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## CROSS-LINGUISTIC EVIDENCE FOR ACQUISITION OF GEMINATES<sup>1</sup>

The goal of this study is to trace the acquisition of geminate consonants over the course of the one-word period in children acquiring Finnish and Japanese. In order to determine whether or not children differentiate singleton from geminate targets in production during this period we measured the durations of the first vowel, stop consonant, and final vowel of disyllables produced by children and compared them with the same segments produced by adults. Our preliminary results suggest that Finnish children acquire the contrast more rapidly than Japanese children. The apparent cross-linguistic differences in rate of acquisition will be discussed in relation to differences in the input.

### **Introduction**

Our primary interest is to discover when children exposed to languages that make a quantitative contrast in medial consonants begin to distinguish them in production. Vihman and Velleman (2000) indicated that children produce long medial consonants in early words even when learning languages such as English and French, which have only short consonants phonologically. These infants produced a wide range of durations of medial consonants at the onset of word production but began to restrict their production to medial consonants at the short end of the duration range by the end of the one-word period. Finnish children, on the other hand, continued to produce a wide range of medial consonants throughout the one-word period. Thus, it seems that the phonological length distinction (or the lack of it) in the ambient language influences the durations of medial consonants by the end of the one-word period. We were interested in identifying just when children exposed to languages with such contrasts are first able to make a distinction between long and short consonants in production, i.e., to produce medial consonants of short durations for short targets and of long durations for long targets, and how differences in rate and

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path of learning are affected by particularities of the adult language being learned. In this paper we will present preliminary results from our ongoing study on the production of singleton (short) vs. geminate (long) stops by Finnish and Japanese children during the one-word period.

Both Finnish and Japanese are said to have phonologically contrastive lengths for both vowels and consonants. For instance, Finnish /mAto/ 'worm' contrasts with /mAt:o/ 'mat' and Japanese /kako/ 'past' contrasts with /kak:o/ 'brackets'<sup>2</sup>. Of the 13 consonants of Finnish, nine can occur as geminates: /p, t, k, n, m, N, l, r, s/ (Iivonen, 1998). Japanese has what has been traditionally regarded as moraic consonants, viz. the mora nasal (/N/) and the mora obstruent (/Q/). When they precede nasals (in the case of /N/) or obstruents (in the case of /Q/), these moraic consonants are, together with the following consonants, phonetically realised as geminates, which can be lexically contrasted to their short counterparts. It is not entirely clear from the existing literature just how many consonants should be regarded as having singleton vs. geminate 'oppositions', as some of them are lexically contrastive, as in the example given above, while others are seemingly used only for pragmatic purposes (e.g., emphasis, surprise), and there are innovating varieties used for loan words whose status is not clear. However, the general consensus seems to be that the nasals /m, n, n&/, the voiceless stops /p, t, k/, the affricate /c&/ and the fricatives /s, s&/ can be quantitatively contrasted at the lexical level (cf. Vance, 1987; Tsujimura, 1996; Akamatsu, 1997).

There is a great deal of variation in the reported duration ratios of singleton and geminate consonants. For example, Lehtonen (1970) reports that Finnish geminates are, in general, about twice as long as the corresponding singleton consonants. On the other hand, Richardson (1998) reports that Finnish /t:/ is about three times as long as /t/. Similarly, according to Han (1992), reports on the duration ratio of Japanese singleton and geminate consonants range from 1:2 to 1:3. Han's (1992) data suggest that the discrepancy mainly depends on whether or not Voice Onset Time (VOT) is included in the measurement of the consonant duration. When we look at various reports, however, it seems that the inclusion or exclusion of VOT does not always play a major role in accounting for these differences (cf. Homma, 1981; Lehtonen, 1970; Richardson, 1998). It seems that the type of consonants measured, differences in speech rate, and the contexts in which the target segments were embedded (at word as well as sentence level), among other things, may be responsible for the discrepancy.

