability of *rendaku* immediately. How do children acquire this seemingly complex knowledge about *rendaku*? Do they know these two conditions from the beginning? Or do they learn them in some order?

Rendaku acquisition studies have assumed that children learn the adult's *rendaku* conditions (Fukuda & Fukuda, 1999, Fukuda, 2002). However, recent psycholinguistic studies have revealed that children do not acquire *rendaku* along with the adult's grammar. Instead, Japanese-speaking preschoolers develop a prosodically-based *rendaku* strategy (preschooler-specific *rendaku* strategy, Sugimoto, 2013a).

(3) Preschooler-specific *rendaku* strategy
Apply *rendaku* if E2 is an unaccented word.

The preschooler-specific *rendaku* strategy is also observed in English-Japanese simultaneous bilinguals (Sugimoto, 2015a). Sugimoto (2015b) reported that

[1] These conditions are not strict restrictions and there are some exceptional cases. For the purpose of conducting experiments, we assume and start from these conditions.

preliterate blind children also show the prosodically-based preschooler-specific *rendaku* strategy.

Japanese is a language with a pitch accent system. Pitch accent is a prosodic feature of a word and it differentiates the meaning of each Japanese word. Pitch accent can be divided into two types: Accented and unaccented. Accented words have a tonal rise followed by a sudden fall. Unaccented words have no such a tonal (rise & fall) contour.

Preschooler-specific *rendaku* processing reflects the distribution of pitch accent types of native vocabulary, to which *rendaku* applies (Table 1). Children are aware that *rendaku* does not apply every word; it applies a particular category of words. They actively construct their own *Rendaku* rule, making best use of their knowledge: Apply *rendaku* if E2 is an unaccented native word.

Table 1: Word categories and pitch accent

Pitch accent / Lexical strata	Accented words[2] (examples)	Unaccented words
Yamato words (=native vocabulary)	29% (ka'rasu 'crow')	71% (sakana 'fish')
Sino-Japanese words (vocabulary of Chinese origin)	49% (hu'dan 'daily')	51% (saihu 'purse')
Loan words (excluding Sino-Japanese)	93% (ke'eki 'cake')	7% (pijano 'piano')

(Sugimoto, 2016, data originally from Kubozono, 2006, p180)

The commonly observed children's prosodically-based *rendaku* processing strategy changes in quality around in the early middle childhood to be adult-like *rendaku*, creating a discontinuity in children's *rendaku* strategies (Sugimoto, 2015b). School age children no longer depend on prosodic information of E2. Their *rendaku* patterns become similar to those of adults being independent from the prosody of E2. These qualitative change in children's *rendaku* processing strategy create a developmental discontinuity.

It is easy to imagine that some developmental changes and learning outcomes during these years might motivate children's *rendaku* strategy at around their entry into elementary school.

What kind of development or learning motivates and determines such changes or a discontinuity?

One possibility would be the influence of literacy. Since three types of Japanese characters represent lexical strata, it could be likely that children become well aware of Japanese lexical strata and word categories along with usages of Japanese *hiragana*, *katakana*, and kanji characters. If literacy affects children's *rendaku* processing strategy, how and why?

The purpose of this study was to investigate factors responsible for this developmental discontinuity. We conducted an experiment using cross-modal linguistic stimuli (prosody & orthography) to see whether literacy affects children's *rendaku* processing strategy or not.

[2] The apostrophe in Japanese accented words (e.g., ka'rasu (=crow)) indicates the position of pitch accent.

(4) Research questions

Q1. Do literate preschoolers know the correspondence between types of orthography and word category?

Q2. How do they use their orthographic knowledge in their *rendaku* processing?

(5) Working Hypothesis

If literate preschoolers use their orthographic knowledge in *rendaku* processing, then their *rendaku* patterns should differ, depending upon types of orthography given.

Method

We used a compound noun formation task (Nicoladis, 2003, Sugimoto, 2013a&b, 2016) to see Japanese-speaking preschoolers' language processing strategy described below.

Participants and ethical considerations

The total number of 73 six-year olds with *hiragana* & *katakana* literacy living in the Tokyo dialect area participated in our study. 40 children were assigned to the no orthography condition (control group); 16 children were in the *hiragana* condition; 17 children were in the *katakana* condition.

Prior to the study, we obtained written form of parental permission from all the participants.

Procedure

Children were tested individually in a quiet room. We went through three trials: 4 warm-up trials, 4 comprehension trials, and finally the 16 test trials (E1=*hima'wari*). In each trial, children were shown 3 types of pictures on a laptop computer, E1 & E2 in a random order. The experimenter read aloud E1 and E2 and then asked the children to name picture C (compound noun).

(6) Compound noun formation task (Sugimoto, 2016)

E1	+	E2	→	C (Compound noun)
hima'wari	+	ka'rasu	→	himawari**ga**'rasu
'sunflower'		'crow'		'sunflower crow'

The experimenter read aloud the following statements followed by a question as in (7).

