

Table 1. Label set used for the segmental labeling of the CSJ

Vowels:	
a, i, u, e, o	(voiced)
A, I, U, E, O	(devoiced)
Plain Consonants:	
k, g, G[ɣ], @[ŋ], s, z, t, c [ts], d, n, h, F, b, p, m, r[r], w, y	
Phonetically palatalized consonants:	
kj, gj, Gj, @j, sj[ʃ], zj[ʒ], cj [tʃ], nj[n̠], hj[ç]	
Phonologically palatalized consonants ('youon'):	
ky, gy, Gy, @y, sy, zy, cy, ny, hy, by, py, my, ry	
Moraic phonemes:	
Long vowel :	H
Geminate ('sokuon'):	Q
Moraic nasal ('hatsuon'):	N

Table 2. Number of samples and averaged devoicing rate of all vowel segments

VOWEL	N	VOICED	DEVOICED	%DEVOICED
a	109624	108432	1192	1.09
aH	3956	3954	2	0.05
e	58154	57401	753	1.29
eH	12363	12361	2	0.02
i	75581	60675	14906	19.72
iH	2650	2646	4	0.15
o	88412	87282	1130	1.28
oH	19445	19437	8	0.04
u	49448	33917	15531	31.41
uH	8340	8307	33	0.40

Table 3. Devoicing in the /C1VC2/ environment as a function of the voicing of C1 and C2

VOWEL	C1	C2	VOICED	DEVOICED	%DEVOICED
a	Co	Co	12214	262	2.10
	Co	Cv	18570	92	0.49
	Cv	Co	24943	481	1.89
	Cv	Cv	19867	29	0.15
e	Co	Co	5550	190	3.31
	Co	Cv	10890	116	1.05
	Cv	Co	11552	323	2.72
	Cv	Cv	11388	29	0.25
i	Co	Co	1475	12124	89.15
	Co	Cv	10556	2219	17.37
	Cv	Co	9200	126	1.35
	Cv	Cv	12072	133	1.09
o	Co	Co	12247	437	3.45
	Co	Cv	19752	365	1.81
	Cv	Co	14650	13	0.09
	Cv	Cv	16802	14	0.08
u	Co	Co	1732	9267	84.25
	Co	Cv	11851	3133	20.91
	Cv	Co	5562	127	2.23
	Cv	Cv	7748	61	0.78

Table 4. Cross-tabulation of the voicing of /i/ in the /CoVnCo/ environment by C1 and C2

VOWEL	C1	C2	VOICED	DEVOICED	%DEVOICED
i	c	C	16	73	82.02
		H	35	7	16.67
		K	31	358	92.03
		P	7	44	86.27
		Q	16	16	50.00
		s	64	41	39.05
		t	32	181	84.98
	h	c	5	80	94.12
		h	22	9	29.03
		k	15	342	95.80
		Q	21	39	65.00
		s	11	3	21.43
		t	21	883	97.68
	k	c	19	62	76.54
		h	167	65	28.02
		k	73	476	86.70
		Q	32	51	61.45
		s	144	262	64.53
		t	53	791	93.72
	p	Q	118	9	7.09
	s	c	7	259	97.37
		h	47	14	22.95
		k	50	1102	95.66
		Q	25	92	78.63
		s	259	178	40.73
		t	49	6507	99.25
	t	k	11	0	0.00
Q		13	0	0.00	

Table 5. Cross-tabulation of the voicing of /u/ in the /CoVnCo/ environment by C1 and C2

VOWEL	C1	C2	VOICED	DEVOICED	%DEVOICED
u	c	c	16	57	78.08
		h	24	10	29.41
		k	44	872	95.20
		Q	13	32	71.11
		s	137	140	50.54
		t	19	207	91.59
	h	c	4	86	95.56
		h	17	16	48.48
		k	15	227	93.80
		Q	25	7	21.88
		s	6	46	88.46
		t	10	248	96.12
	k	c	48	123	71.93
		h	132	56	29.79
		k	151	246	61.96
		p	3	21	87.50
		Q	114	26	18.57
		s	380	1202	75.98
		t	148	1021	87.34
	p	k	8	7	46.67
		s	12	18	60.00
		t	6	12	66.67
	s	c	3	8	72.73
		h	4	8	66.67
		k	31	2207	98.61
		p	2	154	98.72
		Q	23	31	57.41
		s	60	195	76.47
t		37	1210	97.03	

Table 6. Devoicing rate [%] of /i/ in the /CoVnCo/ environment classified by the manner of C1 and C2