The acquisition of quantitatively contrasted medial consonants has not been extensively studied, but the few studies to date suggest that the contrast in production may begin to be made relatively early in Finnish and late in Japanese. For instance, Richardson (1998) conducted an imitation experiment with 18-month-old infants using test words containing word-medial /t/ vs. /t:/. Although the attrition rate was high (61%), the successful infants' performance suggests that some Finnish children produce singleton vs. geminate stops contrastively by that early age. On the other hand, on the basis of a series of investigations on nasal quantity distinctions in Finnish and Japanese, Aoyama (2000) reports that Finnish children distinguished /n/ and /n:/ at 3 years of age, whereas Japanese children did

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<sup>2</sup> In Finnish phonetically long consonants can be interpreted phonologically as sequences of two identical phonemes (Karlsson, 1983, p. 71). On the other hand, [kAk:o] is transcribed as /kAQko/ in traditional Japanese phonological transcription (cf. Vance, 1987, p. 39-43). For the sake of uniformity, however, we will use /C:/ to refer to both Finnish and Japanese long consonants.

not. She attributes the cross-linguistic difference in the mastery of the contrast to the more frequent occurrence of geminate consonants and the greater length distinction between the singleton vs. geminate nasal in Finnish (the ratio of /n/ to /n:/ is 1: 2.88 in Finnish and 1:2.51 in Japanese in her study). At the same time, Hurme and Sonninen (1982) report that only about 30% of the 2-4 year old children and about 80% of the 5-6 year old children produced a statistically significant duration difference in the medial consonants of CVCV and CVC:V words in a picture naming task. On the other hand, in a repetition task (Hurme & Sonninen, 1985) they found that about 70-90% of the 3-year-old children and 90-100% of the 6-year-old children were able to make the quantity distinction. These results suggest that 3-year-old Finnish children do not yet reliably produce the quantitative opposition, at least under certain experimental conditions. In other words, differences in experimental results may be due to task differences.

In the present study, we looked at Finnish and Japanese children's spontaneous production of singleton vs. geminate medial stops at the onset and toward the end of the one-word period (at roughly 13 and 16-17.5 months of age). We asked:

- (1) When do Finnish and Japanese children begin to make a length contrast in stops in spontaneous speech?
- (2) Is there a difference in the rate of acquisition between the two language groups? If so, where does it come from?

To answer these questions we began by looking at the differences between Finnish and Japanese adult production of singleton vs. geminate medial stops. Specifically, we looked at the phoneme frequencies of singleton vs. geminate consonants in mothers' speech directed to children. Furthermore, we made duration measurements of disyllables containing singleton and geminate stops produced by adult speakers of the two languages. The duration measurements were used to compare Finnish and Japanese adults as well as to compare children's production with adults'. Preliminary results of the adult study will be reported in Part I. Further, we obtained children's speech samples from recordings of unstructured play sessions at the two developmental points we had identified. Disyllabic utterances targeting words containing medial stops were chosen, and duration measurements of each segment were made. Preliminary results of the analyses of children's productions will be reported in Part II.

## **Part 1: Adults**

### **Subjects and procedure**

#### *Frequency of singleton vs. geminate consonants in mothers' speech*

In order to study the phonetic characteristics of the input in Finnish and Japanese we calculated the frequency of each consonant phoneme from mothers' speech during half-hour unstructured play sessions between mother and child. The data were collected as part of two longitudinal studies: one group acquiring Finnish (10 participants: Kunnari 2000), the other group acquiring Japanese (5 participants: Boysson-Bardies & Vihman, 1991). One session each from 5 mothers' child-directed speech was orthographically transcribed for each language by a native speaker transcriber, and the occurrence of each consonant was counted. All the recordings analysed here correspond to the session in which 4 or more words were used spontaneously (the '4-word point').