(7) Instructions in the experiment

E1: Kore-wa himawari-desu. 'Here's a *hima'wari*'

E2: Kore-wa karasu-desu. 'Here's a *ka'rasu*.'

C: Koreni namae-o tuketekudasai.
'How would you name it?'

Compound noun formation task with cross-modal linguistic stimuli : Visual(orthography) & auditory (speech) information

We used a modified version of compound noun formation task, cross-modal stimuli, which used two types of visual stimuli (picture and orthography) and auditory stimuli (experimenter read aloud the stimuli).

Design and material

The experiment used a 3 factor inter-subject design: 2(pitch accent)×2(word)×2(orthography). First, the pitch accent of E2 was controlled to two types: unaccented vs. accented (Kubozono, 2006). We used known words and novel words. As for novel words, we counterbalance poss

In order to counterbalance possible phonotactic effects, we divided each condition group into two subgroups and switched types of pitch accent assignment between the subgroups of each condition (see Tables 2 &3 in Appendix).

We also used three types of Japanese orthography conditions (visual stimuli) as in (8).

(8) 3 orthography conditions
A. No orthography (control)
B. *Hiragana* condition
C. *Katakana* condition

Visual stimuli for each of these three conditions are illustrated in Figures 1a-c, respectively.

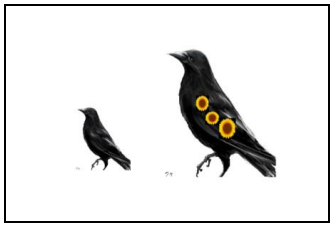

Figure 1a: No orthography condition (control group)

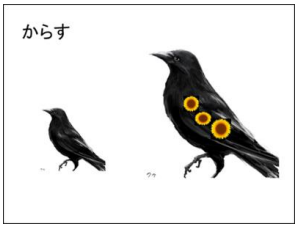

Figure 1b: *Hiragana* condition (からす= 'crows' in *hiragana*)

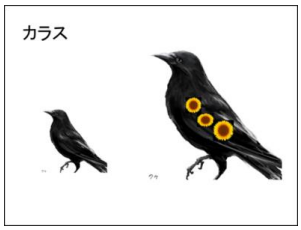

Figure 1c: *Katakana* condition (カラス＝ 'crows' in *katakana*)

Measures

During the experiment, we used a SONY IC recorder (ICD SX-1000) and recorded the children's utterances. After the experiment, two people, one of whom was the author, listened separately to the recordings and transcribed them, judging whether or not the children voiced the target consonant. The reliability of the judgments (Cohen's kappa coefficient (Omura, 2000)) was calculated. The agreement ratio was κ =.96, which is considered highly reliable.

Our scoring was the following. All of the 16 compound nouns in the test trial are subject to *rendaku* (see Table 2 in Appendix). When a subject voiced the morpheme-initial obstruent of E2, then we judged that he/she had correctly applied *rendaku*; for each compound, one point was added to the score. We calculated the total scores and subtotals by condition (pitch accent, orthography, and word type).

Results

Descriptive statistics is shown in Table 4. A three-way ANOVA found a significant interaction of pitch accent and orthography [$F(2,70)=15.061$, $p<.001$, $\eta^2=.301$]. The simple effect of pitch accent was significant in the control group and in the *hiragana* condition [$F(1,70)=93.092$, $p<.001$, $\eta^2=.571$], [$F(1,70)=4.750$, $p=.033$, $\eta^2=.064$], respectively. But the simple effect of pitch accent was not significant in the *katakana* condition [$F(1,70)=.20$, $p=.888$, $\eta^2<.0001$].

Table 4: Descriptive statistics of *rendaku* score

	Condition	Mean	SD	N
Unaccented words（８）	Control	6.2	1.244	40
	Hiragana	3.38	2.391	16
	Katakana	1.82	1.286	17
	Total	4.56	2.444	73
Accented Words（８）	Control	3.58	1.893	40
	Hiragana	2.44	2.366	16
	Katakana	1.76	1.888	17
	Total	2.9	2.122	73

(8 pts. are the maximum score for each pitch-accent type)

Multiple comparisons of within-condition show significant differences between unaccented words and accented words in the control and the *hiragana* conditions (Figure 2). In the two conditions, children used the prosodically-based preschooler-specific *rendaku* strategy. On the other hand, the *katakana* condition show no significant difference between the two pitch accent types ($p<.001$, 95%*IC*: .891-774). Thus, children in the *katakana* condition did not used the preschooler-specific *rendaku* strategy. Compared to the other two conditions, their *rendaku* processing rates in the *katakana* conditions were inhibited, but when we look at the within-group difference, children in the *katakana* condition applied *rendaku* to accented words more often than unaccented words.