		C2			
		Affricate	Fricative	Stop	
C1	Affricate	81.1	33.3	89.4	78.3
	Fricative	96.3	38.1	98.4	94.6
	Stop	80.2	51.5	89.3	77.3
		91.0	43.8	47.7	

Table 7. Devoicing rate [%] of /u/ in the /CoVnCo/ environment classified by the manner of C1 and C2

		C2			
		Affricate	Fricative	Stop	
C1	Affricate	77.2	48.1	94.5	83.6
	Fricative	95.1	61.2	97.5	93.5
	Stop	80.8	74.0	80.1	77.1
		84.4	68.8	35.9	

Table 8. Effect of the following geminate on devoicing rate  
Pooled data of /i/ and /u/

C1	C2 non /Q/			C2 /Q/		
	Voiced	Devoiced	%Devoiced	Voiced	Devoiced	%Devoiced
Affricate	454	2021	81.7	29	49	62.8
Fricative	860	14099	94.3	112	181	61.8
Stop	1464	4954	77.2	282	87	23.6

Table 9. Voicing of the first two vowels in the environment of consecutive devoicing

		SECOND VOWEL	
		VOICED	DEVOICED
FIRST VOWEL	VOICED	17	44
	DEVOICED	171	84

Table 10. Devoicing rate of /i/ in the /CoVn Cv/ environment classified by the manner of C1 and C2

		C2					
		Approximant	Fricative	Liquid	Nasal	Stop	
C1	Affricate	12.8	9.7	8.4	18.2	9.4	12.5
	Fricative	20.2	8.7	10.4	38.4	10.2	28.3
	Stop	5.8	5.7	2.0	9.6	5.9	7.8
		14.0	8.2	7.1	24.4	8.6	

Table 11. Devoicing rate of /u/ in the /CoVn Cv/ environment classified by the manner of C1 and C2

		C2					
		Approximant	Fricative	Liquid	Nasal	Stop	
C1	Affricate	13.8	20.6	6.9	28.3	12.9	19.8
	Fricative	46.5	16.7	5.5	65.6	22.1	36.8
	Stop	4.7	2.6	3.1	3.8	5.0	3.9
		18.4	12.6	4.6	35.8	15.9	

Table 12. Devoicing rate of /a/ in the /CoVncCo/ environment by the manner of C1 and C2

		C2								
		Affricate		Fricative		Stop		Geminate		
C1	Affricate	-	(1)	-	(7)	0.0	(47)	1.3	(79)	0.7
	Fricative	3.1	(389)	5.0	(714)	1.5	(1206)	1.3	(316)	2.7
	Stop	0.8	(880)	1.1	(2537)	2.8	(5162)	1.1	(1134)	2.0
		1.5		1.9		2.5		1.1		

Table 13. Devoicing rate of /e/ in the /CoVncCo/ environment by the manner of C1 and C2

		C2								
		Affricate		Fricative		Stop		Geminate		
C1	Affricate	-	(1)	-	(0)	-	(0)	-	(7)	0.0
	Fricative	0.9	(333)	2.2	(45)	7.5	(388)	0.0	(132)	3.7
	Stop	0.6	(176)	4.4	(1083)	3.4	(2925)	1.2	(650)	3.2
		0.8		4.3		3.9		1.0		

Table 14. Devoicing rate of /o/ in the /CoVncCo/ environment by the manner of C1 and C2

		C2								
		Affricate		Fricative		Stop		Geminate		
C1	Affricate	-	(3)	-	(3)	1.7	(59)	4.0	(455)	3.8
	Fricative	2.6	(76)	4.1	(410)	4.3	(1205)	1.7	(119)	4.0
	Stop	2.6	(721)	2.1	(2070)	3.8	(7208)	1.1	(355)	3.3
		2.8		2.5		3.9		2.6		

Table 15. Devoicing of the first vowel of two identical morae in the /CoVncCo/ environment

VOWEL	VOICED	DEVOICED	%DEVOICED
a	458	54	10.5

e	112	5	4.3
o	490	141	22.3

Table 16. Devoicing rate in the /CoVncCo/ environment as a function of laughter

VOWEL	LAUGHTER	N	VOICED	DEVOICED	%DEVOICED
a	0	12184	11940	244	2.00
	1	292	274	18	6.16
e	0	5616	5434	182	3.24
	1	124	116	8	6.45
o	0	12396	11977	419	3.38
	1	288	270	18	6.25