Table 1. Adults' production material

	(C)VCV		(C)VC:V	
	orthography	transcription	orthography	transcription
Finnish	ato	/ato/	atto	/at:o/
	kaka	/kaka/	kakka	/kak:a/
	opu	/opu/	oppu	/op:u/
	pupu	/pupu/	puppu	/pup:u/
	tätä	/toto/	tättä	/tot:o/
Japanese	アタ	/ata/	アツタ	/at:a/
	ガコ	/gako/	アツタ	/gak:o/
	タタ	/tata/	アツタ	/tat:a/

*Durational study of adult production of singleton vs. geminate stops*

Speech samples directly comparable to children's word productions were obtained from adult speakers of the two languages. That is, adults were asked to produce pseudowords designed to match the segmental sequence and phonotactic shape of child productions but with medial consonants of the two contrastive lengths. For example, if a child produced [tat[:]a] for Japanese /tot:e/ 'get (it for me)', the adults produced /tata/ and /tat:a/, so that the medial consonants produced by the children could be compared with both adult /t/ and /t:/. Table 1 shows the pseudowords analysed for comparison between child and adult productions. In addition to the pseudowords based on children's forms, adult productions of /papa/ vs. /pap:a/ were elicited and analyzed for both Finnish and Japanese in order to directly compare the oppositions in the two languages.

The Finnish data were collected in Oulu, Finland. So far, we have recorded 5 speakers, all female students from the University of Oulu. They ranged in age from 20 to 34 years. According to the subjective evaluation of the first author, all the students spoke standard Finnish with no perceptible regional accent. The Japanese data were collected in Bangor, Wales. We have recorded 4 speakers, all female students from the Kanto area as defined by Shibatani (1990, p. 188), the dialects of which form the basis of Standard Japanese. The speakers' ages ranged from 20 to 27. None of the speakers in either language group reported any history of speech or hearing problems. The pseudowords were presented in randomised order, using the orthography of each language to elicit the production. The speakers were instructed to read each word at a natural speed and as if they were real words. They were also instructed to repeat the word whenever they thought that they had made a mistake. Each word was repeated three times within the randomized list. A total of 180 pseudowords suitable for analysis [(6 singleton + geminate pairs) x 3 repetitions x 5 speakers] were obtained from Finnish speakers and 96 pseudowords [(4 singleton + geminate pairs) x 3 repetitions x 4 speakers] were obtained from Japanese speakers.

All the adult speech samples were extracted from the original recordings and digitized using a 16 bit Audiomedia board at a sampling rate of 22.2 kHz. The durations of the first vowel, medial consonant, and final vowel of the extracted words were measured using the SoundScope Speech Analysis Package. The durations of word initial stops could not be measured, as all words were produced in isolation. Segmentation followed rules devised as part of an earlier study (Vihman, DePaolis & Davis, 1998). Since the onset of stop release was not always easily found in child productions, we analyzed VOT as part of the

Table 2. Frequency of geminates in mothers' speech

	Segment	Finnish %	Japanese %
Stops			
voiceless	p:, t:, k:	5.2	3.6
voiced	b:, d:, g:	0.0	0.1
Affricates	c:ç	-	0.9
Fricatives	s:, ç:, h:, f:	1.6	0.3
Nasals	m:, n:, ŋ:, ɲ:	2.3	1.6
Liquids	l:, r:	4.1	0.0
Total		13.2	6.5

stop consonants for adult as well as child productions, permitting us to apply consistent segmentation criteria to all of our data. Voiceless stops are normally unaspirated in both Finnish and Japanese (short-lag VOT), and the stop closures we obtained in pseudowords were much longer than those in Han (1992), whereas the durations of VOT were more or less comparable to those in her study. Therefore, it was thought that the exclusion or inclusion of VOT as part of consonants was not a critical issue.

## Results

### *Frequency of singleton vs. geminate consonants in mothers' speech*

Table 2 provides an overview of the distribution of geminates in Finnish and Japanese mothers' speech as a percentage of all consonant occurrences. In general, in both languages geminate consonants occurred much less frequently in the mothers' speech than did their singleton counterparts. The frequency of geminates was highest in stop consonants in both the Finnish and Japanese samples. Of the three geminate stops, /t:/ seemed to occur more frequently than /k:/ or /p:/ (in Finnish 2.6%, 1.8%, 0.8% and in Japanese 2.8%, 0.7%, 0.2%, respectively). In Finnish /l:/ was also frequent (4.0%). Over all, geminate consonants constituted a total of 13.2% of all the consonant occurrences in Finnish and 6.5% in Japanese. Thus, the quantity contrast is almost twice as frequent in Finnish as in Japanese. These results are consistent with Aoyama's (2000) findings based on analysis of children's books (Finnish: 9.9% vs. Japanese: 5.1%).