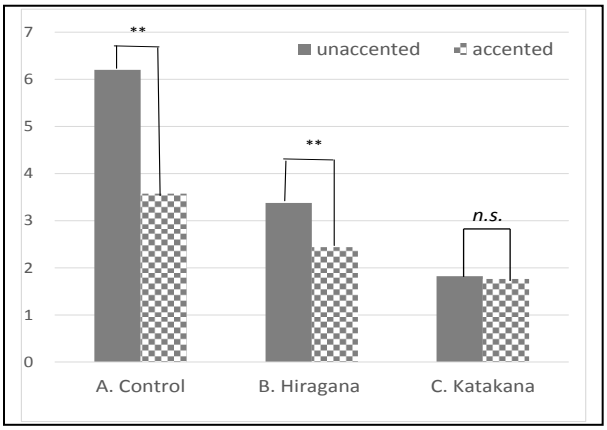

Figure 2: *Rendaku* Score by Condition (8pts.)

Discussion

The significant interaction of pitch accent and orthography conditions, which indicates that literate preschoolers were affected by orthographic cues and showed different *rendaku* processing. Children in the no orthography condition (control) and in the *hiragana* condition showed similar *rendaku* patterns: apply rendaku to unaccented E2s. But children in the *katakana* condition showed a different *rendaku* pattern: they did not apply rendaku to unaccented words, contrary to the other two groups. When *katakana* is given, which represents foreign loan words in Japanese, children's *rendaku* processing was inhibited. Children in (c) did not to apply *rendaku* to non-native vocabulary as much as those in the other conditions did.

It follows from this that the *katakana* condition made children assume the word stimuli were nonnative vocabulary. *Katakana* is used for foreign loan words in the Japanese writing system. Children seem to know *katakana* is used for non-native vocabulary, and judged that the stimuli (both existent native vocabulary and novel words were given) were non-native vocabulary, to which *rendaku* does not apply.

Our results suggest that literate preschoolers used orthographic cues in *rendaku* processing. Preschoolers used different strategies, depending on types of orthography provided in the stimuli.

Preschoolers in the 'no orthography' and the *hiragana* conditions showed the similar tendency: they applied rendaku to unaccented words more often than accented words while those in the *katakana* condition seemed reluctant to apply it. It follows from these that children attend to orthographic cues but children still use prosodically-based rendaku strategy.

Table 5: Orthographic cues and children's application of *rendaku*

Condition	Application of *rendaku*	Use of preschooler-specific strategy
No orthography (pictures only)	Yes	Yes. U > A
Hiragana	Yes	Yes. U >A
Katakana	Yes, but highly inhibited	**No. U≒A**

(U = unaccented words, A= accented words)

Why, then, did preliterate preschoolers in the *katakana* condition were not willing to apply rendaku to unaccented words more often than accented words? We can think of the following possibilities. Preliterate children may be aware of some correspondence between types of orthography and word categories. That is, they may know *hiragana* is used for a certain category of words and *katakana* for another. They may also be aware that *katakana* is used to represent non-native Japanese vocabulary, to which rendaku does not apply.

Preschoolers first define the *rendaku* word category based on prosodic information, that is, pitch-accent (preschooler-specific *rendaku* strategy). We only found that our literate preschoolers can differentiate *rendaku* strategies based on a rough *katakana* vs. non-*katakana* distinction, not *hiragana* vs. *katakana* distinction. We need their longitudinal data to consider orthographic effects on the developmental changes in children's language processing.

Conclusion

Japanese speaking preschoolers, when they have no orthographic knowledge, first define the *rendaku* category based on pitch-accent, i.e., preschooler-specific *rendaku* strategy. After acquiring orthography, children seem to gradually change their *rendaku* processing strategy, using information such as the relationship between orthography and word category. Something more is needed for their redefinition of the *rendaku* category, which may cause the developmental change in their *rendaku* processing strategy. We need developmental paths of individual children.

Acknowledgments

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Appendix

Table 2: List of stimuli for 16 E2s used in the test trial

	8 known words		8 novel words (Old Japanese)	
	Accented	Unaccented	Accented/Unaccented[#]	Unaccented/Accented [#]
1	ta'nuki 'racoon dog'	sakura 'cherry blossom'	tokama 'reaping hook '	tekona 'virgin'
2	ka'rasu 'crow'	tsukue 'desk'	hikime 'long arrow'	hokai 'food container'
3	ho'uki 'bloom'	hatake 'field'	sasara 'an old musical instrument'	tatara 'bellows'
4	ho'taru 'light bug'	kuruma 'car'	koromo 'Kimono'	hokora 'god's palace'

(E1: himawari 'sunflower'; E2: 16 words listed in Table 2)

[#] For 8 novel words, we created two types of pitch accent assignment patterns to counterbalance possible phonotacitic effects (see Table 3 below). In particular, we divided children in each of three conditions into two groups and used different pitch accent assignment for each group in each condition.

Table 3: Two types of pitch accent assignment

Groups / Novel word stimuli (E2)	Group A of each condition	Group B of each condition
tekona, hokai, tatara, hokora	Accented e.g., te'kona (antipenulte)	Unaccented e.g., tekona (no pitch accent)
tokama, hikime, sasara, koromo	Unaccented e.g., tokama (no pitch accent)	Accented e.g., to'kama (antipenulte)