Table 17. Comparison of the devoicing rate of the first vowel of consecutively devoiceable sequence and that of /CoVnCo/ environment pooled over /i/ and /u/

MANNER	V1	/CoVnCo/
F/A	98.3	95.9
F/S	95.3	98.1
A/S	94.4	92.6
S/A	91.6	80.7
A/A	75.0	79.3
S/F	62.5	68.6
F/F	42.3	48.9
S/S	39.2	84.4
A/F	22.2	43.1

Table 18. Difference of devoicing rate due to speech type

Environment	APS		SPS	
	N	%DEV	N	%DEV
CoVnCo	11028	85.9	13570	87.8
CoVnCv	10943	18.4	16816	19.9
CoVncCo	12215	2.5	18685	3.1

Figure 1. Devoicing rate of two vowels in the environment of consecutive devoicing

Numbers in parenthesis show the number of samples for each combination.

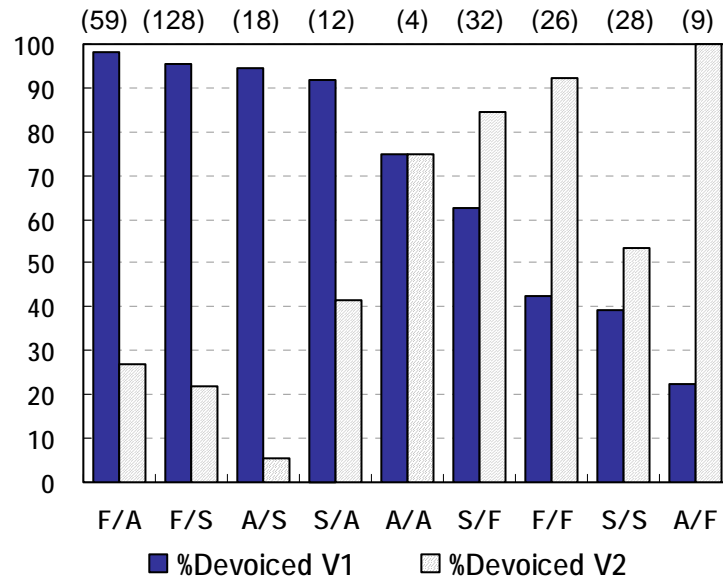


Figure 2. Word-frequency and devoicing rate in the /CoVn Cv/ environment

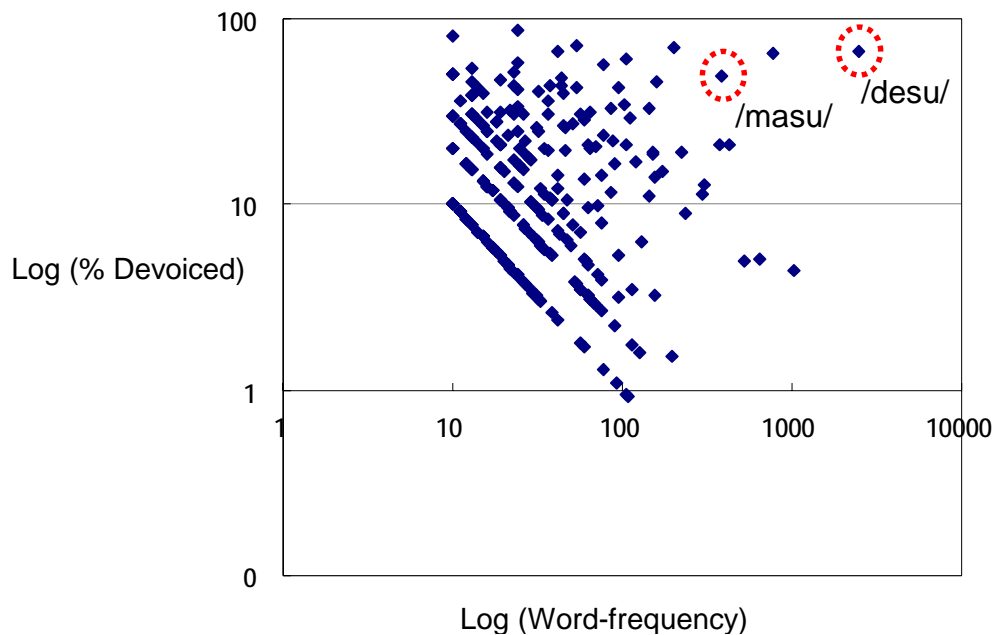


Figure 3. Effect of speaking rate on devoicing rate in the /CoVncCo/ environment