### *Durational study of adult production of singleton vs. geminate stops*

The mean and standard deviation of the absolute duration of each segment (excluding the word initial stop) of the disyllables produced by Finnish and Japanese adults are presented in Tables 3 and 4, together with their proportional durations (calculated as the percentage of the total for each of the three measurable segments). For comparison, Finnish and Japanese production of the pseudowords /papa/ and /pap:a/ are tabulated separately from the rest in Table 3 (see also Figure 1). Because of the small number of speakers in each language, no statistical analyses were carried out. As expected, the mean durations of geminate stops (absolute and proportional) were longer than those of singleton stops for all the pseudoword pairs in both languages. The singleton vs. geminate duration ratios (based on absolute durations) ranged from 1:2.38 to 1:2.80 for Finnish and 1:2.15 to 1:2.35 for Japanese, which is in line with the figures reported in Richardson (1998) for Finnish

Table 3. Finnish/Japanese adult production /papa/ vs. /pap:a/

Language	Word		Absolute duration (ms)			Proportion (%)		
			V1	midC	V2	V1	midC	V2
Finnish	/papa/	mean	97.4	133.1	158.0	25.1	34.4	40.5
		sd	(15.9)	(20.7)	(34.0)	(2.4)	(4.3)	(5.5)
	/pap:a/	mean	87.7	350.3	104.4	16.3	64.3	19.4
		sd	(13.6)	(61.0)	(16.4)	(2.9)	(4.7)	(3.4)
Japanese	/papa/	mean	94.5	148.9	149.2	24.0	38.3	37.7
		sd	(17.2)	(8.0)	(29.1)	(3.2)	(4.7)	(4.3)
	/pap:a/	mean	110.3	332.5	132.7	19.2	57.9	22.9
		sd	(18.0)	(43.9)	(31.2)	(3.3)	(6.6)	(4.4)

Figure 1. Finnish and Japanese /papa/ and /pappa/ productions by adult speakers. The box represents the portion of the distribution falling between the 25th and 75th percentiles. The horizontal line represents the median and the vertical lines connect the largest and smallest values.

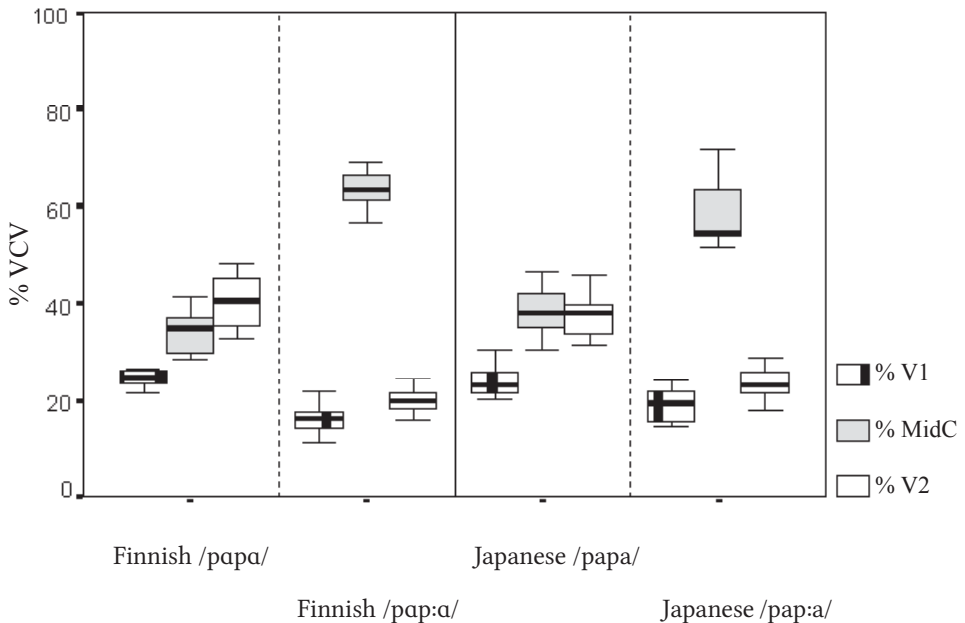


Table 4. Adults' productions of child word forms (sd in brackets)

Language	Word	Mean absolute duration (ms)			Proportional duration (%)			
		V1	midC	V2	V1	midC	V2	
Finnish	/ato/	90.2 (21.9)	135.9 (25.2)	143.0 (21.6)	24.2 (4.3)	36.7 (4.8)	39.1 (6.8)	
	/kaka/	90.1 (13.0)	138.2 (21.7)	145.0 (22.1)	24.1 (2.7)	37.0 (5.0)	38.8 (4.6)	
	/opu/	101.2 (19.9)	154.4 (20.6)	145.5 (24.1)	25.1 (3.5)	38.6 (4.7)	36.3 (5.4)	
	/pupu/	90.3 (16.8)	138.4 (18.5)	157.3 (26.0)	23.2 (2.4)	36.1 (5.2)	40.7 (5.2)	
	/tætæ/	99.0 (20.3)	127.3 (19.7)	154.7 (25.6)	25.9 (3.7)	33.5 (4.4)	40.6 (5.6)	
	<u>mean</u>	<u>94.2 (18.8)</u>	<u>138.8 (22.5)</u>	<u>149.1 (24.0)</u>	<u>24.5 (3.4)</u>	<u>36.4 (5.0)</u>	<u>39.1 (5.6)</u>	
	/at:o/	87.5 (12.1)	375.3 (43.6)	91.0 (19.5)	15.9 (2.0)	67.7 (2.6)	16.4 (2.7)	
	/kak:a/	78.5 (14.4)	360.9 (61.2)	98.7 (20.9)	14.7 (2.4)	67.0 (3.8)	18.4 (2.8)	
	/op:u/	90.7 (14.8)	367.4 (57.1)	100.0 (23.1)	16.2 (1.8)	65.7 (4.7)	18.1 (4.3)	
	/pup:u/	81.2 (18.3)	370.4 (62.7)	104.2 (26.5)	14.6 (2.8)	66.5 (5.9)	18.9 (4.9)	
	/tæt:æ/	92.6 (13.7)	356.3 (63.7)	107.2 (17.8)	16.8 (2.5)	63.8 (3.5)	19.4 (2.6)	
	<u>mean</u>	<u>85.7 (16.2)</u>	<u>363.7 (59.9)</u>	<u>102.5 (22.0)</u>	<u>15.6 (2.5)</u>	<u>65.7 (4.6)</u>	<u>18.7 (3.7)</u>	
	Japanese	/ata/	93.9 (15.6)	156.6 (11.9)	142.1 (33.3)	23.9 (2.5)	40.3 (5.0)	35.8 (4.5)
		/gako/	99.6 (20.6)	162.6 (11.5)	120.9 (46.8)	26.0 (2.5)	43.7 (8.0)	30.3 (8.2)
/tata/		93.6 (16.5)	141.4 (5.3)	127.8 (35.8)	25.9 (3.9)	39.5 (4.8)	34.6 (6.4)	
<u>mean</u>		<u>95.7 (17.4)</u>	<u>153.6 (13.3)</u>	<u>130.3 (39.0)</u>	<u>25.3 (3.1)</u>	<u>41.2 (6.2)</u>	<u>33.6 (6.8)</u>	
/at:a/		112.0 (6.3)	336.2 (39.0)	140.9 (34.4)	19.0 (2.4)	57.2 (5.9)	23.7 (4.7)	
/gak:o/		118.8 (20.3)	353.6 (51.2)	120.3 (35.8)	20.2 (3.8)	59.7 (7.3)	20.1 (5.0)	
/tat:a/		115.5 (14.1)	333.6 (50.6)	138.3 (30.5)	19.8 (2.8)	56.7 (6.7)	23.5 (4.8)	
<u>mean</u>		<u>115.5 (16.8)</u>	<u>341.2 (46.7)</u>	<u>133.2 (33.9)</u>	<u>19.7 (3.0)</u>	<u>57.9 (6.6)</u>	<u>22.5 (5.0)</u>	

/t/ vs. /t:/ and in Homma (1981) for Japanese voiceless stops. The results also suggest that the proportional durations of medial consonants may differ slightly between Finnish and Japanese. Japanese singleton stops seem generally longer than Finnish singleton stops, while Japanese geminate stops are shorter and more variable than Finnish geminate stops. Thus, in accordance with Aoyama's (2000) report on the nasal contrast, singleton vs. geminate stops seem to be more sharply contrasted in Finnish than in Japanese.

## Part 2: Children

### Subjects and procedure

Like the data used in the analysis of mothers' speech, the children's production data derive from 5 children each included in Kunnari (2000) and the Japanese study reported in Boysson-Bardies and Vihman (1991). In this paper we will report the results of acoustic measurements made of the disyllables produced by three children each acquiring Finnish or Japanese (2 girls and 1 boy in each case). All the children came from monolingual homes and had normal developmental histories. The children were audio- and video-recorded either fortnightly or monthly at home in unstructured half-hour play sessions with their mothers. Children's speech samples were taken from two developmental points (4- and 25-word points), defined on the basis of the number of words produced spontaneously in a session. The two word points roughly correspond to the beginning and the end of the one-word period. The number of words produced by the children was determined using

Table 5. Number of speech samples analysed from the children’s data

Language	Word point	Singleton targets	Geminate targets
Finnish	4-word point	23	10
	25-word point	8	20
Japanese	4-word point	0	7
	25-word point	3	22

Vihman and McCune’s (1994) word identification procedure. The mean age of attaining the criteria for the 4-word point was 13 months for both language groups and for the 25-word point, 16 months for Finnish and 17.5 months for Japanese.

From the audio recordings of the two word point sessions ‘attempted words’ were extracted and transcribed for further analyses. As with the adult speech, all the samples were digitized using a 16 bit Audiomedia board at a sampling rate of 22.2 kHz. From the extracted speech samples we chose disyllabic utterances for further acoustic analyses following the criteria below:

- (1) Both the target word and the attempted word were of either (C)VCV or (C)VC:V structure;
- (2) The medial consonant of the target word was a stop that can be categorized as either singleton or geminate (which excluded some onomatopoeia);
- (3) The medial consonant of the attempted word matched that of the target word in place and manner (regardless of duration).

Thus, for instance, in Japanese the child form [hoto] for /mot:o/ ‘more’ was included, whereas [baba] for /bak:~/ ‘back’ and [tetete] for /tot:e/ ‘get (it for me)’ were excluded

Figure 2. Production of singleton and geminate target words by Finnish children and adults

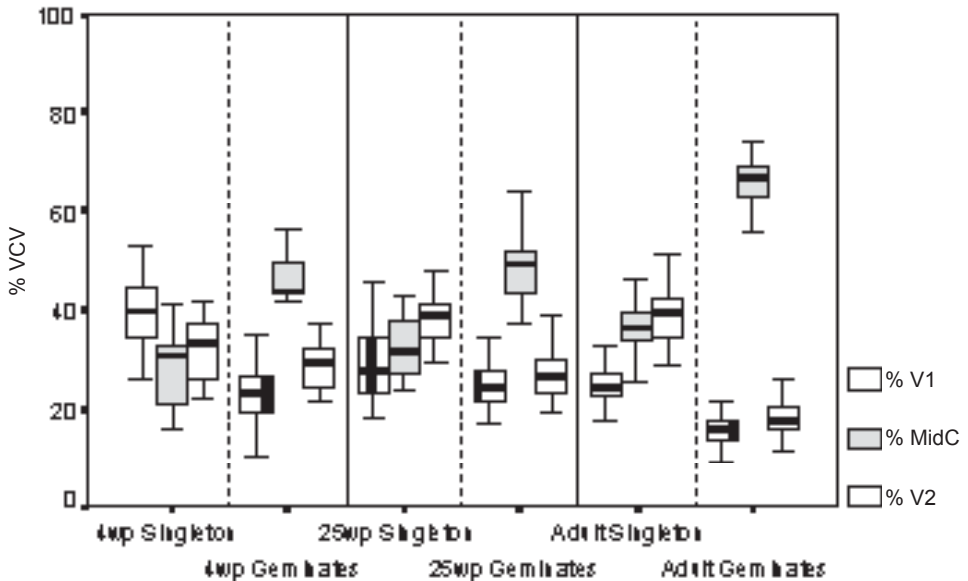




Table 6. Children's productions (sd in brackets)

Language	Word point	Target	Mean absolute duration (ms)			Proportional duration (%)			
			V1	midC	V2	V1	midC	V2	
Finnish	4-wp	singleton	197.6 (32.7)	140.3 (47.1)	164.9 (48.5)	40.0 (8.1)	27.6 (7.4)	32.4 (6.2)	
		geminate	141.7 (34.4)	317.8 (148.6)	182.8 (40.5)	23.1 (6.6)	47.8 (7.9)	29.1 (5.2)	
	25-wp	singleton	174.1 (68.3)	189.8 (46.3)	225.1 (53.2)	29.3 (8.9)	32.4 (6.7)	38.3 (5.7)	
		geminate	192.3 (53.6)	376.8 (107.3)	205.4 (70.1)	25.0 (5.4)	48.5 (6.9)	26.5 (5.7)	
	Japanese	4-wp	singleton	-	-	-	-	-	-
			geminate	153.5 (51.2)	208.3 (164.2)	309.2 (122.5)	25.0 (11.4)	28.7 (13.1)	46.3 (13.6)
25-wp		singleton	118.4 (35.7)	154.6 (62.2)	142.9 (47.4)	21.9 (7.9)	37.0 (14.1)	33.9 (8.9)	
		geminate	118.4 (56.5)	228.2 (72.0)	249.9 (212.8)	29.0 (10.0)	37.0 (14.2)	33.9 (8.9)	

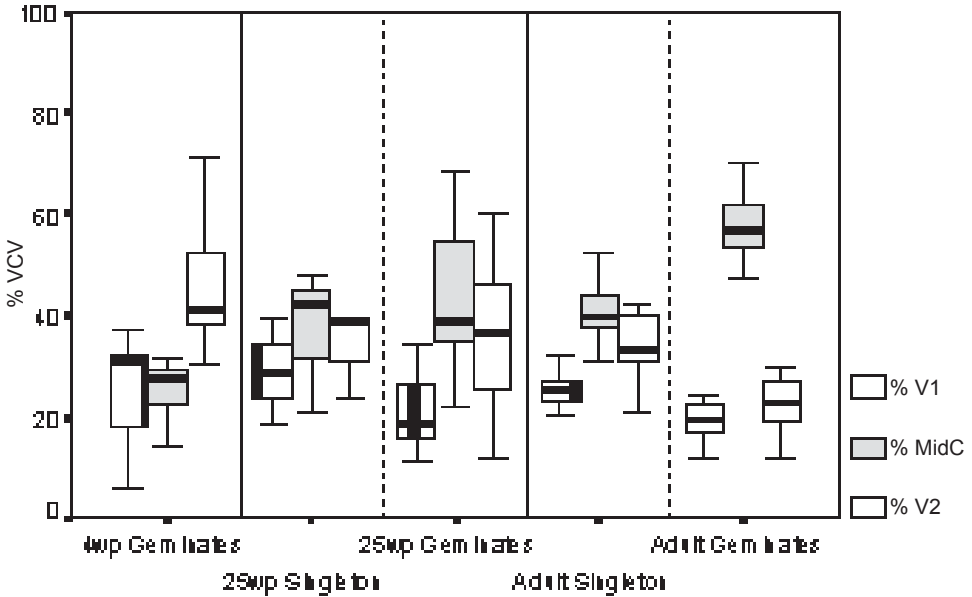
from the analyses. Disyllables with interfering noise were also excluded. The numbers of speech samples that satisfied the above criteria are presented in Table 5. The selection criteria considerably limited the number of analyzable utterances, but they were necessary to allow for relatively straightforward comparisons of segmental durations of utterances produced by different languages and age groups, and to ensure that the medial consonant in the child utterance represented a genuine attempt to produce that of the target word. The utterances analyzed for the Japanese 4-word point are particularly few, due to the fact that the targets of most attempted words were onomatopoeic whose medial consonants could be either singleton or geminate (e.g., [b̥ːb̥ː] and [b̥ːb̥ː]) are both acceptable forms of an onomatopoeic word meaning 'car'). Duration measurements of the selected speech samples were made following the same segmentation criteria used for adult speech.

## Results

The means and standard deviations of absolute and proportional durations of each measurable segment in children's disyllables are summarized in Table 6 by language group and word point. Figures 2 and 3 plot separately for Finnish and Japanese the proportional durations of segments produced by different age groups. Since the number of analyzed child utterances is small and the segmental durations of each contrast produced by adults seem similar across different CVCV-CVC:V pairs, the adult values presented here are averages summarizing all the contrastive pairs listed in Table 4.

As can be seen in Table 6 and Figure 2, on average already at the 4-word point Finnish children's productions of words with geminate targets were longer than their productions of words with singleton targets both in absolute and proportional terms. The difference in the proportional durations between singleton and geminate stops did increase with age, however, so that the durational opposition is more adult-like at the 25-word point, while still

Figure 3. Production of singleton and geminate target words by Japanese children and adults



falling short of the adult standard. The data obtained at the 25-word point are comparable to the results of Richardson's (1998) study on the imitation of the contrast by children of a similar age group (18 month olds). A comparison of the absolute duration of each segment in child and adult productions suggests that the difference may be partially due to children's inability to produce sufficiently short vowels (e.g., the first vowel in CVCV and the two vowels in CVC:V words), as Richardson (1998) also points out. Furthermore, most of the standard deviations are much larger for child than for adult segments. These observations are compatible with earlier studies on young children's speech production that report slow speech rate (i.e., long segments) and large variability (Smith, 1978; Kent & Forner, 1980).

On the other hand, although the results need to be interpreted with caution as the number of Japanese singleton samples is very small, the Japanese children did not seem to differentiate the opposition reliably even at the 25-word point (see Table 6 and Figure 3). Although the mean duration of geminate stops is longer than that of singleton stops in terms of absolute duration, the difference is smaller than that observed in adult production. Furthermore, the singleton and geminate stops do not appear to be differentiated in proportional terms. In addition to the small differences in absolute durations between singleton and geminate consonants, this seems to be due to the long durations of the vowels following the geminate stops; on average, vowels following geminate stops are 1.7 times longer than vowels following singleton stops.

## Discussion

Our results, although preliminary, seem to suggest that Finnish children begin to distinguish singleton vs. geminate stops in production by the end of the one-word period,

possibly even early in this period, whereas Japanese children do not reliably distinguish them even at the end of the one-word period. The apparent cross-linguistic difference in rate of mastery of the contrast may be due to the differences in input frequency as well as in the degree of distinctiveness of the contrast in adult speech, as Aoyama (2000) suggests for the length contrast for /n/ in the two languages. It may also be due to a difference in the degree of consistency in the segmental lengths to which children are exposed. In Japanese long consonants or vowels are often used for purely pragmatic or stylistic purposes (which in turn is perhaps not unrelated to the fact that they are lexically contrasted less frequently), and our impressionistic observation of mothers' speech is that the segments of target words can be more freely stretched in Japanese. For instance, [hap:a], [ha:p:a], [hap:a:] and [ha:p:a:] are all possible productions for the word 'leaf', and this kind of length variation appears to be relatively frequent in child-directed speech. This, in turn, suggests the possibility that Japanese children may be more successful in distinguishing the singleton vs. geminate contrast than is evident here; if it is the case that they are stretching some of the neighbouring segments (in this case, the vowels following medial geminate stops) in a manner similar to adults. That is, their CVCV and CVC:V words may be perceived by Japanese adults as CVCV and CVC:V. On the other hand, although acoustic measurements suggest that Finnish children may differentiate the contrast already at the 4-word point to a certain degree, whether the difference produced in those early productions is distinctive enough to be perceived as such remains an unanswered question. Work is currently underway to address these questions.

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